Stakeholder Charrette Report

Charrette #5: Design | May 26 , 2021

Char-rette: a meeting in which all stakeholders in a project attempt to resolve conflicts and map solutions

Background

Decarbonizing the way we heat and cool our buildings is essential to a stable climate and a zero-emissions future.

HEET[1], a non-profit climate solutions incubator, has designed a method for gas utilities to deliver renewable, non-emitting and non-combusting heating and cooling. This technology, known as networked geothermal[2], consists of pipes filled with water that are installed in the street and connected to ground source heat pumps in buildings. The system can be installed and operated by existing gas utilities, providing a way forward for a transition off natural gas and for states and municipalities to meet emission reduction mandates.

Increasingly, utilities and energy advocates across the U.S. and internationally are considering networked geothermal as a viable electrification pathway, business model and alternative to fossil fuels. In Massachusetts, six networked geothermal demonstration projects have been approved for installation and are moving forward.

Each of HEET's charrettes is an ongoing effort to work together across diverse perspectives and backgrounds, generate ideas and anticipate barriers. In this way, we can move towards a just energy transition—one with clean, safe and accessible energy, low customer bills and good jobs—as rapidly, wisely and justly as possible.

Executive Summary

HEET hosted its Design Charrette on May 26, 2021 to identify key design considerations for networked ground source heat pumps and compare systems to find an optimal design. The

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[1] HEET, Home Energy Efficiency Team, is a Massachusetts-based non-profit dedicated to cutting carbon emissions now by driving systems change.
[2] Networked geothermal is also commonly referred to as thermal energy networks. In the past, it has been called the GeoMicroDistrict or GeoGrid.

charrette included presentations on four different installations by designers, contractors and utility representatives. Presenters shared their experiences and supported short discussions on each project. This report captures a summary of the case studies and related discussion.

The 76 stakeholders present included utility executives, regulators, labor and workforce representatives, community organizations, advocates, geothermal designers and installers, and heat pump installers and manufacturers.

HEET deeply thanks all the participants for their input. This report will be shared with participants and other stakeholders, including utilities and state regulators.[3] *HEET also thanks E4theFuture and other funders for their support of HEET's charrettes.*

Introduction

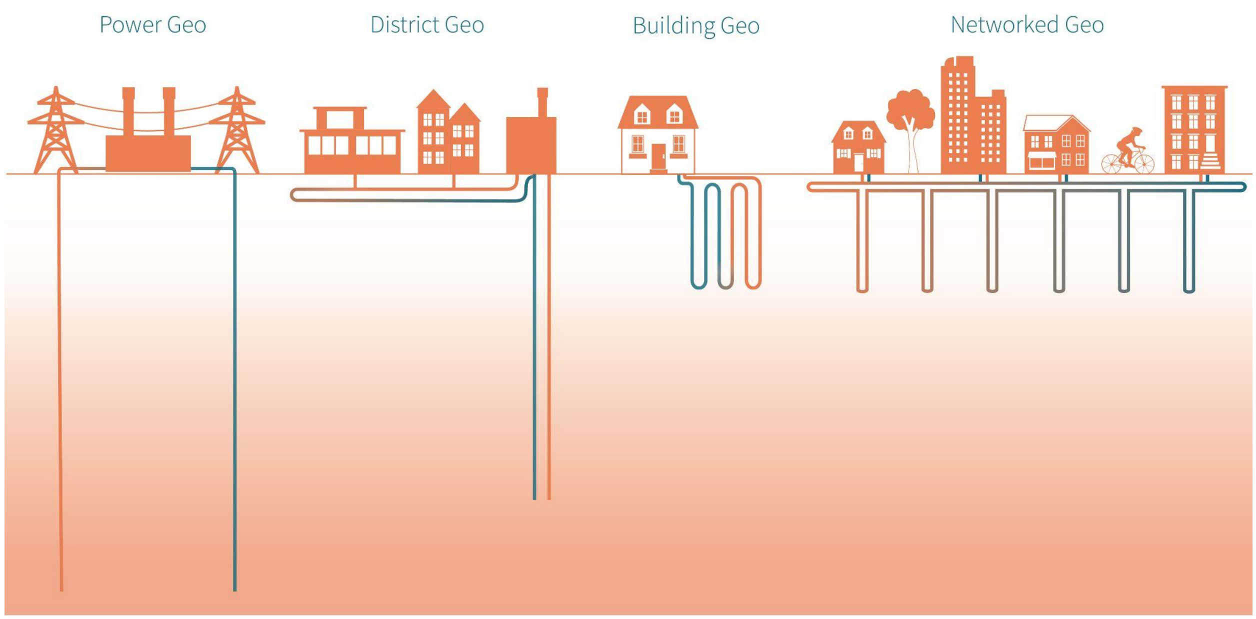
HEET Co-Executive Directors Audrey Schulman and Zeyneb Magavi opened the charrette with updates on planned networked geothermal demonstration installations in Massachusetts. State regulators have approved an installation for Eversource Gas[4] and an additional installation to be built in Merrimack Valley. National Grid is currently seeking approval from the Department of Public Utilities (DPU) for a networked geothermal installation that is expected to cover 100-200 homes and businesses. In New York, NYSERDA has committed $15 million to building a networked geothermal installation and Mayor de Blasio has announced legislation[5] that could allow the future installations to scale.

Nikki Bruno, Director of Clean Energy Technologies at Eversource Energy, spoke about Eversource's plans and reiterated the utility's commitment to moving forward with the initial demonstration system in Massachusetts. Site selection is in process and forecast to be finalized by the end of the summer. Construction is expected to begin in the fall of 2021.

Magavi presented a short overview of the different types of geothermal systems and clarified how networked geothermal is distinct. **Power geo** is electricity created from deep geothermal, generally where underground steam or hot water is available. **District geo** is centrally heated using steam or hot water from deep geothermal energy. **Building geo** is a single building with shallow boreholes connected to a ground source heat pump.

[3] The HEET Library holds a variety of work produced by HEET, all of which is licensed under an Attribution-ShareAlike 4.0 International license, which is provided by the nonprofit Creative Commons. This license allows for commercial uses of our work, and it permits adaptations of our work to be adapted and shared, as long as work is shared under the license that we have chosen or a similar, compatible license.
[4] For current updates on Eversources's installation and site selection, see: https://www.eversource.com/content/residential/save-money-energy/clean-energy-options/geothermal-energy
[5] Legislation has since been signed into law that allows gas utilities in New York to sell thermal energy. https://www.geothermal.org/our-impact/blog/new-york-approves-landmark-thermal-network-legislation

The focus of HEET's work and charrettes is **networked geothermal**, where multiple buildings and shallow boreholes are interconnected by a loop of ambient-temperature water. The water is pumped through boreholes and to local thermal sources and sinks to maintain its temperature. Each building has one or more heat pumps that provide heating and cooling to the building as needed.



Schulman explained that the charrette's discussion would focus on key design components that are essential for an efficient and reliable networked geothermal system:

- **Ambient temperature water:** A thermal network can be designed with one pipe for cold water and one for hot, or can use a single pipe. In a single pipe design, the pipe takes in both heating or cooling from buildings on the system. As a result, the water in the pipe remains at an ambient temperature.
- **Opportunistic design:** Accessing thermal sources and sinks.
- **Central pumping on a shared loop:** In this design, there is one water pump for an entire loop, which moves heating or cooling to different buildings, rather than using individual water pumps for each building. This saves both money and electricity.
- **Central thermal management and optimization:** Adding different heating and cooling uses to the loop and releasing temperature as needed keeps heat pumps working at their highest efficiency and reduces electric peak load.

Presenters

- **Chong Lin**, Manager of Statewide Energy Program Field Operations at National Grid
- **Nichol Brunner**, Innovation Expert on 5th Generation District Heating and Cooling at

Mijnwater BV

- **Brian Urlaub**, Director of Geothermal Operations at Salas O'Brien (previously MEP Associates) - slide deck
- **Cary Smith**, US Managing Member at GreyEdge Group and owner of Sound Geothermal Corporation

Chong Lin

Chong Lin is the Manager of Statewide Energy Program Field Operations at National Grid and holds six years of experience in energy efficiency. Lin presented a summary of National Grid's geothermal demonstration project built in Glenwood Village, New York.

> Glenwood Village is a community of 10 homes built between 1976-2017. These homes were too far from the local gas infrastructure to make it financially viable to provide them with gas heating.
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>
> Instead, National Grid installed a closed-loop geothermal system that could provide 30 tons of heating or cooling (a "ton," a common HVAC unit, is enough heat to melt or freeze a ton of ice. The average home in New England requires about three tons of heat). 30 tons of capacity covers 99% of the needed heat for the buildings. To supply the backup heat when needed, each home has access to five kW of supplemental electric resistance heating.
>
> The geothermal system was designed to provide heating and cooling, but not domestic hot water. The design includes 20 boreholes, each about 250 feet deep. Compared to prior energy usage, customers have saved 31-60%.

YES	NO	DESIGN CHOICE
✓		**Ambient Temperature Water** • Decentralized thermal generation - heat pumps at buildings • Bidirectionality which allows waste thermal capture
	✓	**'Opportunistic Design' - Utilizing Thermal Sources & Sinks** • Diverse heating and cooling needs for participating buildings • Alternate or supplemental thermal, i.e. rivers, data centers... • Design for smart sum instead of simple sum of building loads
	✓	**Central Pumping on Shared Loop**
✓	✓	**Central Thermal Management & Optimization** • 'Backup' or supplemental on central water loop • Integration with electric grid • Internet of energy - smart energy components locally optimizing

> National Grid installed British thermal unit meters (BTUs are a method of measuring thermal energy) in the homes to measure how much heat each unit used. All homes in the Glenwood Village complex were fairly new and similarly constructed, which allowed for lower construction costs. The system turned out to be slightly oversized; future similar installations could have smaller infrastructure while fulfilling the same heating/cooling needs. The total cost of the project, including underground infrastructure and heat pumps, was $301,000.

Nichol Brummer

Dr. Nichol Brummer, Innovation Expert on 5th Generation District Heating and Cooling at Mijnwater BV, discussed the [Mijnwater] project, located in the Netherlands.

> In 2003, the municipality of Herleen discovered that an old coal mine filled with water could serve as a source of renewable thermal energy. The water in the mine stays between 18-28 degrees Celsius (64 to 82 degrees Fahrenheit). In the winter, the warm water at the bottom of the mine, close to a mile deep, is pumped to heat local buildings. In the summer, the cooler water at the top of the mine is pumped to cool buildings. The hot and cold water is delivered through separate pipes via a central plant. Heat is then distributed within the buildings via radiant heat (water) or warm air. A booster heat pump in the buildings is also used to create domestic hot water.
>
> This district system began by serving one large office building, the National Statistics Bureau, and a social housing project in Heerlen. In 2013, it was upgraded to a fully functioning 5th Generation Heating and Cooling grid (5GDHC).
>
> An important new feature of the Mijnwater project is that the grid is able to exchange thermal energy between all customers simultaneously, while the mine water system is used to store thermal energy.

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Brian Urlaub

Brian Urlaub is an expert in the geothermal heat pump industry and Director of Geothermal Operations at [Salas O'Brien] (previously MEP Associates). Urlaub spoke about the [Berczy-Glen installation], located in Toronto.

Berczy-Glen is a project that will connect 312 newly-built homes with a loop of ambient-temperature water. The homes are still in the process of being constructed.

The geothermal infrastructure is located under the street and includes 144 boreholes at 850 feet deep. The original design of a hybrid open-loop system with horizontal and vertical boreholes was changed due to space constraints. Pumps located in underground vaults circulate water. This installation delivers the same temperature fluid to all homes within +/- two degrees Celsius. The ground source heat pumps deliver temperature through air ducts in homes, maintaining a comfortable temperature. The installation also provides up to 60% of domestic hot water heating.

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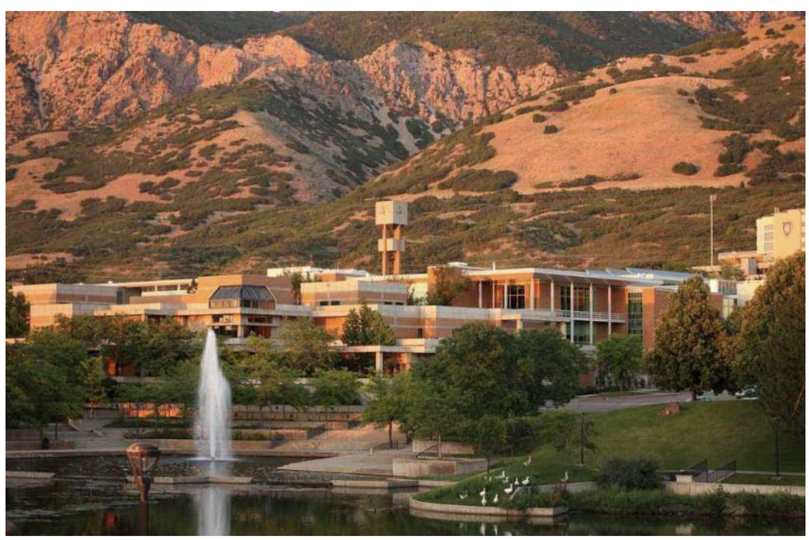
Cary Smith

Cary Smith is the US Operations Manager for the GreyEdge Group, owner of Sound Geothermal Corporation and an experienced networked geothermal engineer. Smith presented the design of Weber State University in Utah, a retrofit of an existing hot water distribution system.

Weber State University (WSU)'s goal to achieve carbon neutrality by 2050 inspired a shift in how the campus heated and cooled its buildings. Smith and the GreyEdge Group helped the university install shared-loop geothermal that connected multiple buildings by repurposing chiller (air conditioning) lines.



This retrofit began in 2014 to convert non-heat pump buildings to water source heat pumps, with the overall goal of optimizing energy savings and minimizing water use. By the second year, use of the gas boiler was reduced to seven percent of what it was before the project started. The university automatically funnels savings on its energy bills back into expansion of the system, allowing it to continually grow.

Results: Direct greenhouse gas emissions have been reduced by 31% since the baseline year of 2007; electricity consumption has dropped 29%; natural gas consumption is down 33% and energy costs are down 40%. Weber State's carbon footprint has been reduced by 7,881 metric tons/year from 2008-2018 and the university has realized annual savings of $1.9 million.

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Discussion and Attendee Comments

At the conclusion of the presentations, participants were assigned to breakout groups and asked to provide feedback on the benefits and challenges of the following key design components:

- Ambient temperature water, with decentralized thermal generation (heat pumps within buildings)
- Opportunistic design (utilizing thermal sources and sinks)
- Central pumping on a shared loop
- Central thermal management and optimization

Ambient-temperature water

- Benefits
    - Avoids the need for insulated pipes, reducing materials costs.
    - Does not need two separate pipes, reducing infrastructure and installation costs.
    - Horizontal pipes filled with water also absorb temperature from the ground, functioning essentially as horizontal boreholes and reducing the need for vertical boreholes.
    - Takes advantage of thermal recapture by reusing thermal energy shed from different buildings.
    - Exchanges energy with diverse energy sources like loopfields, surface water,

    solar thermal and waste thermal energy sources.
  - Expected to have lowest pumping costs since there is only one pipe.
- Challenges
  - Some areas may have limited drilling capacity for boreholes.
  - Not a familiar approach to many engineers and infrastructure contractors.
  - Incurs electrical infrastructure upgrade costs.
- Other thoughts
  - In cases like the Mijnwater system, where there is access to water at very different temperatures, there is a significant advantage to using a two-pipe system to distribute the water separately. This can be difficult to implement if there are regulatory restrictions on aquifer water.

Opportunistic design: utilizing thermal sources and sinks

- Benefits
  - Heat can be shared, harvested, stored and reused.
  - The efficiency may result in reducing the number of boreholes required, also reducing construction costs and time.
- Challenges
  - It can be difficult to find an ideal balance of thermal sources and sinks and to balance temperature over time.
  - The design depends on the types of buildings included in the network, so rules of thumb and cookie cutter designs are not optimal. Designs should be site specific.
- Other thoughts
  - This approach may pay back most quickly on larger projects because of the effort and cost required to interconnect the system to thermal sources and sinks.

Central water pumping on a shared loop

- Benefits
  - More resilient design if there is more than one water pump on a central loop; if any one pump breaks, the others can keep the water moving.
  - If there is more than one water pump on the central loop, each can run at a low power, moving the water at the correct speed while using less power overall than one pump working at peak all the time.
- Challenges
  - Individual buildings are dependent on long term maintenance of the central pumping system.
  - Ground source heat pumps have mainly been installed on individual buildings, so there is limited data for comparative costs and efficiencies for designs of central water pumping on a shared loop.
- Other thoughts

- May be better suited for larger projects because of more rapid cost recovery.
- Centralized equipment might be more attractive to campuses, co-ops or utilities.

Central thermal management and optimization

- Benefits
    - With proper thermal management of an ambient-temperature loop, the heat pumps in the attached buildings will work at peak efficiency.
    - As additional sections and load diversity are added to the network, the size and diversity of the various segments provide greater opportunities to balance the thermal loads.
- Challenges
    - Need to have permission or cooperation from the connected buildings to manage the thermal load.

Additional Information:

Slide decks:

HEET slide deck

Brian Urlaub, MEP Associates: Toronto Berczy-Glen slide deck

For more information about HEET and its work on networked geothermal:

https://heet.org

https://heet.org/who-we-are/our-people/

https://heet.org/geo/

https://heet.org/community-charrette-reports/

https://heet.org/library/