Stakeholder Charrette Recommendations

Data Collection Plan

February 17, 2021

Char•rette

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noun

A meeting in which all stakeholders in a project attempt to resolve conflicts and map solutions.

Networked geothermal (ground source heat pumps) is a non-emitting renewable method of delivering heating and cooling. Given that Massachusetts has a mandate to reduce emissions to net zero by 2050, networked geothermal is a potential method for local gas distribution companies to continue to meet residents' needs for heating and cooling in our lower emitting future.

In Massachusetts, two networked geothermal installations are planned for this year. In an effort to support and improve the demonstration installations, HEET is organizing monthly charrettes throughout 2021, where diverse stakeholders share knowledge to identify issues and find solutions.

The two-hour February 17th charrette covered questions we want answered by the pilots and therefore the data we need to collect.

The 43 participants in the charrette included utility executives, regulators, labor representatives, community organizations, advocates, legislators, geothermal designers and installers, and heat pump installers and manufacturers. The participants were split into working groups that produced the following recommendations for data collection.

This report is a summary of the stakeholders' recommendations. The resulting data can help networked geothermal iterate and scale at the speed we need to move to local non-emitting renewable thermal.

HEET deeply thanks all the participants for their work, which is shared with gas utilities, state regulators, and other stakeholders.

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Executive Summary: Stakeholder Recommendations

See Appendix A for the detailed recommendations and other notes by the stakeholders. The executive summary below captures high level data categories and examples and is not exhaustive or comprehensive.

Data Collection Criteria

Note that the critical designation is based on our current understanding of how best to transform the system and to drive change. It will almost certainly change over time.

Critical

To allow the first few pilot installations to iterate and scale, the data collection scheme must allow data and learning to be collected, transparent and evaluated, using best Open Data practices such as the FAIR Principles (findability, accessibility, interoperability, reusability) and open licensing.[1] While installations may vary widely in many details, we must seek to maximize the commonalities and consistency of what's learned at each step.

Recommendations are summarized below in three categories:

1. Baseline data and design
2. System operation
3. Information about people and communities

Baseline data and design

A thorough set of baseline information about site conditions and buildings is important with the first pilots so future installations can identify potential constraints and cost drivers.

It is essential to understand the costs of both the installation of the infrastructure in the street and of the building retrofits. For example, some buildings might not have the needed electric service to be able to run the heat pumps.

In the Street

- *How best to manage installation logistics?*
  Sample data needed: Drill rig accessibility, rights of way, overhead clearance, and subsurface utility congestion

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- *How do hydrogeologic conditions affect cost, installation, system design, and efficiency?*
  Sample data needed: depth to basement, water table depth, and properties of any hydrogeological units between alluvial fill and basement.
- *What are the costs of siting, designing, and installing a system?*
  Sample data needed: costs of site selection, design, and installation

In Buildings

- *How is cost and energy needed determined for the building size and configuration of structures and rooms?*
  Sample data needed: Baseline HERS (Home Energy Rating System) for existing buildings, DOER Home Scorecard , Benchmark heating BTU load for a triple decker, interior space inventory—room dimensions and geometry
- *What is the cost and time needed to retrofit existing heating and cooling systems?*
  Sample data needed: Existing heating and cooling in use: gas, oil, electric, individual space heaters, and AC units vs central air, Complete replacement of prior systems, or hybrid and backup? Design and components of upgraded in-building HVAC distribution systems, Cost of customer building-side HVAC installation (maximum, minimum, median, average)
- *What other retrofit costs are incurred, such as upgrades required to electric service?*
  Sample data needed: Electric service per building and per living unit, In-building electric service rating and capacity, distribution mechanisms, structural considerations (e.g. chases, presence of asbestos)

Whole System

- *How much does the system cost to locate, design and install?*
  Sample data needed: site selection costs, construction costs, DFOS costs, building retrofit costs, building system costs

System Operation and Performance

Making data from the pilots transparent (including design parameters and ongoing operational data) will allow future pilots to use the information to improve and scale, while reducing costs. The system provides an alternate method of electrification of buildings (moving buildings' energy use to electricity). Because the alternate method (networked ground source heat pumps) is so efficient, it is critical to understand the total amount of electricity the system will use, including both the heat pumps in the buildings, as well as the water pumps for the central loop, in order to know the true future impact on the electric grid if the system were scaled up.

It is essential to understand if the system can supply the needed thermal energy without requiring supplemental heating or cooling. It is also important to get a solid understanding of the ground loop thermal performance and any degradation over time.

In the Street

- *What is the operational load profile and cost of the central pumping system?* Sample data needed: Run-time and electricity consumption (hours and kWh) of central loop infrastructure
- *How much energy can be stored for how long?* Sample data needed: Fiber optic system output in real time

In Buildings

- *What is the difference before installation and after in the relationship between temperature called for, temperature delivered and energy use?* Sample data needed: Historic energy use, thermostat, ambient temperature, energy use
- *What kinds of heat pumps work best with what kind of buildings?* Sample data needed: Ongoing output from ground source heat pumps, Heat pump models
- *What are the customer side maintenance and repair costs to be incurred when connecting to a community ground loop?* Sample data needed: Cost of annual customer-side preventative maintenance and unscheduled repairs

Whole System

- *What is the impact on the grid?* Sample data needed: Grid impact analysis, Grid demand load curve, kWh rates, aggregate substation area demand, aggregate substation to transmission demand, aggregate ISO-NE demand
- *How much energy does the system save overall?* Sample data needed: piping loss, heat exchangers, and pumping systems as well as whole system outputs including levelized cost of heat
- *How much does the system cost to run and what are the cost savings?* Sample data needed: Changes in customer heating and cooling costs
- *How much does the system reduce overall emissions?* Sample data needed: Emission reductions, air pollution reductions

Information about people and communities

It is important to understand concerns that participants will likely have since they will not only experience changes to their homes and lifestyles but also disruptions to their neighborhoods. Outreach events and communication of benefits such as improved air quality leading to better health and lower energy costs may help mitigate concerns. Other environmental benefits are the health of street trees and lower GHG emissions.

Data to answer the following questions is critical to collect:

- *How receptive will customers be to any change from the current system, and what are the perceived benefits?*
  Sample data needed: Customer awareness of benefits, Customer satisfaction during installation, customer level of comfort after installation
- *What is the impact to respiratory health of participants*?
  Sample data needed: local statistics on asthma, indoor air quality, outdoor air quality
- *What is the impact to the neighborhood?*
  Sample data needed: Level of disruption to street, traffic patterns, repaving required, outdoor air quality, tree canopy
- *How much disruption will the participant experience?*
  Sample data needed: Current cooking fuel: gas, electric, or propane. Willingness to use electric induction cooking? Changes to heating and cooling. Length of retrofit time. Damage to building. Responsibility for paying for repairs.
- *What is the impact to workers and skills*?
  Sample data needed: Level of knowledge on renewable energy and GeoMicroDistricts, prior job history, training acquired during pilot

During the pilot it will be critical to capture Lessons Learned and Best Practices that can be applied to future installations and institute a culture of learning and continuous improvement from inception.

Recommended

Other points were highly recommended, but not required.

- Lead time. Factor in time needed for customer acquisition, workforce hiring and training, equipment procurement, installation, testing?
- Log the range of possible cost vs. performance tradeoffs in the design, and the design choices made that influence the result.
- Develop a building pre- and post-flight checklist
- Open-ended questions for people surveys
- Keep track of all unexpected situations and their resolutions

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Appendix A: Detailed Notes from Stakeholders

In the charette session, stakeholders were organized into four sectors to discuss and compile detailed recommendations and other notes for their sector. This appendix presents the results from each group.

Data Collection Sectors

- Infrastructure in the Building
- Infrastructure in the Street
- People and Communities
- System as a Whole

Infrastructure in the Building

Building Retrofits

- ➢ How much energy efficiency is needed and helpful in the buildings?
- ➢ What is cost vs performance?
- ➢ Data:

  - Baseline HERS (Home Energy Rating System) for existing buildings and post-retrofit HERS. HERS for new buildings using Manual J Blower door test, Infrared cameras

  - Benchmark heating Btu load for a triple decker

Distribution System

- ➢ Electric service readiness? 200A or not? Many triple deckers 100A whole building, 60A per floor

  Data:
  - Electric service per building and per living unit. Existing and required electric service per building. Existing and required electric service per living unit.

Heat Pumps

- ➢ What kinds of heat pumps work best for different types of buildings?
- ➢ Better understand (and, in the future, advise on) the cost to install or retrofit existing customer-side HVAC systems to function with a community ground loop; understand cost range across system types
- ➢ Data:
  - Ongoing output from ground source heat pumps
  - Cost of customer building-side HVAC installation (maximum, minimum, median, average) Log using invoiced cost for each customer's system
  - Building size, required heat pump heating, cooling capacity

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- Living unit size, heat pump details (brand, model, BTUs heating, BTUs cooling capacity, EER, SEER, etc)

Meters

- ➢ What is the difference before installation and after in the relationship between temperature called for, temperature delivered and energy use?
- ➢ Data:
  - Historic energy use, thermostat, ambient temperature, energy use

Operations & Maintenance for Infrastructure in the Building

- ➢ Better understand (and, in the future, advise on) the customer side maintenance and repair costs to be incurred when connecting to a community ground loop
- ➢ Understand the tendency of scale to occur and whether condenser water should be provided directly to customers or via a heat exchanger; determine who would own the heat exchanger
- ➢ Data:
  - Cost of annual customer-side preventative maintenance and unscheduled repairs
  - Amount of water quality impact and scale buildup (from both Company and customer sides of loop).
  - Monthly water quality tests (PPM, scale, etc.) in two locations within the central loop as well as at two randomly-selected customer connections

Other

- ➢ Thermal service basis—how do pricing, customer support work?
- ➢ Can other upgrades to houses, e.g. gas stove replacement to electric induction, be incorporated?
- ➢ What are design guidelines for room by room distribution? Thinking about how ASHP heads are allocated around a building

Opportunities

- ➢ Develop a Building checklist during pilot - “building pre- and post-flight checklist: for future installations

Concerns

- ➢ Retrofits for steam heated buildings
- ➢ Many triple deckers (100 A whole building, 60A per floor)
- ➢ Lead paint and asbestos concerns if construction gets disruptive

- ➢ Ownership transfer if property is sold; is heat pump leased and transferred?
- ➢ How to ensure the gas infrastructure is safely capped when turned off

Infrastructure in the Street

Physical Site Conditions

- ➢ What types of sites are economically feasible?
- ➢ Does the site allow access for a drill rig? Right of way at surface, requirement for lane closures, traffic control, overhead clearance, etc. (and associated expense). Existing utility congestion in subsurface.
- ➢ Is there sufficient accessible square footage for drilling to provide the necessary thermal storage?
- ➢ Data:
    - Desk Study
    - Hydrogeologic including depth to basement, water table depth, and properties of any hydrogeological units between alluvial fill and basement, other site data and

Ground Loop

- ➢ How much does the temperature of the water in the ground loop vary over seasons and years?
- ➢ Assess the need for supplemental heating and cooling equipment (i.e., cooling tower and boiler) in order to maintain the effectiveness of the ground loop throughout its operational life.
- ➢ How much can water temperature range in the ground loop while keeping the heat pumps "happy" and efficient.)
- ➢ Assess the flow requirements of the system during varying climate conditions (i.e. How fast does the water need to be pumped in different weather conditions to provide needed thermal energy to the connected buildings?). Identify any central flow imbalances (i.e. leaks)
- ➢ Assess the typical volume and cost requirements of keeping the system full of working fluid (i.e. If it leaks how much does it leak?
- ➢ How far can the thermal energy be pumped via the ground loop without losing too much temperature? i.e. 1 mile? 2 miles?
- ➢ Data:
    - Ground loop water supply temperatures (°F) to buildings; year-over-year comparisons

- Ground loop delta T (°F) between return and supply over time. How to get the data: Btu and temperature meters on the ground-loop heat exchanger's supply and return connections; heat flows and temperatures logged and stored every hour throughout operational life of project. Fiber optic cable would be an excellent way
- Data: Ground loop water flow (GPM) over time; Data comes from: Flow meters on the ground-loop heat exchanger's supply and return connections; water flows (GPM) logged and stored every hour throughout operational life of project
- Addition of make-up water/glycol (gallons) over time (if required due to leaks, flushing, etc.)
- Consumption meter (gallons) on the make-up system; log of glycol purchases, if applicable

Borehole Array

➢ How much heating or cooling can be taken from the boreholes in what length of time?
➢ How much energy can be stored for how long?
➢ Best practices for cost effectively, sustainably charging the wellfield (e.g. during nighttime off-peak hours if an electric boiler on a TOU rate structure) (i.e. What are cost effective and sustainable methods to return the borehole field to temperature?)
➢ Data:
    - Geothermal, hydrogeological modeling of subsurface, Capture Fiber optic system output in real time
    - Cost / time required to charge the wellfield (if needed to balance the wellfield temperature) Capture from Boiler trends (supply/return temperatures, fire rate, flow) logged on an hourly basis and stored throughout operational life of project

Central Pumping

➢ Better understand the operational load profile and cost of the central pumping system
➢ Data:
    - Run-time and electricity consumption (hours and kWh) of central loop infrastructure. Capture from Trends programmed for each central pump and temperature and flow Submetering water and electricity systems, ideally with smart thermostats in each building

Operations & Maintenance for Infrastructure in the Street

- ➢ Field temperature, pressure regulation
- ➢ Ongoing Electrical use patterns.
- ➢ Data:
    - ○ Track electric use over time for each pump and GSHP

Other

- ➢ Is it important/valuable to the design and optimization of the system to have separate ground temperature measurements (either in the wells or at monitoring points away from the wells)?
- ➢ Is this data important as a baseline (prior to system installation), during operation, or both? Temperature of water can be measured in the loop piping at various points in the system; easiest at surface

Opportunities

- Partnering with city departments/public works to share installation costs

Concerns

- Site constraints and right of way
- Does the site allow for a drilling rig

People and Communities

Participating People

- ➢ Customer Acceptance (i.e. Would customers accept/prefer this system? What are its perceived benefits?)
- ➢ What are the attitudes and beliefs about buildings and climate before installation
- ➢ Workers and Landlords
- ➢ How has the technology affected you
- ➢ Do you understand the technology? (Do you feel that you could explain how the technology works to friends, neighbors, etc.)
- ➢ Understand customers' satisfaction levels with the GSHP condenser water service.
- ➢ Data:
    - ○ Customer Satisfaction Surveys—Customer Comfort, space conditioning pre and post surveys, were concerns addressed, are people maintaining this accountable/responsible
    - ○ Survey both participants and near neighbors, along with a control group

Workers

- ➢ Previous risk as a utility worker?
- ➢ Track chemical exposure and safety?
- ➢ Are you interested in transitioning into this type of job?
- ➢ Im a gas worker. How can I be part of the Eversource pilot?
- ➢ How can Eversorce make me a part of the pilot as a current gas worker/
- ➢ What type of technology,equipment is involved with GEO?
- ➢ Do you know how GMDs work?
- ➢ Do you understand the risk/danger in working with gas pipelines?
- ➢ What skills do you have
- ➢ Data:
    - OSHA, insurance records, incident reporting, lost time injuries, Monitoring
    - Survey and interview, open ended?
    - Questions for GMD owner/operator

Community

- ➢ Tenants and people spending time at home
- ➢ Do you know anything about the technology?
- ➢ Do you know who to call if something goes wrong?
- ➢ Do you know how to take care of your hookup to the GMD?
- ➢ Do you know how to fix something that goes wrong with your current system?
- ➢ How disruptive is the installation?
- ➢ Do you know what this is?
- ➢ Do you know if there is gas in your neighborhood?
- ➢ Household energy
- ➢ Neighborhood hazards
- ➢ Data:
    - Interview or survey with open ended answers

Health Impacts

- ➢ Respiratory health of participants
- ➢ Respiratory health of neighborhood
- ➢ Air pollution indoors
- ➢ Mental Health/ PSTD
- ➢ Energy security
- ➢ Data:

- Interview or survey with open ended answers
- Sensors in home

Opportunities

- Improved respiratory health
- Reduced air pollution indoors
- Better energy security (due to energy cost savings)

Concerns

- Disruption during installation
- Need for homeowner training to operate new systems
- Need for training on new technology

System as a Whole

Emissions

- Carbon Reductions (i.e. How much does the system reduce overall emissions?)
- Data:
  - Emission reductions • System performance

Energy

- How much energy does the system save overall? (Necessary)
- Technology Performance (Necessary)
- Grid Impact Analysis Data - flattening the peaks? Raising the troughs? decreasing overall energy use in comparison to air source heat pumps?
- Data:
  - BTES, piping loss, heat exchangers, and pumping systems as well as whole system outputs including levelized cost of heat, net present value, and internal rate of return.
  - Changes in Customer Energy Consumption • System performance
  - kWh rates, aggregate substation area demand, aggregate substation to transmission demand, aggregate ISO-NE demand

Costs

- How much does the system cost to locate, design, install and run? (Necessary)
- Cost Savings (Necessary)

- ➢ Better understand time requirements for customer acquisition, equipment and labor procurement, and construction activities across a range of installation types
- ➢ How long does the system last in the street and in the buildings?
- ➢ Data:
    - Site selection costs, construction costs, DFOS costs, building retrofit costs, building system costs, and operational costs. (DFOS= Fiber optic sensors)
    - Changes in customer heating and cooling costs
    - Timeframes

Opportunities

- Avoided costs
- Avoided emissions
- Health benefits associated if the system were scaled up

Concerns

- What is the reliability
- How long does the system last in the street and in the buildings
- Cost of training workers? Geo Drilling, pipe laying
- Hvac and retrofits
- What is the cost of homeowner/tenant disruptions - pain adjusted savings? And how to reduce that
- How to roll out program large scale
- What are the emissions from electricity generation used to power the system wide heat pumps

What's missing—More questions

Hybrid or Backup Solutions

- ➢ If the loop is not sized to support 100% of a design day in the summer does the utility plan to use large centralized chillers to "flash" the loop for cooling or is the district going to have enough ground loop capacity to cover 100% of a summer design day for cooling?

- ➢ What happens if the business or homeowner doesn't decide to be part of the plan in a given grid/district before and/or after installation? Is there a way to opt out?
- ➢ Consider 2-step process—replace gas furnace or boiler with heat pump; leave gas stove.
- ➢ Data:
    - Survey whether people will stay with newer system vs older gas?
    - Energy consumption over time, Utility usage history vs current

Customer Reluctance- Risks vs benefits

- ➢ Minimize risk to homeowner
- ➢ Will older systems (ie radiators) be replaced by ducted systems?
- ➢ How is customer cost impacted (buy-in cost vs energy cost)
- ➢ Data:
    - Track damage/repair costs during pilot
    - Measure Transfer of electric costs from say air-conditioning to geothermal
    - Survey satisfaction of customer after installation
    - Track replacement vs retrofit of existing heating systems in Pilot
    - Customer energy costs before and after
    - Customer buy-in cost (Heat pump, appliances, retrofits)

Neighborhood impact

- ➢ How to get neighborhood to sign up
- ➢ What is the neighborhood profile
- ➢ Disruption during drilling
- ➢ How to sell the Benefits
- ➢ Data:
    - Record damage incidences
    - Outreach events, Survey customer satisfaction, testimonials
    - homeowners vs tenants, # businesses in pilot, how many participants in favor
    - Tree canopy before and after, and in 5 years

Other

- ➢ What is the plan re: mechanical contracting of the loop drilling/install, unit and building side distribution installation?
- ➢ Who will be responsible for assessing each building's heating and cooling loads?
- ➢ Is it possible or less disruptive to do horizontal trenching vs vertical

➢ How does "system participant" share surplus thermal gain, or realize benefit
➢ How to quantify benefits such as cooling, versus the increase in energy costs. Benefit of having central a/c instead of window AC units.

Opportunities

- Promote greater comfort of heat pump system, getting A/C
- Resiliency
- Utilities are on board, investing in Geothermal
- Big oil companies (Mobil?) are investing in Geothermal
- Can drilling companies expand scope to drill boreholes?
- Awareness/Training benefits of induction cooking

Concerns

- Public is not familiar with Geothermal systems, need for messaging
- Disruption to communities—drilling in neighborhoods
- Disruption to customers, getting their agreement to work inside homes, potential damage (holes in walls)
- What are regulatory hurdles?
- Overcoming resistance from drilling and transmission line companies
- Customer resistance to change
- Customer reluctance to lose gas appliances
- Customer lack knowledge cooking with induction stovetops
- New cookware (pots and pans) may be needed
- How will appliance selection be done