

BUILDINGENERGY BOSTON

Climate Justice is Right Under Our Feet: Ground Source Heat Pumps and Community Thermal Networks

**Dave Hermantin (Brightcore Energy)
Lauren Hildebrand (Brightcore Energy)
Audrey Schulman (HEET)**

Curated by Silvana Bastante Muñoz and Kurt Roth

**Northeast Sustainable Energy Association (NESEA)
March 29, 2023**

LEARNING OBJECTIVES

1. Describe the fundamentals of ground source heat pump HVAC systems and the ability to configure them into district/community systems.
2. Define the characteristics that make a building or neighborhood a promising fit for GSHP implementation, and those posing significant challenges in consideration of traditional geothermal vs. geothermal networks.
3. Identify upcoming federal, state, and local incentives and financing options to lower the up-front cost challenges.
4. Describe how these technologies can contribute to an equitable transition for Low to Middle Income housing.

Scary Statistics

90%

Time we spend indoors

75%

Deaths caused by chronic disease, up from 13% in 1800

85%

Of the 82,000 chemicals in use lacking available health data



Today's kids are the first generation

expected to have shorter life expectancy than their parents

What determines health outcomes?

>5% Genetics/biology

≈20% Lifestyle/behavior

≈20% Medical care

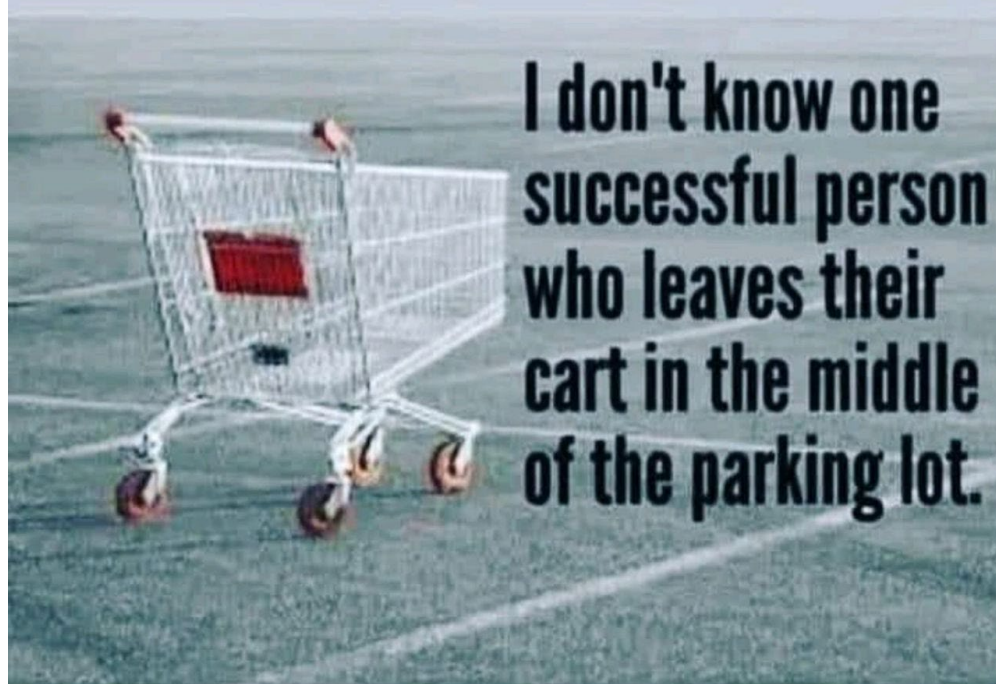
≈55% Physical & social environment

It's not your genetic code...

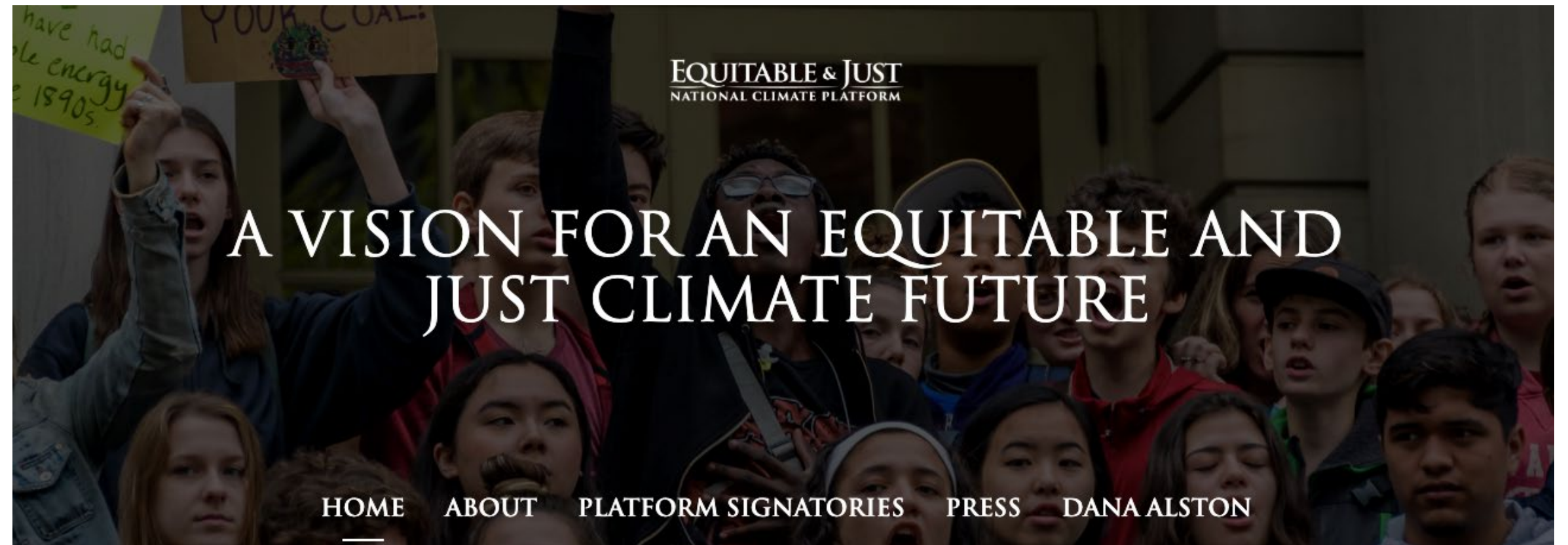
it's your zip code!



Reasons for Hope: We know more now than we have ever known!



If you're too big to do the small things,
you're too small to do the big things.



GEOHERMAL RENEWABLE HEATING & COOLING

Our geothermal solutions eliminate the use of fossil fuels to heat and cool buildings, reducing carbon emissions and lowering operating costs

 **Brightcore**
BUILDING ENERGY PERFORMANCE™

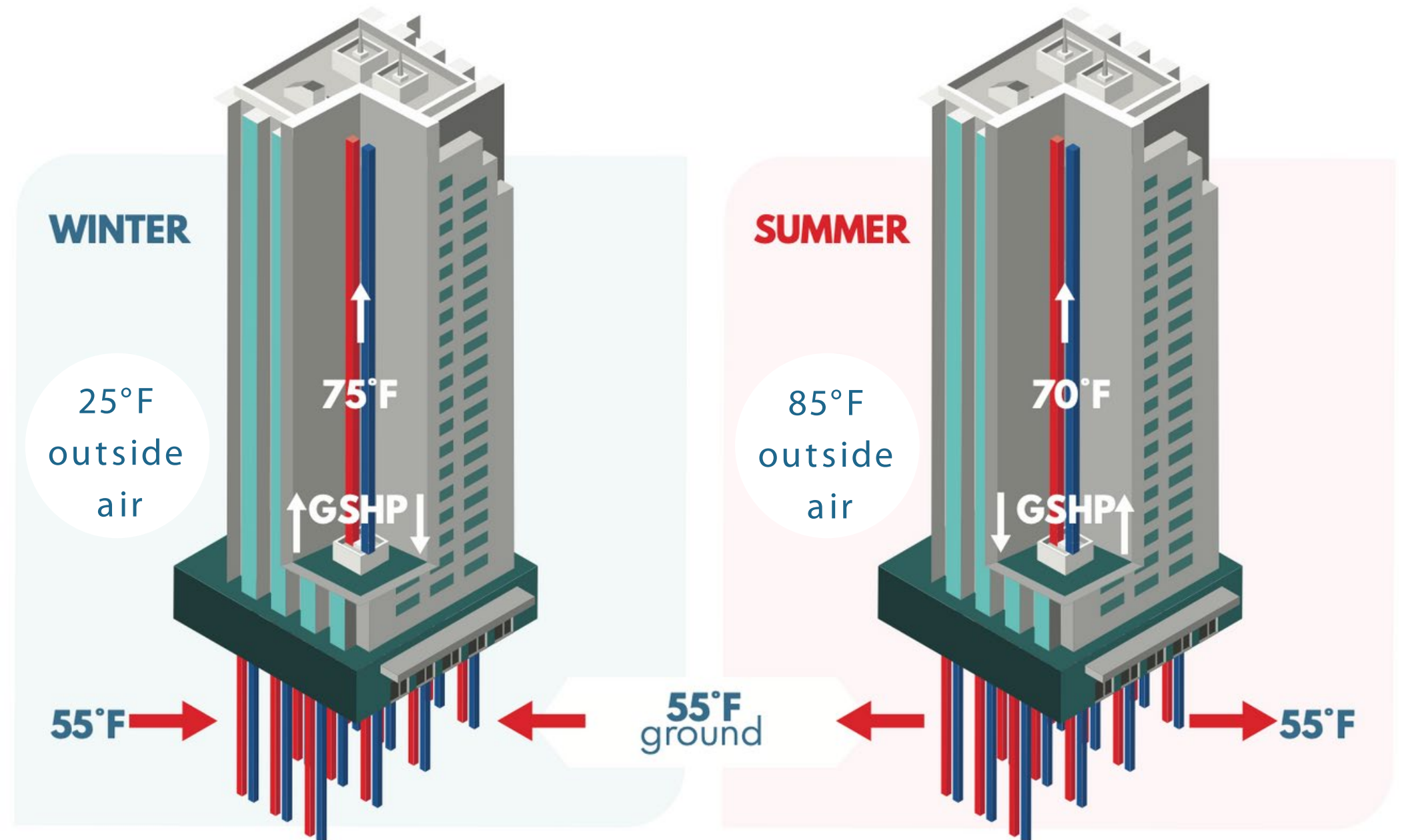


The ability to "pre-heat" or "pre-cool" the system from the earth's 55 degree ambient temperature dramatically reduces system demand compared to conditioning peak outside air temperatures.

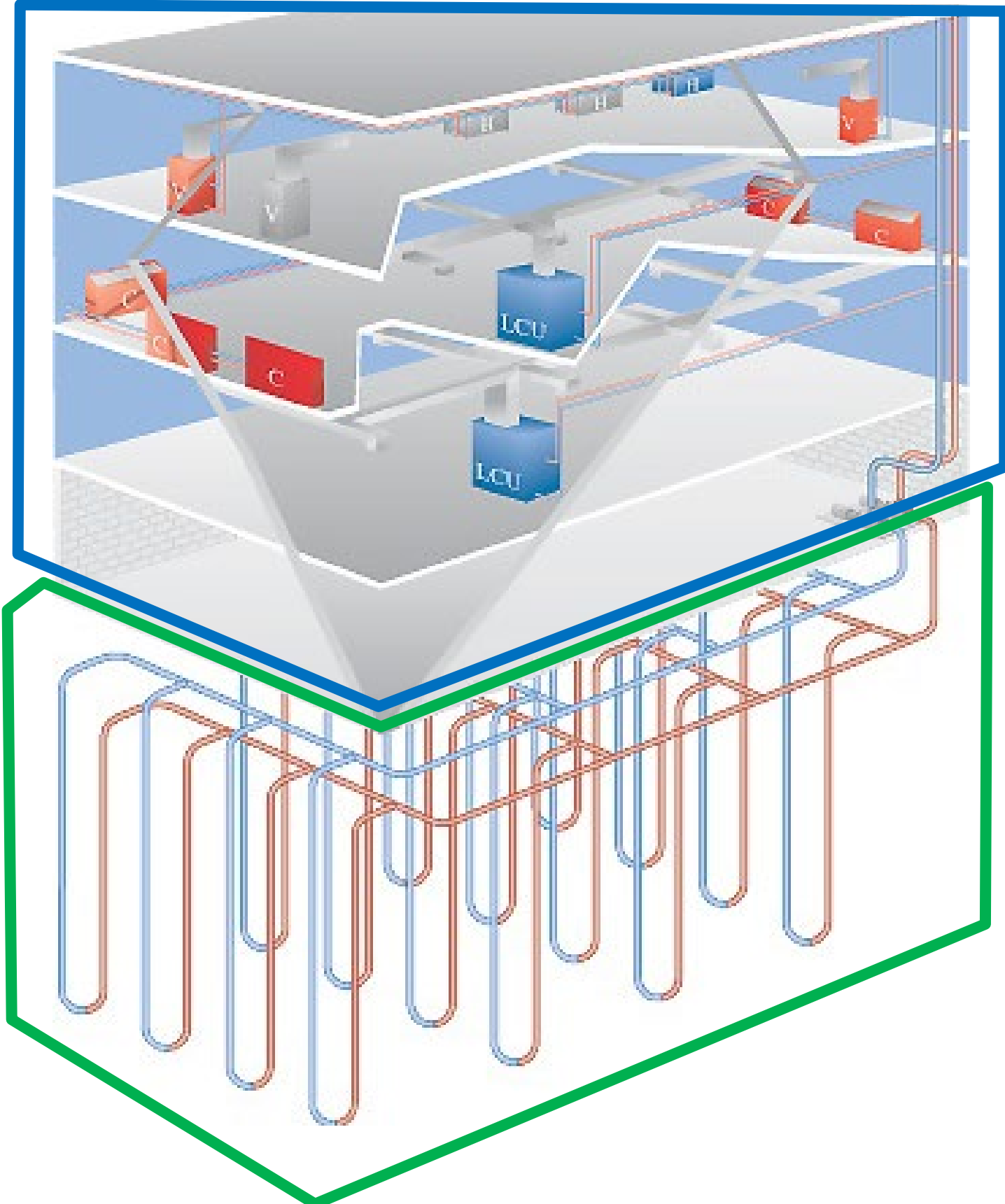


Geothermal solutions provide efficiencies more than 400%, while traditional fossil fuel systems are limited to 78-90%.

BASICS OF MODERN CLOSED-LOOP GEOTHERMAL SYSTEMS



GEOHERMAL SYSTEM DESIGN ELEMENTS



Building System (HVAC):

Water Source Heat Pumps, Interior Piping, Circulating Pumps, DHW Heating Equipment, etc.

Ground Connection (GLHE): Ground heat exchanger (sub-surface lateral piping, and the manifold / header)

GSHP CONNECTION INTERNAL HVAC SYSTEM

There are several options for how to retrofit GSHPs in buildings. There are pros and cons to any option.

Figure 4.1
Centralized Water-to-Air GHP System

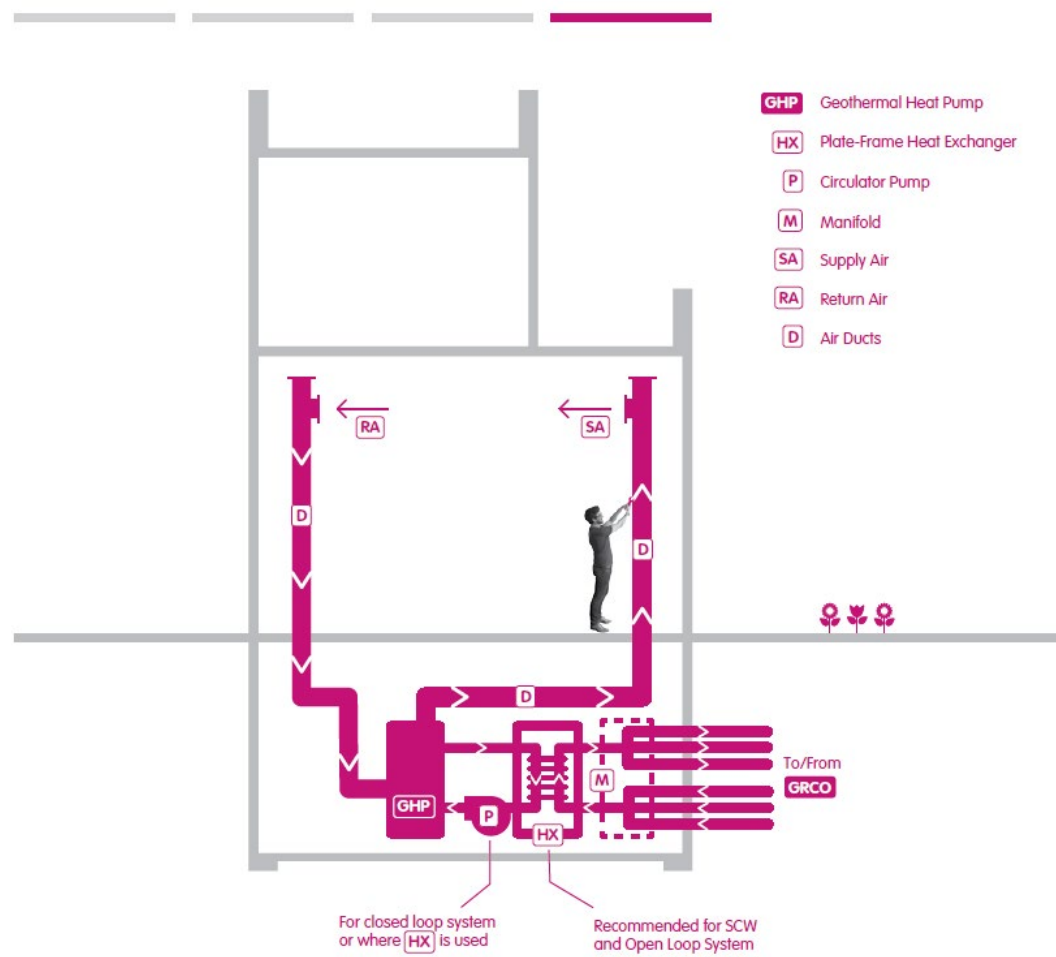


Figure 4.2
Distributed Water-to-Air GHP System

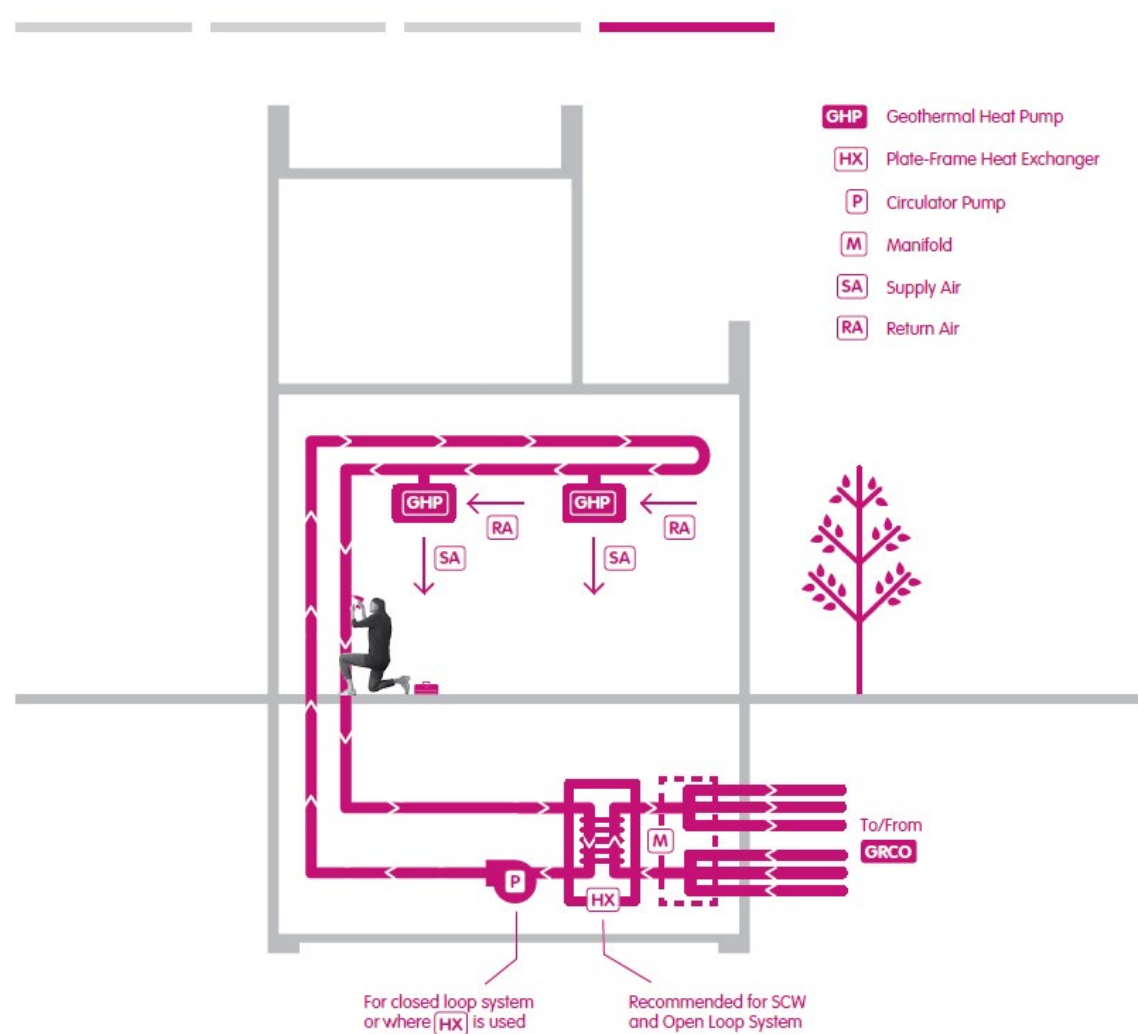
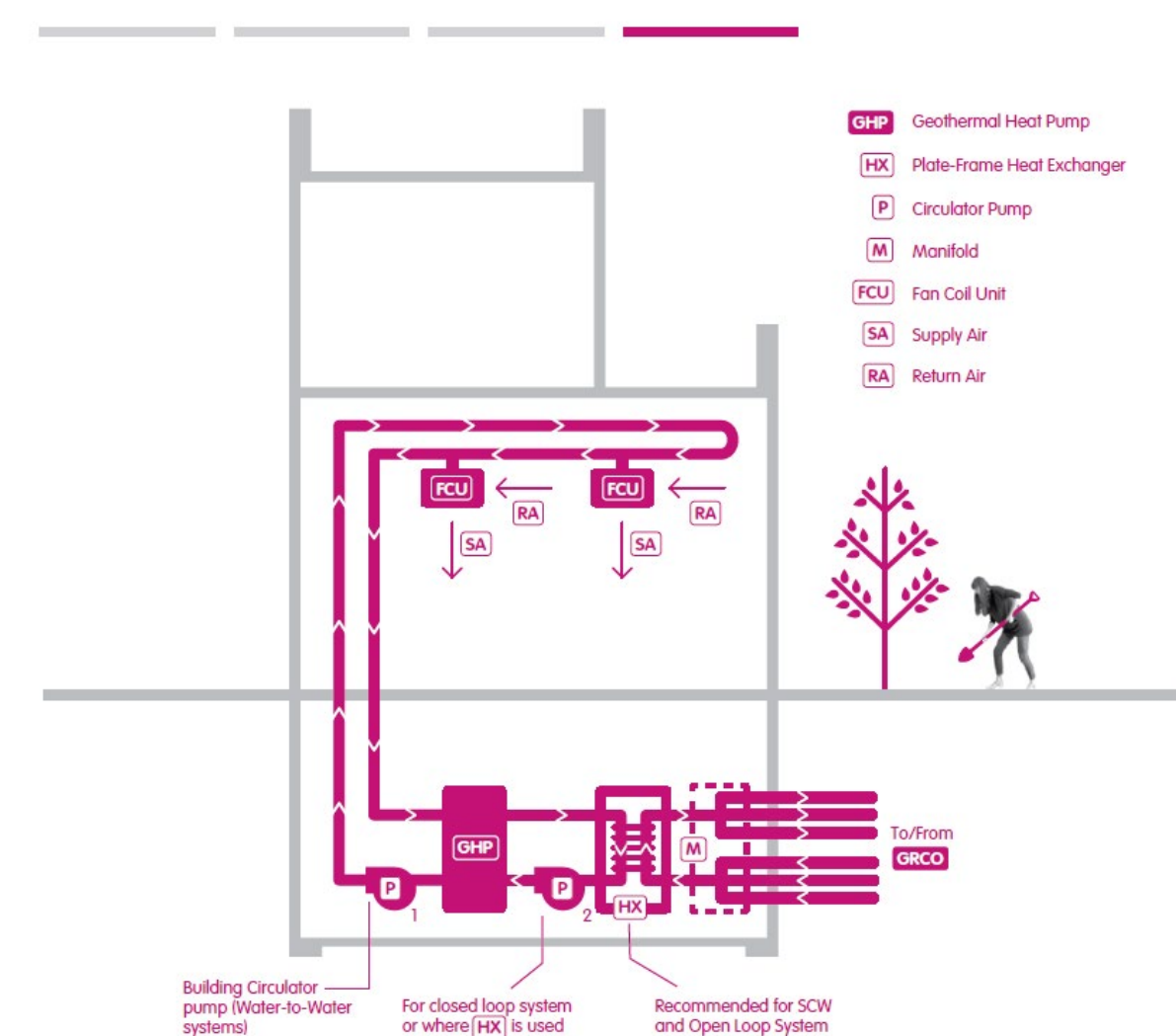
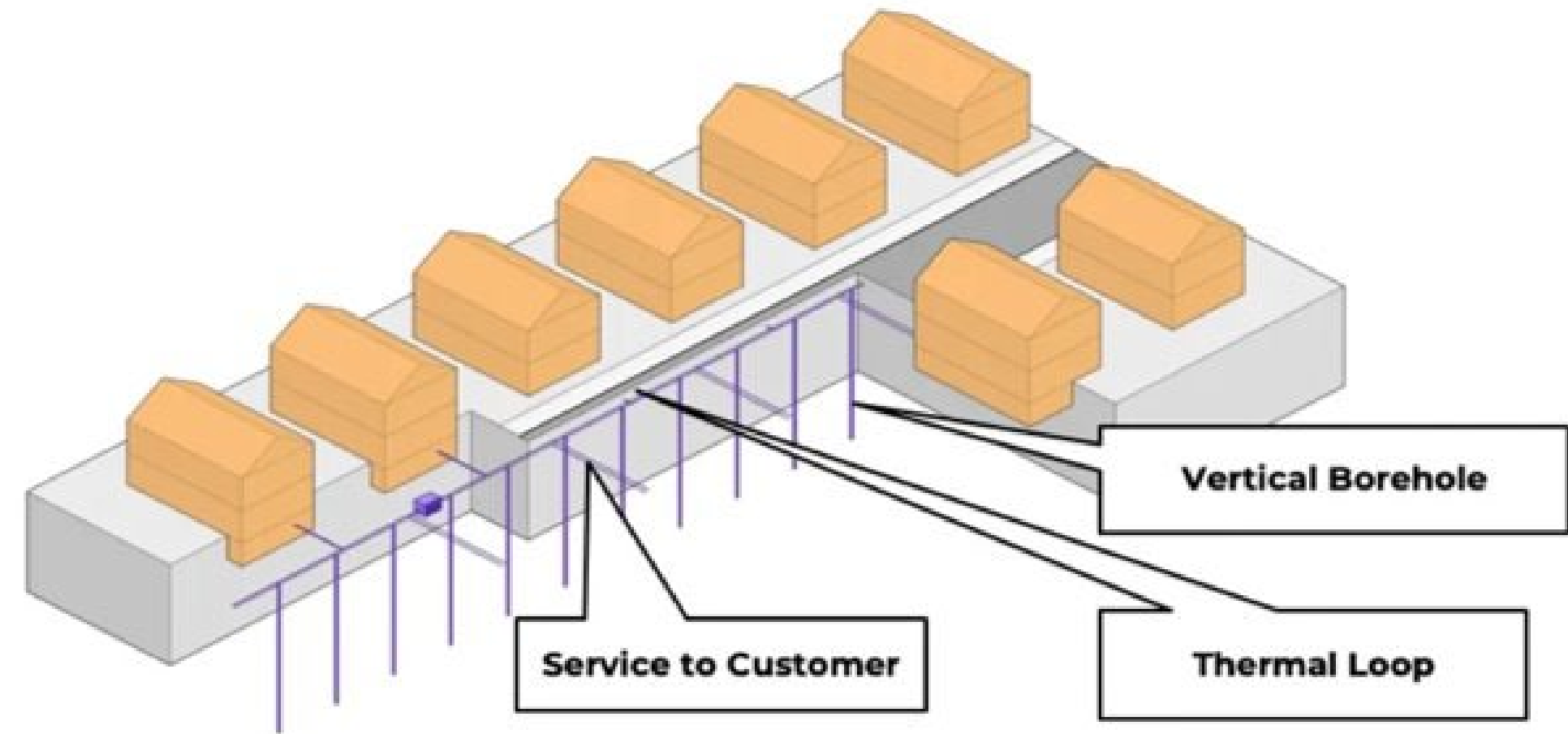


Figure 4.3
Centralized Water-to-Water GHP System

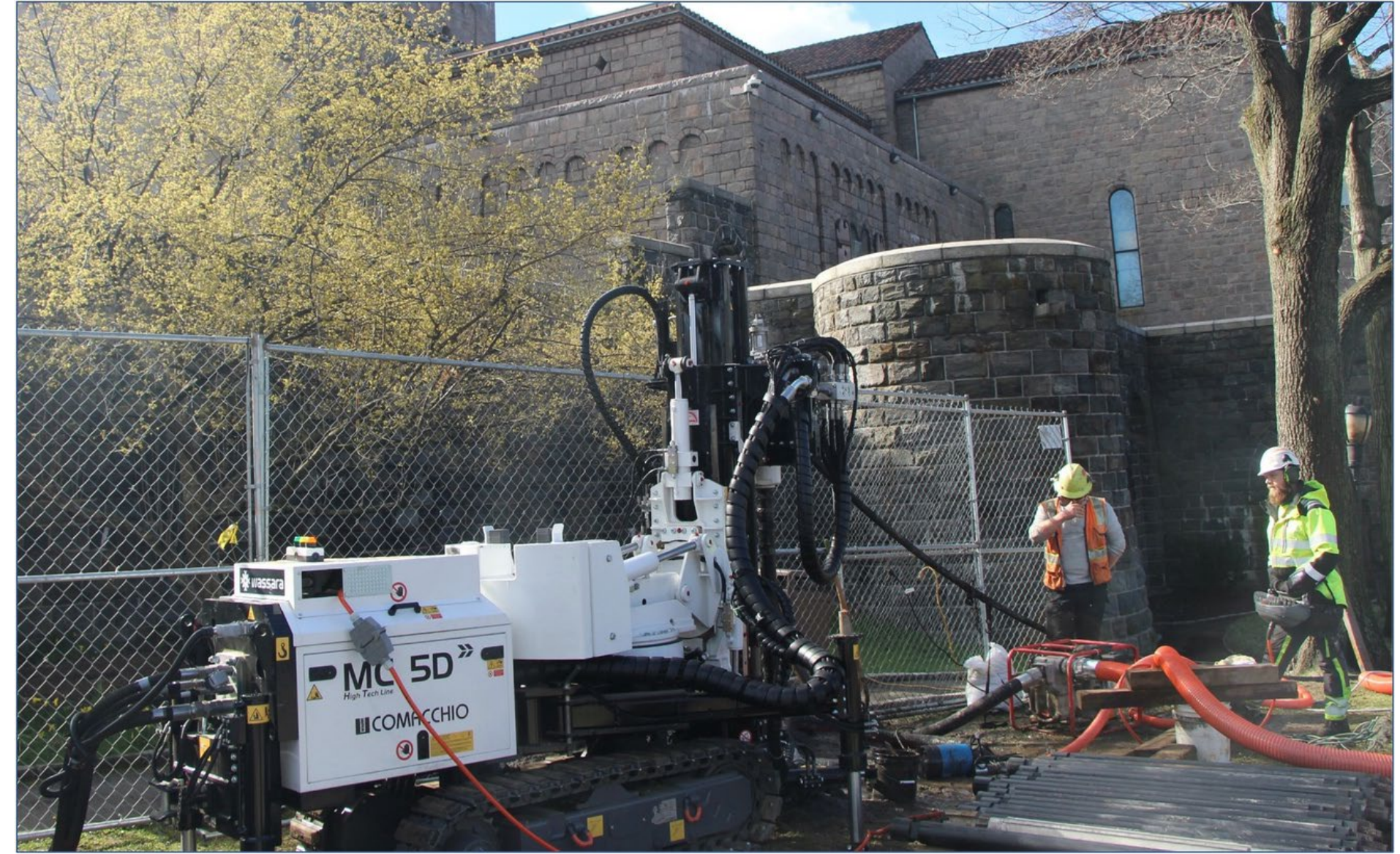


BASICS OF MODERN CLOSED-LOOP WATER SOURCE HEAT PUMPS & AMBIENT TEMPERATURE NETWORKS

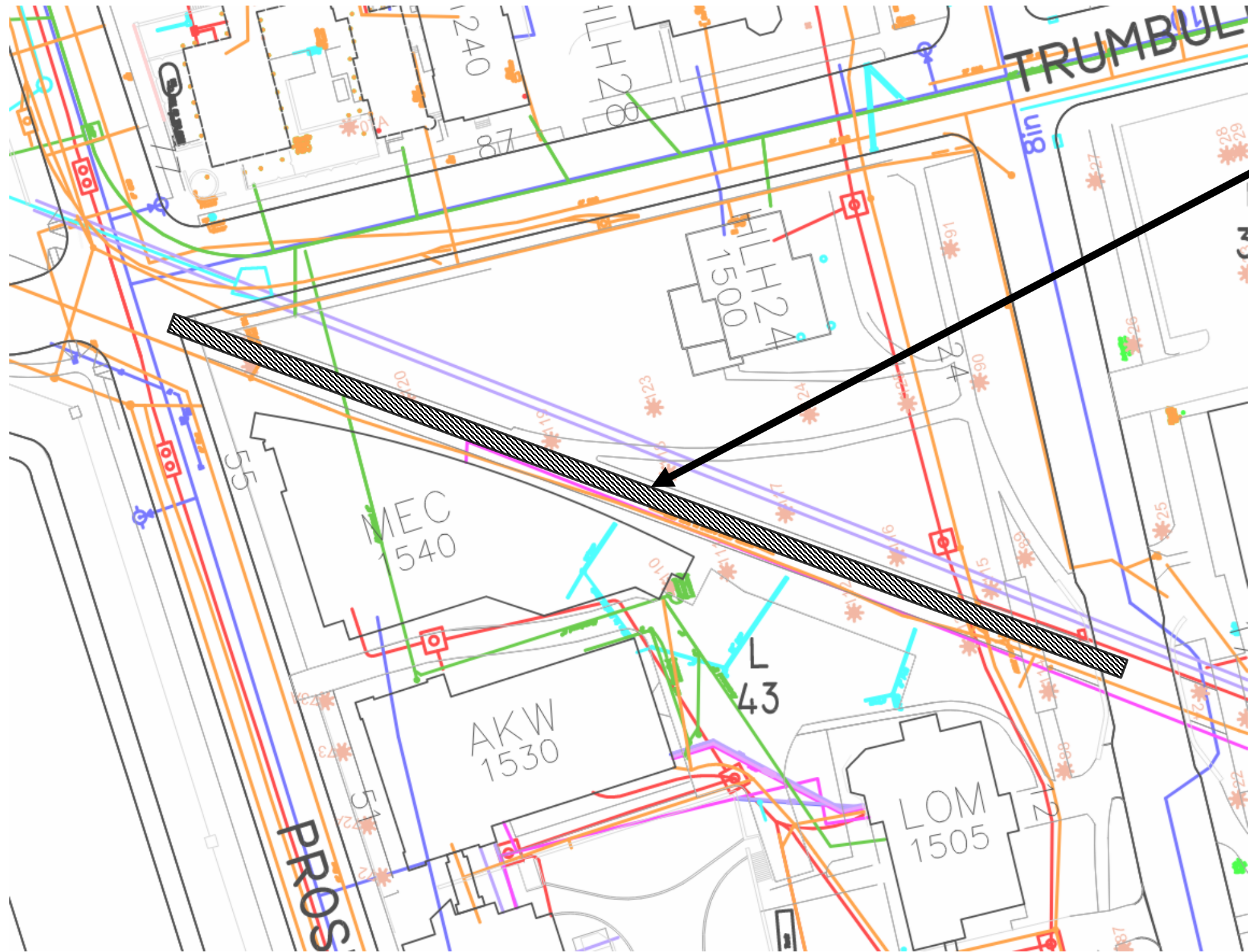
- Water-to-water and water-to-air heat pumps leverage the ambient temperature loop to provide the most efficient heating and cooling
- Buildings with synchronous opposing loads can benefit from each other's energy use when connected to an ambient temperature network
- Ambient temperature loops can also source energy from closed-loop geothermal, wastewater heat recovery, combine sewer overflow (CSO), and surface water



GEOHERMAL APPLICATIONS AND INNOVATION CONVENTIONAL V. SPECIALIZED DRILLING RIG SIZE



CONSTRAINED DRILLING AREA

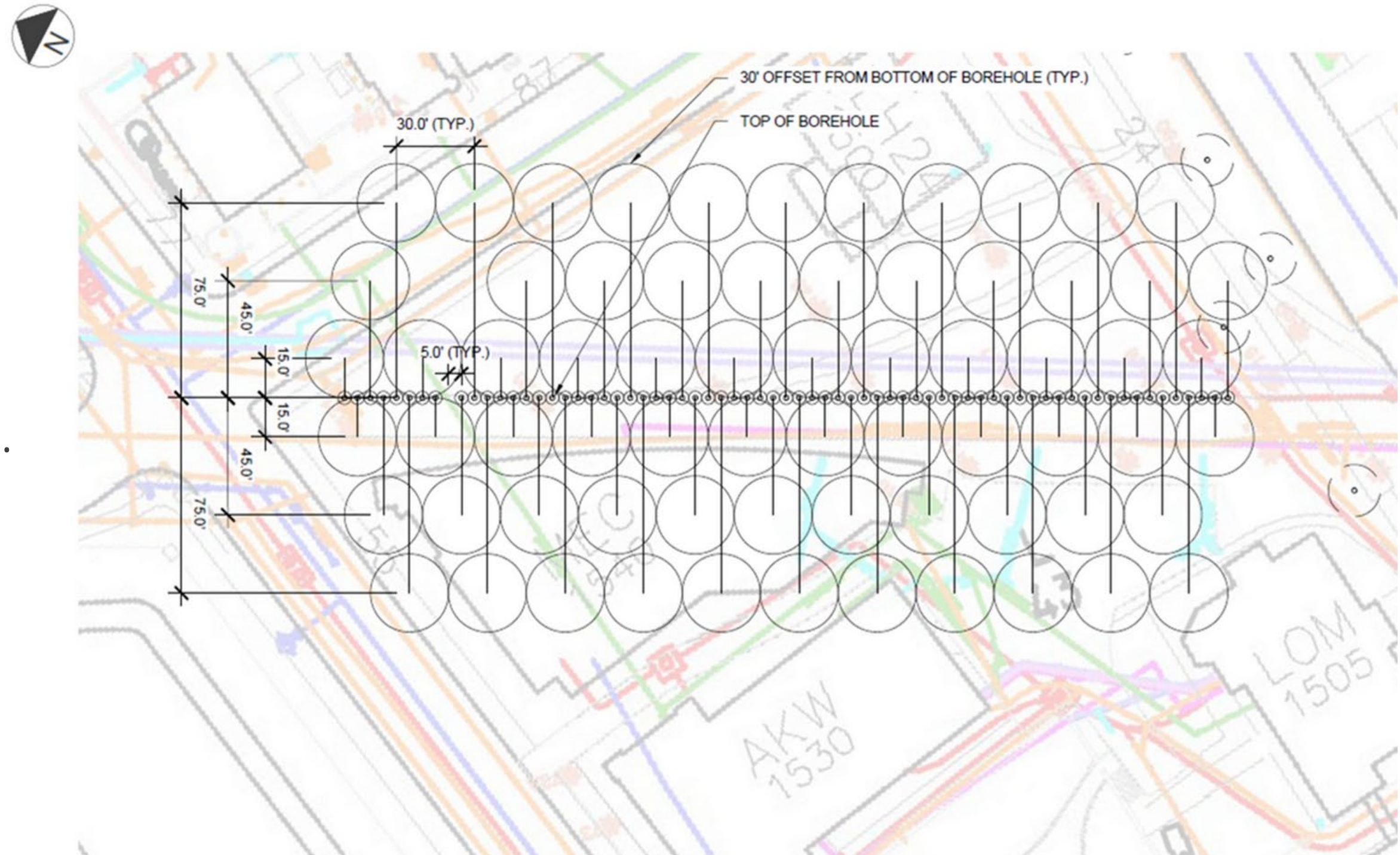


This area has many obstacles that would prevent conventional geothermal drilling methods from being installed because conventional geothermal installations typically need 20ft spacing between drilled boreholes. Obstacles include:

- Trees
- Narrow Street
- Underground utilities
- Sensitive research buildings nearby

TECHNOLOGICAL INNOVATION INCLINED BOREHOLES

- Advanced drilling technology is capable of drilling at straight inclined angles.
- These inclined boreholes can be drilled in a small surface area and extend to contact an overall greater thermal mass.
- Boreholes can extend from the drilling area to the building or property footprint boundaries.





INSTALLATION COST CONSIDERATIONS CURRENT FEDERAL INCENTIVES

INFLATION REDUCTION ACT (H.R. 5376)

The Inflation Reduction Act of 2022, the \$369 billion climate legislation that was signed into law by President Biden, has an extremely robust set of financial incentives that will now benefit geothermal heating and cooling projects in the built environment.

These provisions are going to make installing and incorporating geothermal systems into your buildings extremely financially attractive.

- Up to 40% tax credit for the cost of both the ground loop, heat pumps and related HVAC equipment
- Tax credits can easily be converted into cash



heet

Efficient Equitable Electrification of Heat

10



Putnam
Foundation



Winslow
Foundation



HEET Methods

Environmental Science & Technology

Repair Failures Call for New Policies to Tackle Leak Distribution Systems

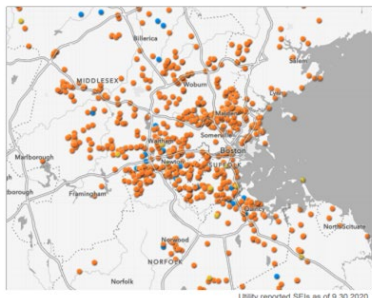
Morgan R. Edwards,* Amanda Giang, Gregg P. Macey, Zeyneb Magavi, Dom Robert Ackley, and Audrey Schulman

Cite This: <https://doi.org/10.1021/acsc.1c07531> Read Online



Significant

Shared Ac
Utilities E



Environmental Science & Technology

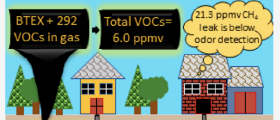
Home is Where the Pipeline Ends: Characterization of Volatile Organic Compounds Present in Natural Gas at the Point of the Residential End User

Drew R. Michanowicz,* Archana Dayalu,† Curtis L. Nordgaard, Jonathan J. Buonocore,† Molly W. Fairchild, Robert Ackley, Jessica E. Schiff, Abbie Liu, Nathan G. Phillips, Audrey Schulman,† Zeyneb Magavi, and John D. Spengler

Cite This: <https://doi.org/10.1021/acsc.1c08298> Read Online

ACCESS | Metrics & More | Article Recommendations | Supporting Information

ABSTRACT: The presence of volatile organic compounds (VOCs) in unprocessed natural gas (NG) is well documented; however, the degree to which VOCs are present in NG at the point of end use is largely uncharacterized. We collected 234 whole-NG samples across 69 unique residential locations across the Greater Boston metropolitan area, Massachusetts. NG samples were measured for methane (CH₄), ethane (C₂H₆), and nonmethane VOC (NMVOC) content (including tentatively identified 15 compounds) using commercially available USEPA analytical methods. Results revealed 296 unique NMVOC constituents in



scientific reports

OPEN

Inefficient Building Electrification Will Require Massive Buildout of Renewable Energy and Seasonal Energy Storage

Jonathan J. Buonocore^{1,✉}, Parichehr Salimifard^{2,3}, Zeyneb Magavi⁴ & Joseph G. Allen³

Building electrification is essential to many full-economy decarbonization pathways. However, current decarbonization modeling in the United States (U.S.) does not incorporate seasonal fluctuations in building energy demand, seasonal fluctuations in electricity demand of electrified buildings, or the ramifications of this extra demand for electricity generation. Here, we examine historical energy data in the U.S. to evaluate current seasonal fluctuation in total energy demand and management of seasonal fluctuations. We then model additional electricity demand under different building electrification scenarios and the necessary increases in wind or solar PV to meet this demand. We found that U.S. monthly average total building energy consumption varies by a factor of 1.6x—lowest

Energy Policy
Volume 162, March 2022, 112778

Environmental justice analysis of distributional natural gas leaks in Massachusetts, USA

✉, Dominic Nicholas ^b✉

deley Share Cite

10.1016/j.enpol.2022.112778

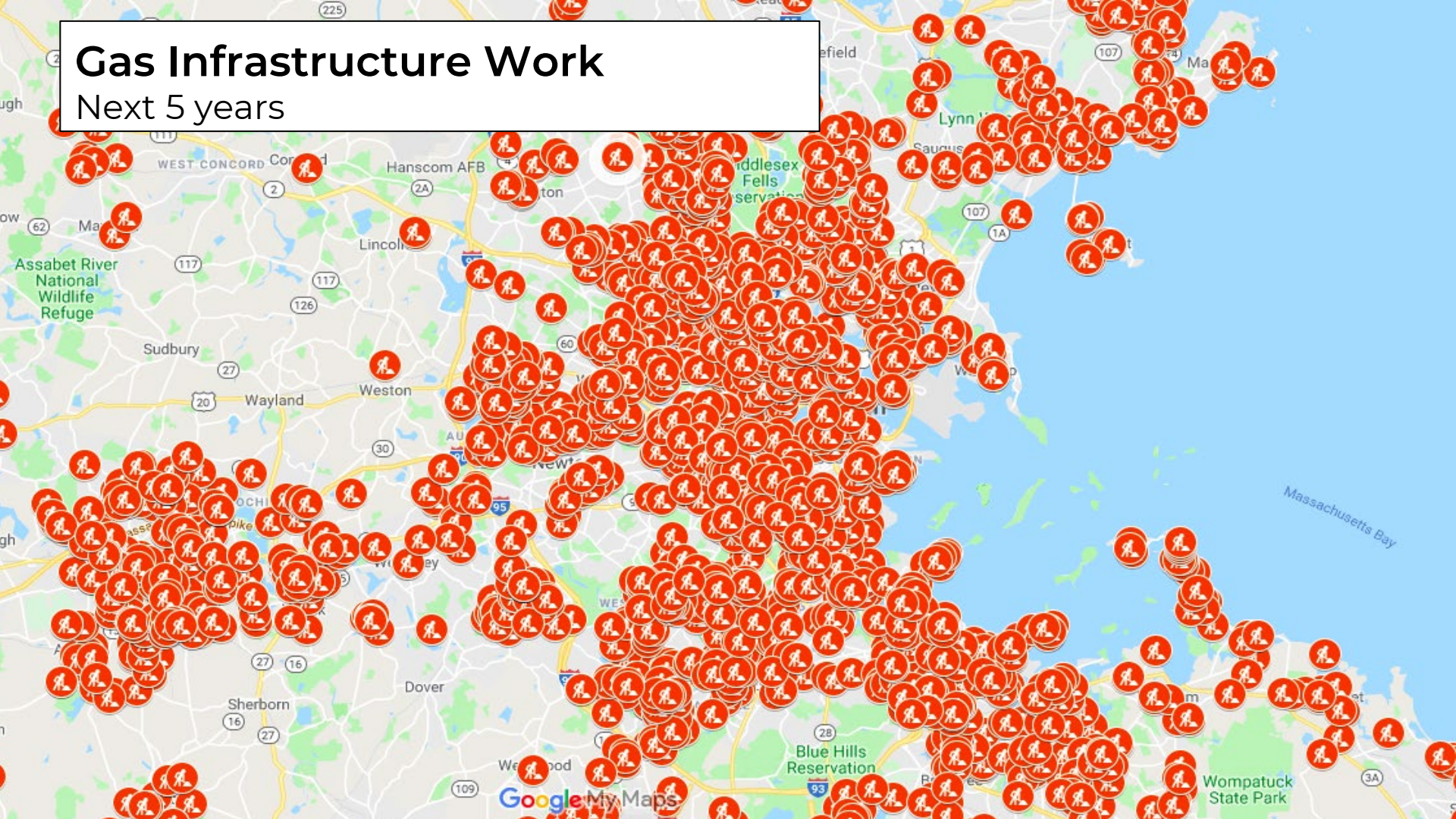
Commons license

Get rights and content

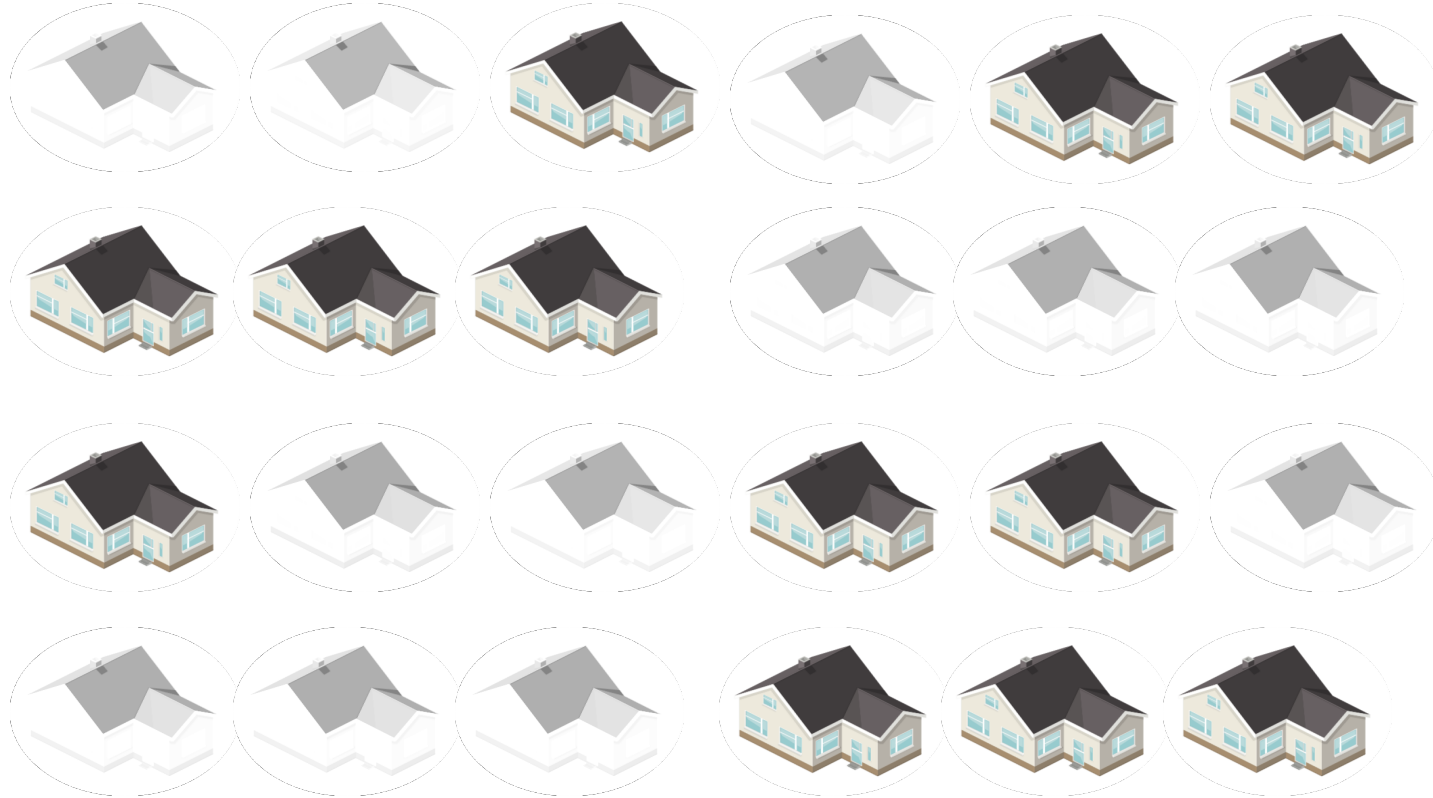
Open access

Gas Infrastructure Work

Next 5 years



Fleeing Customers, Increasing Gas Bills

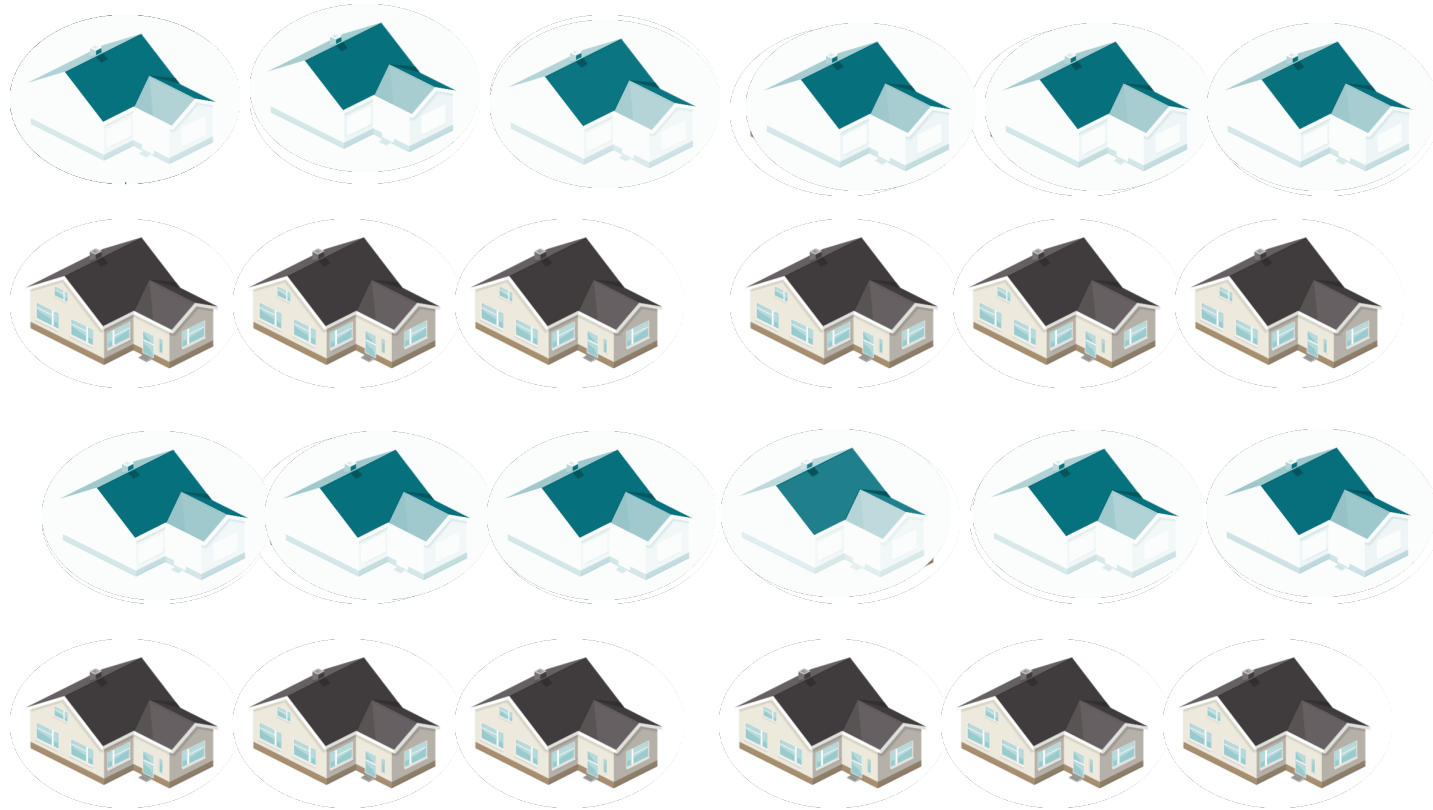


Networked Geothermal



- Infrastructure in the street
- “Shallow” boreholes
- Ambient temperature
- Single pipe
- No glycol
- Sized for stochastic load
- Active thermal management

Customers Stays with Same Utility, Energy Bill Stays Low



Outcomes

Merrimack Valley Gas Disaster 2018

➤ Safer

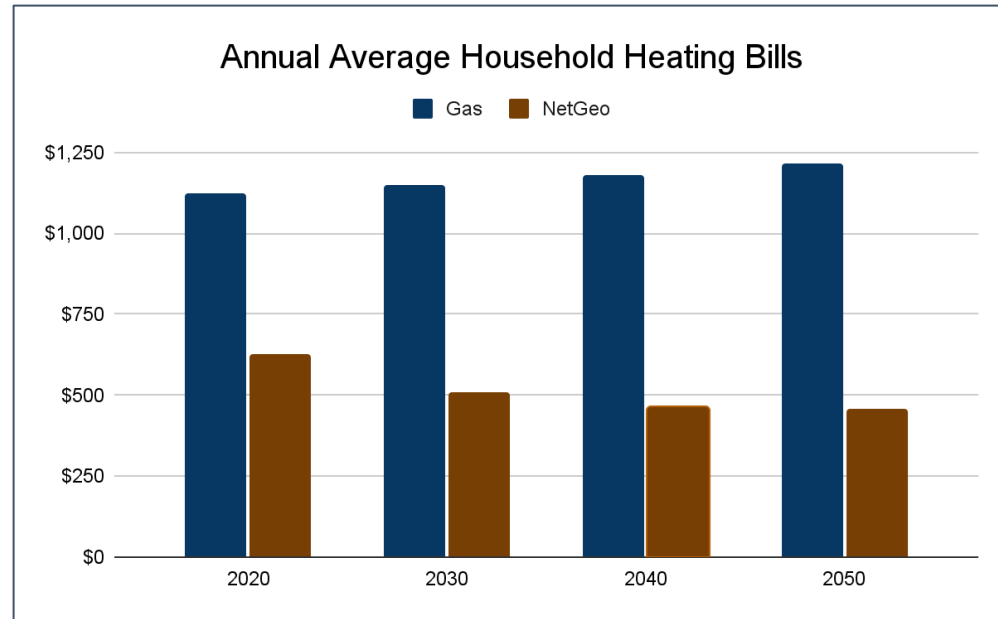


Outcomes

- Safer
- Lower customer bills

MA Energy Bill Projection (gas vs. networked geothermal)

(Applied Economics Clinic Brief)

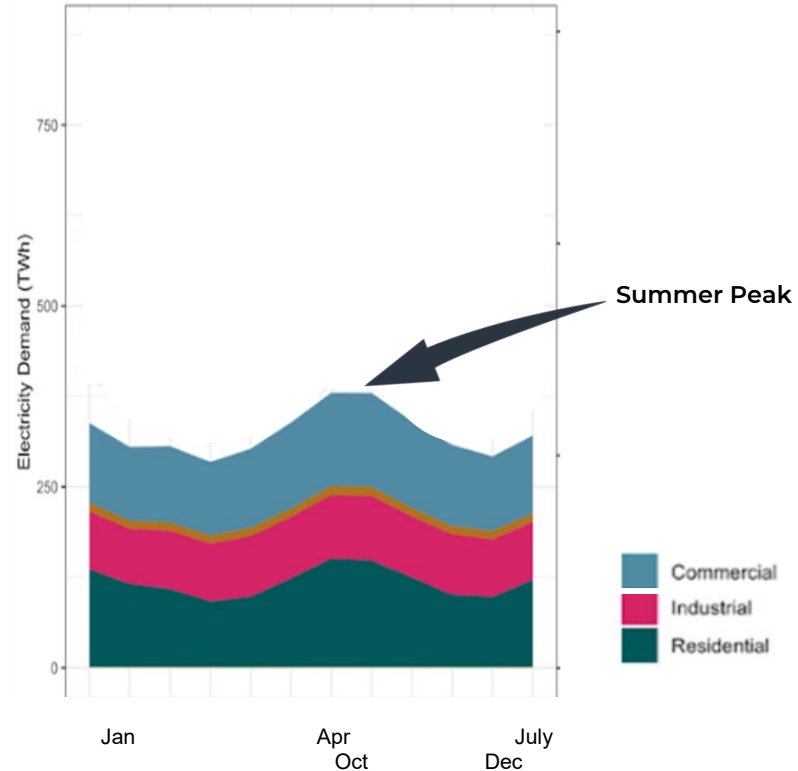


Outcomes

- Safer
- Lower customer bills
- Lower electric peaks

Current US Seasonal Electric Peaks

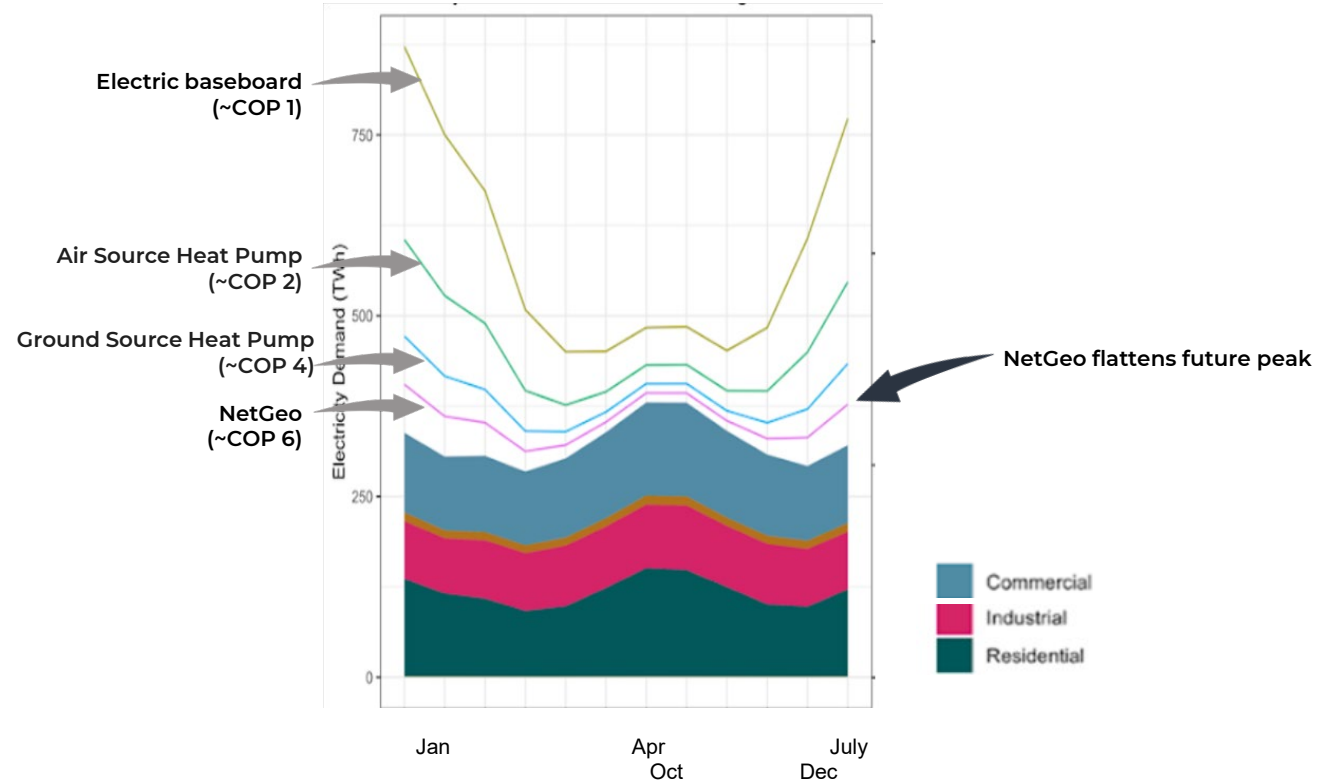
(for buildings)



Outcomes

- Safer
- Lower customer bills
- Lower electric peaks

Future US Seasonal Electric Peaks (as we electrify)



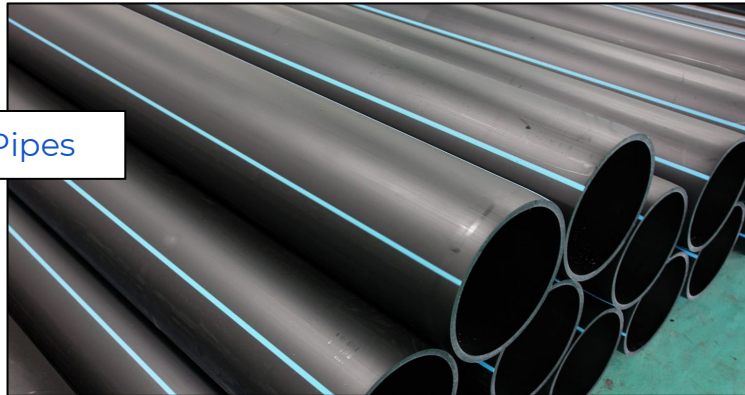
Outcomes

- Safer
- Lower customer bills
- Lower electric peaks
- Equitable
- Workforce can transition

Gas Pipes



Water Pipes



Outcomes

- Safer
- Lower customer bills
- Lower electric peaks
- Equitable
- Workforce can transition
- Lower emissions

Gas Heating

**NetGeo
Now**

60% less

**NetGeo
2050**

Eversource & National Grid Installations

Eversource

- 1 installation approved
- Site selected in Framingham
- Fire station, school, a few businesses, and homes including low-income
- Test boreholes completed, install complete summer 2023

National Grid

- 4 installations approved
- First site selected in Lowell
- 100% electrification



Progress by State

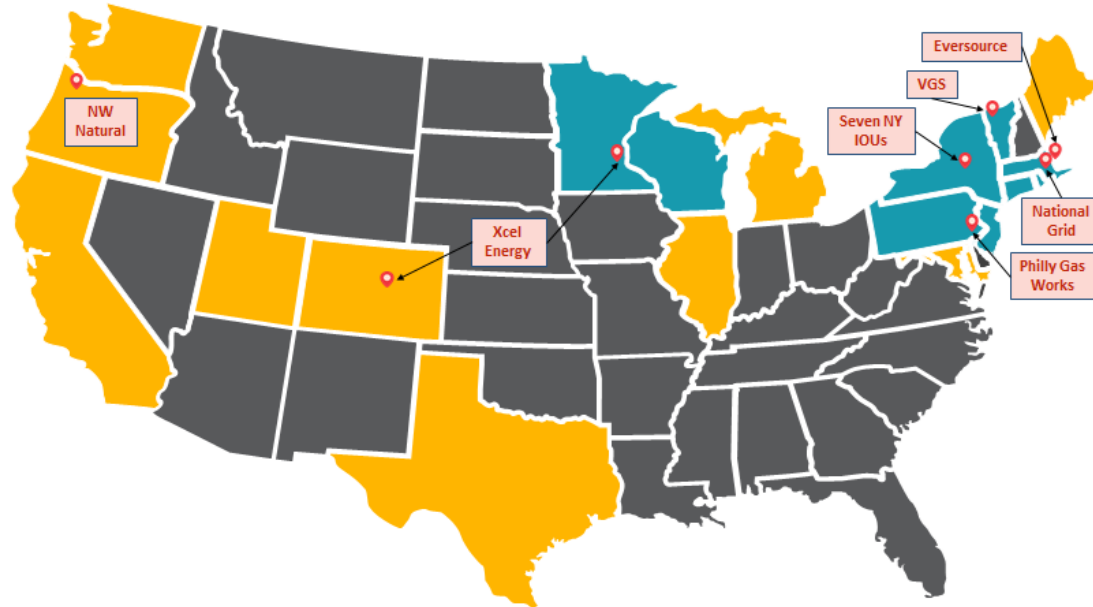
- DC - \$4M installation
- Maryland - Proposed legislation & feasibility study
- Minnesota - Natural Gas Innovation law
- New York - >40 studies, 1 approved installations, Utility Thermal Energy Network & Jobs law
- Philadelphia - \$500k to feasibility study
- Oregon - feasibility study
- Vermont - Installations requested



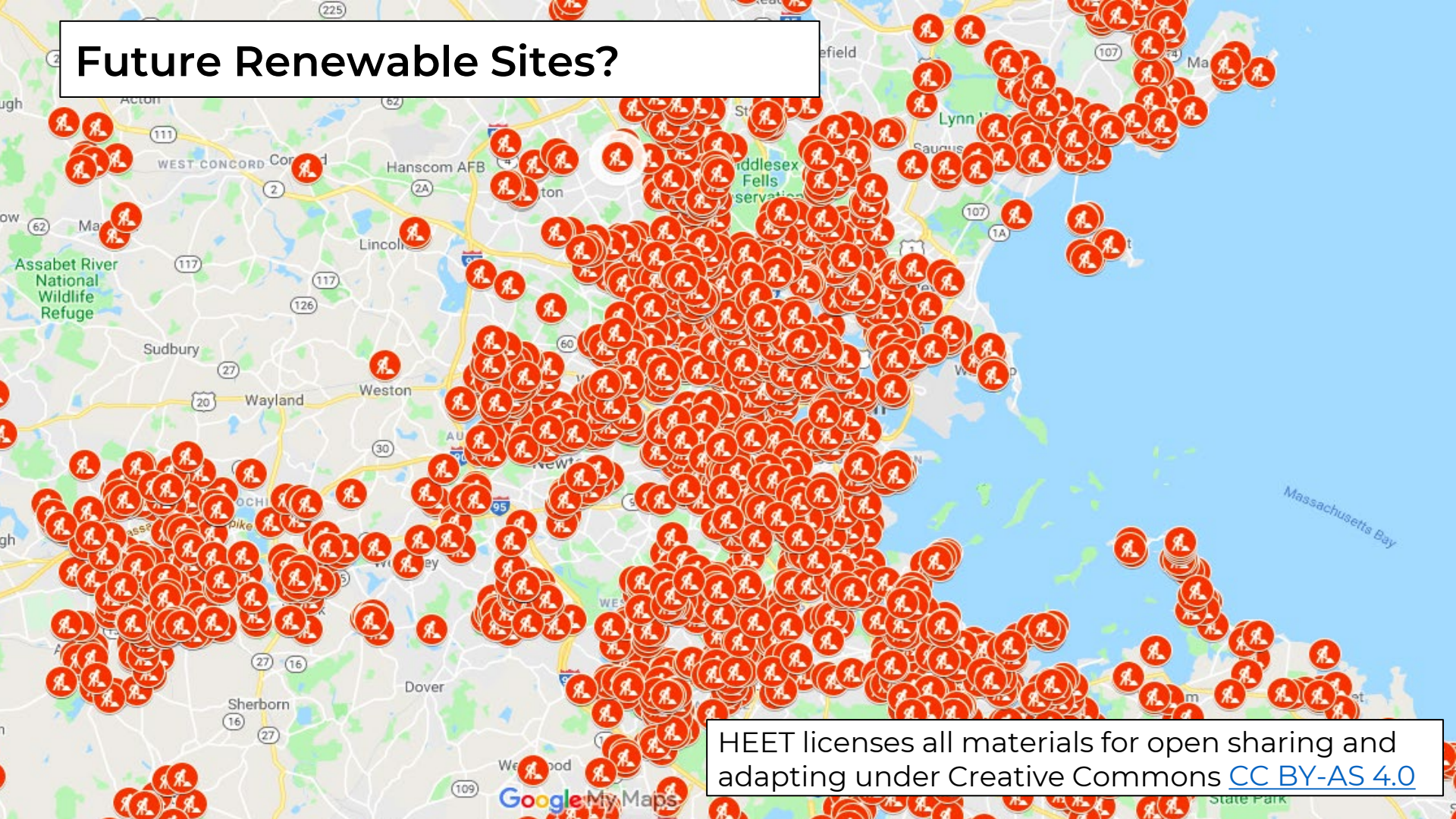
National Gas Utility Coalition

Stage	Utilities	Headwinds	Tailwinds
Curious	WGL PGW National Fuel Cascade	<ul style="list-style-type: none"> • Anti-gas/anti-gas utility sentiments • Complexity of Geo • Lack of helpful policy 	<ul style="list-style-type: none"> • Industry progress • The logic of gas to geo
Researching	NWN Xcel	<ul style="list-style-type: none"> • Understanding/creating the biz case • Potentially helpful policy but lacking specific directive or demonstrated geo application • Lack of internal capacity and consistent understanding of geo 	<ul style="list-style-type: none"> • Potentially helpful policy • Conceptually seen as a great solution to GHG/political challenges
Pilots submitted	NG Avangrid ConEd	<ul style="list-style-type: none"> • Determining where netgeo makes sense- feasibility studies expensive- can't do everywhere 	<ul style="list-style-type: none"> • NY Order requiring pilot submissions – creates clarity and reduces utility risk
Pilots underway	VGS Eversource	<ul style="list-style-type: none"> • Work force availability: designers, drillers • Some municipal permitting 	<ul style="list-style-type: none"> • Customers and jurisdictions lining up to be included in studies and installations

National Advocate Coalition



Future Renewable Sites?



HEET licenses all materials for open sharing and adapting under Creative Commons [CC BY-AS 4.0](https://creativecommons.org/licenses/by-as/4.0/)