A GRCx Event: Clean Heat – The Potential of Networked Geothermal

GRCx is an interactive program series from the Boston Green Ribbon Commission designed to accelerate the implementation of the City's Climate Action Plan by providing high-quality, useful content on climate resilience and carbon mitigation to the Boston community.

GRCx

GREEN RIBBON COMMISSION
Climate Action Exchange

Introductions

Zeyneb Magavi
Co-Executive Director
HEET

Audrey Schulman
Co-Executive Director
HEET

Mike Goldman
Director or Energy Efficiency
Eversource

Owen Brady
Future of Heat
National Grid

heet

To cut carbon emissions NOW by driving systems change

Putnam Foundation

Barr Foundation

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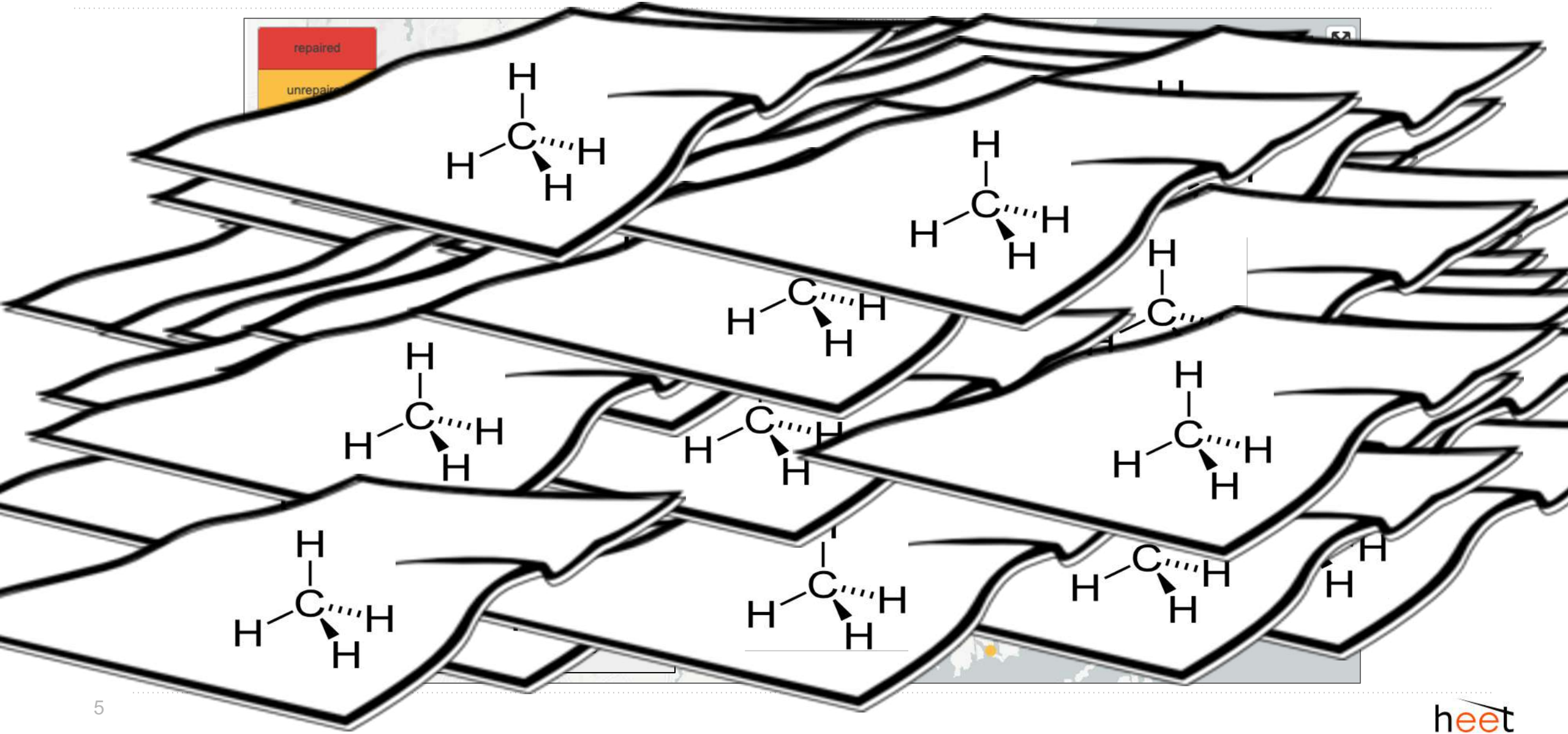
Aging Natural Gas Infrastructure

Source: detail of National Grid natural gas pressure map

What’s the Problem?



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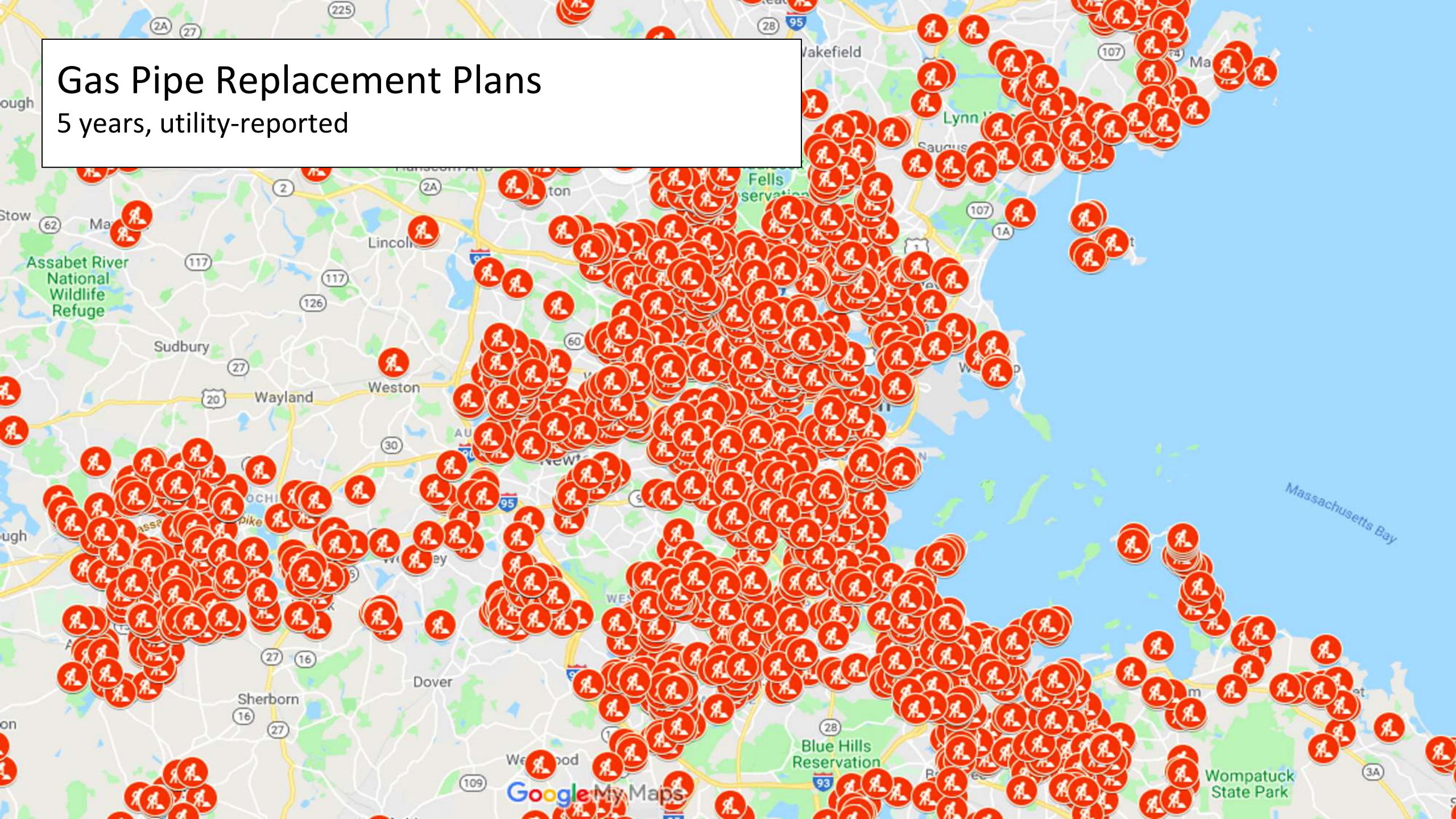
Gas Pipe Replacement Plans

5 years, utility-reported



Air Source Heat Pumps

- Burden on electric grid
- Inequity of access
- Requires collapse of gas industry

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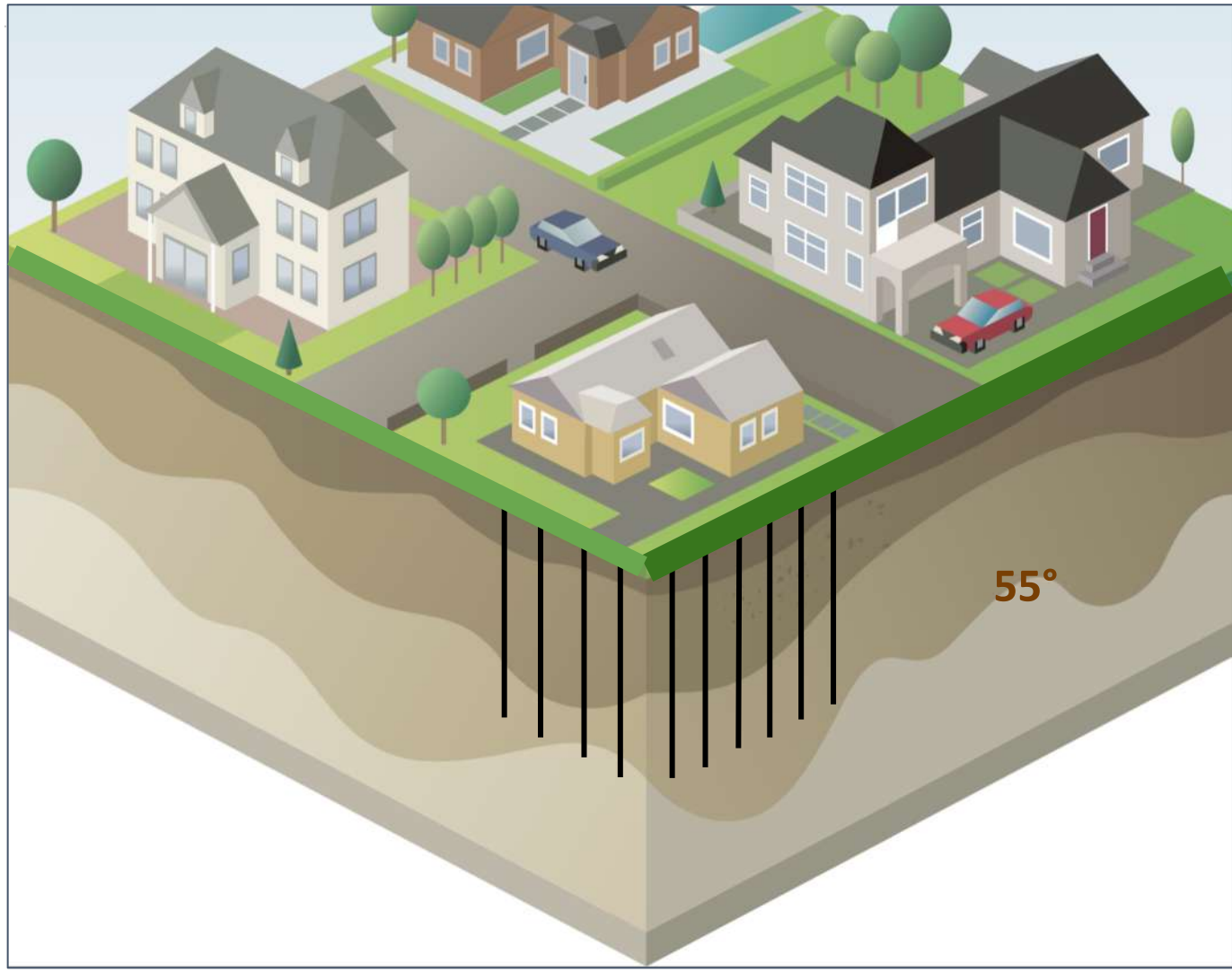
Geothermal (Aka Ground Source Heat Pump)

- Lower burden on electric grid
- Inequity of access
- Requires collapse of gas industry
- Maintaining thermal balance over time



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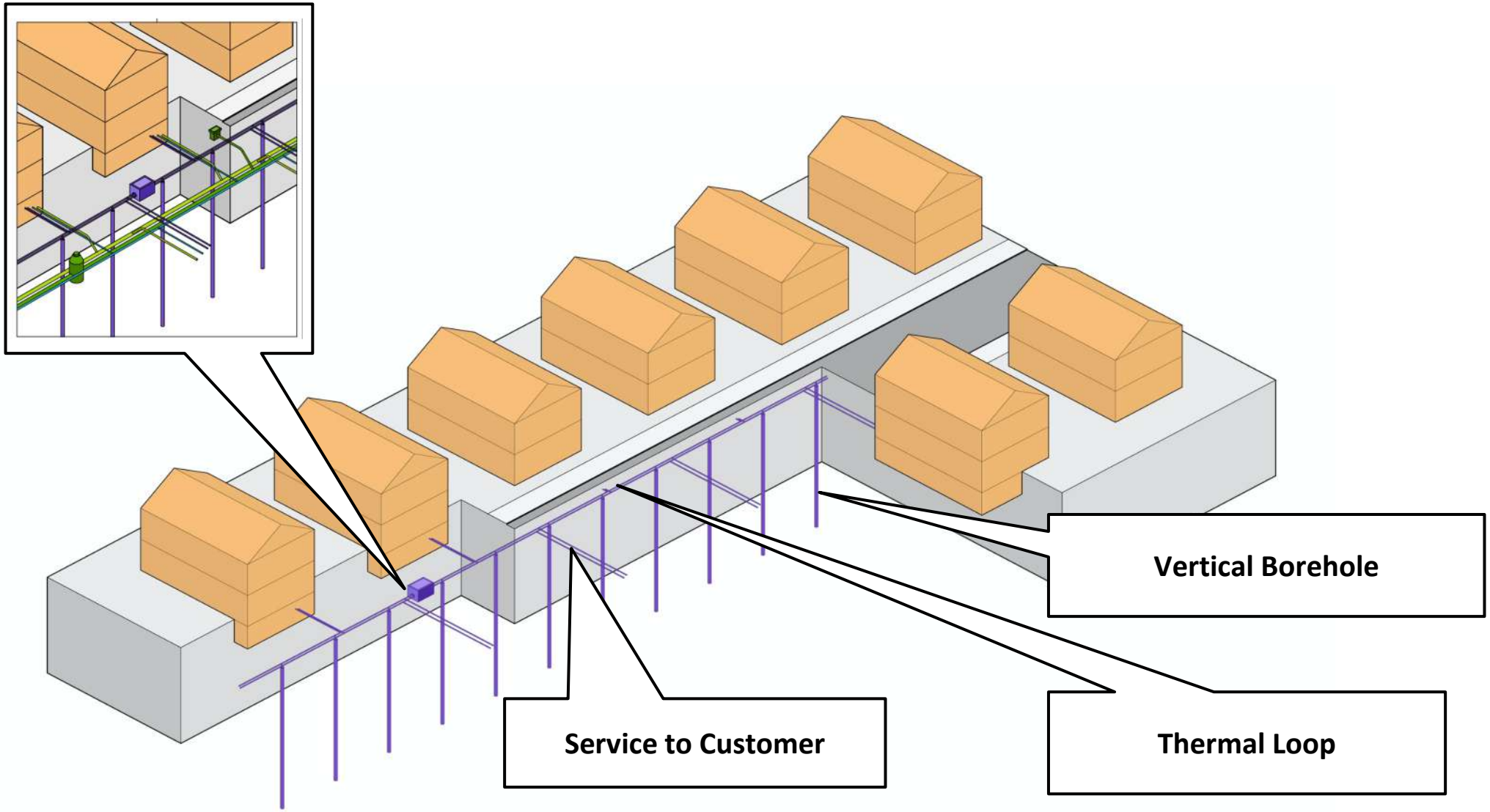
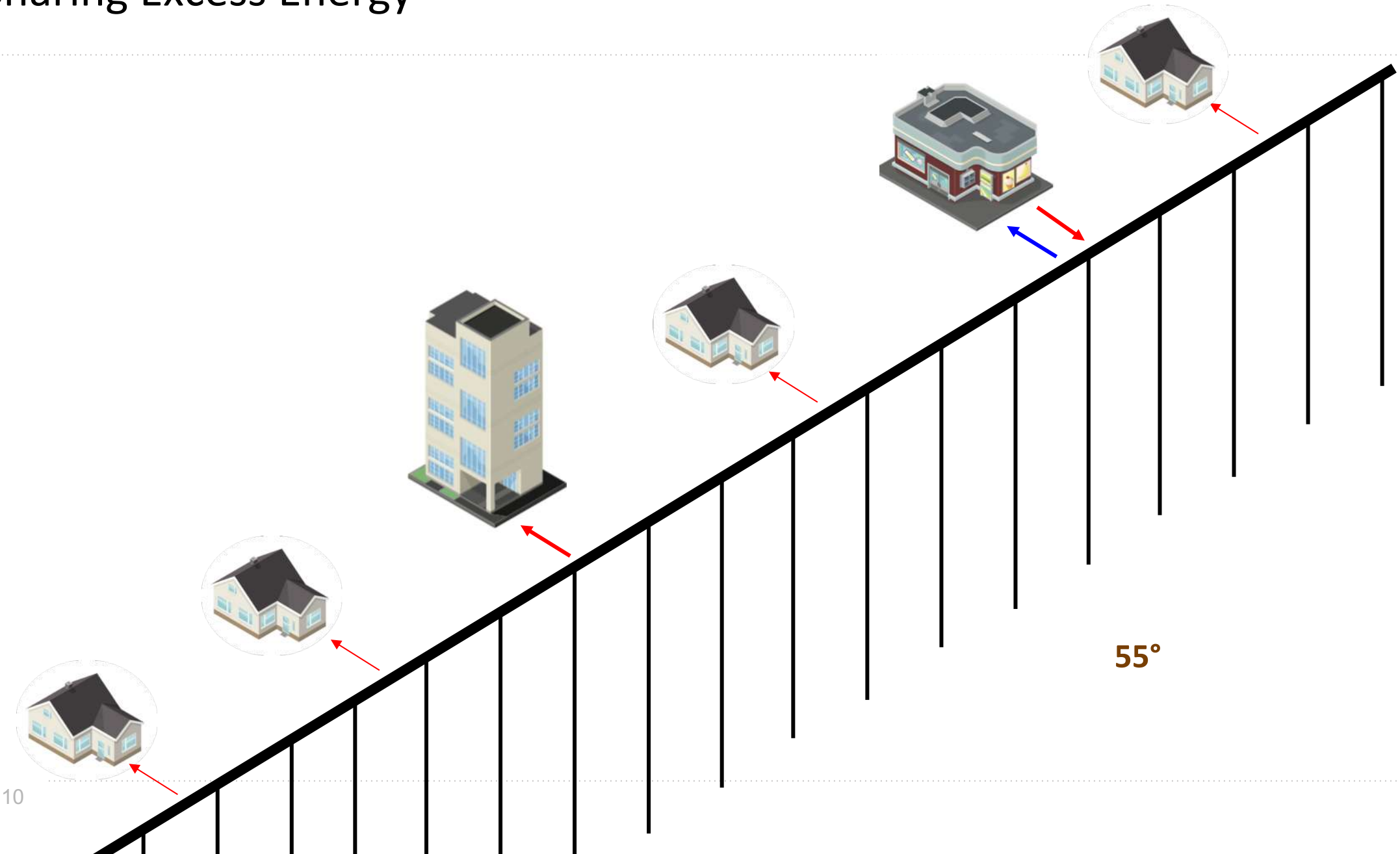
HEET's GeoMicroDistrict



BUROHAPPOLD ENGINEERING heet

Sharing Excess Energy



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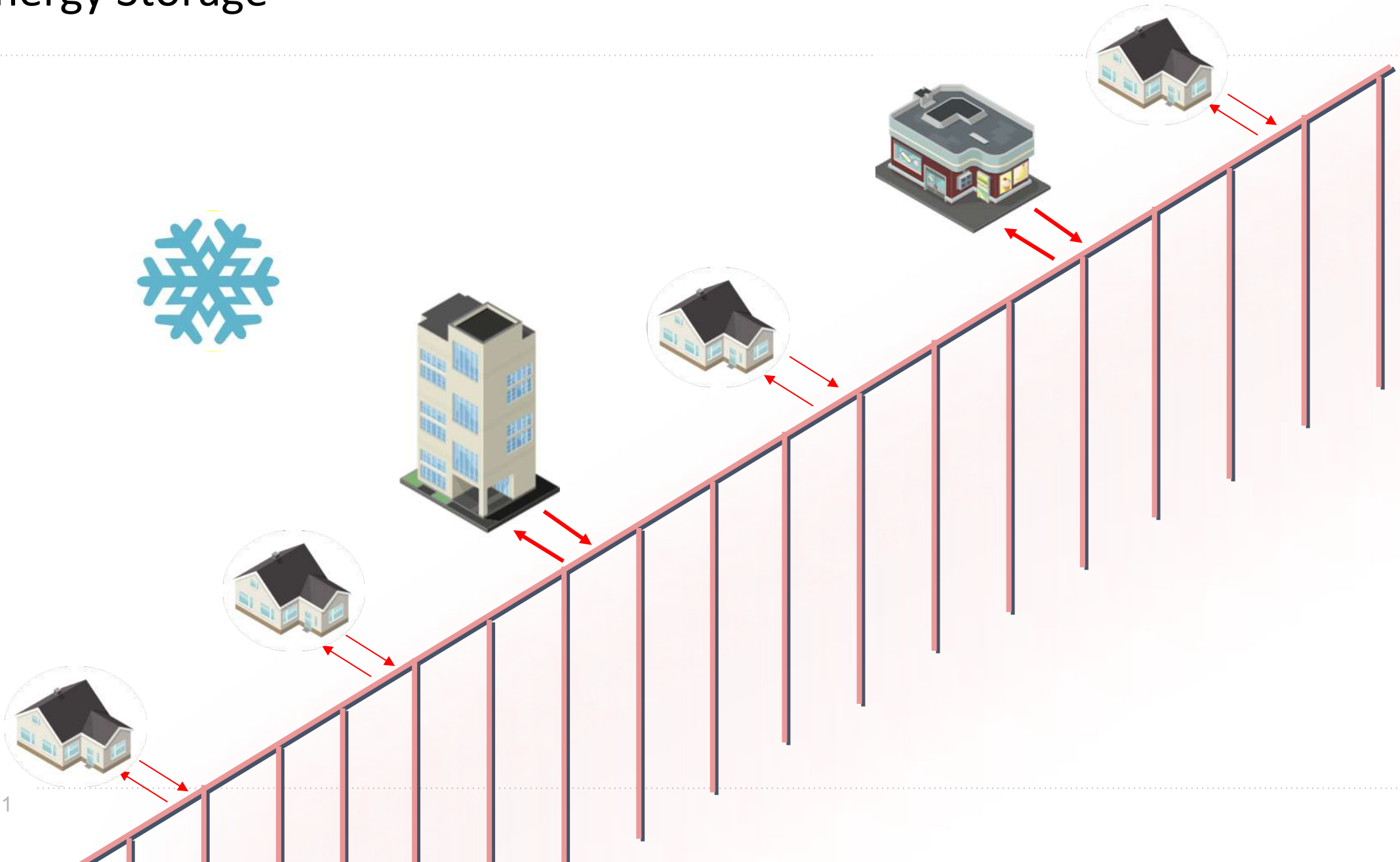
Energy Storage



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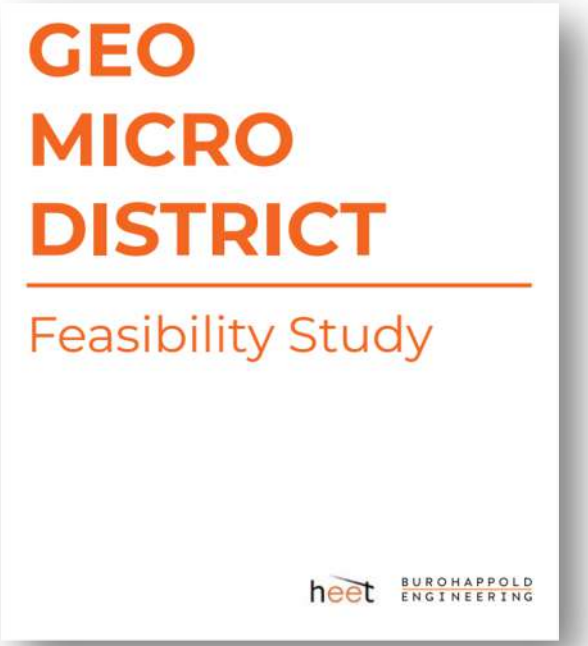
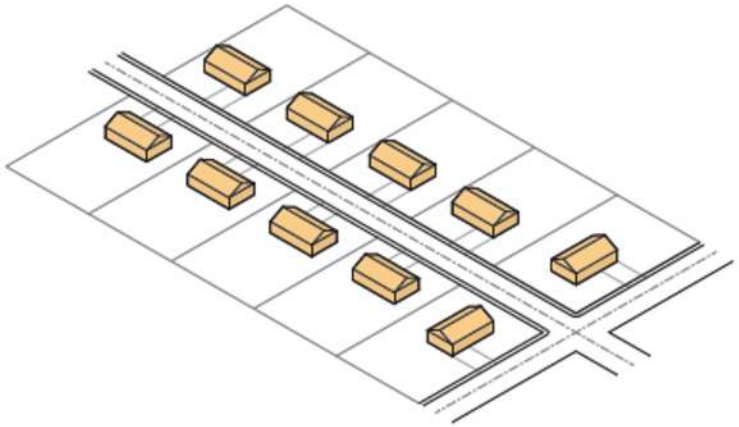
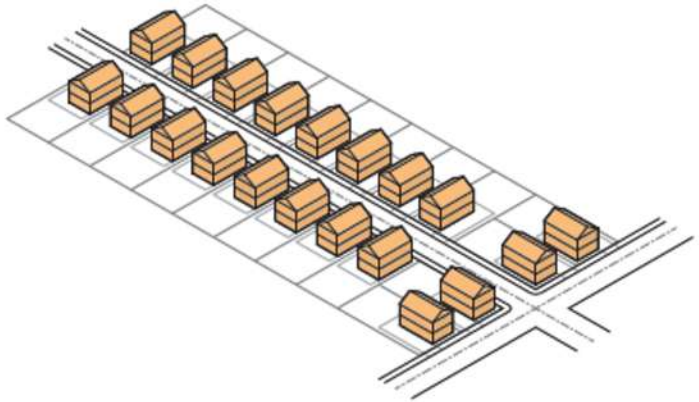
Buro Happold Feasibility Study

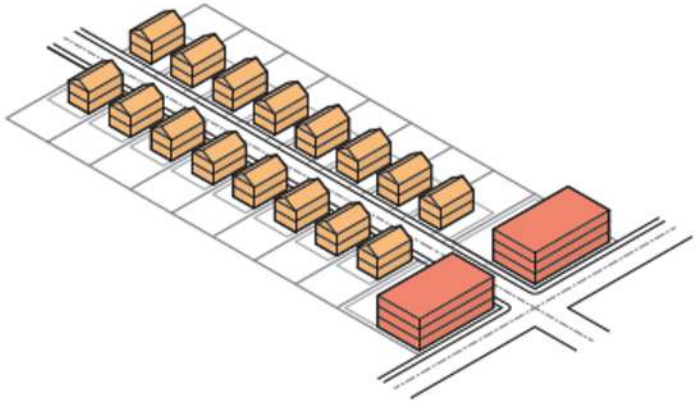




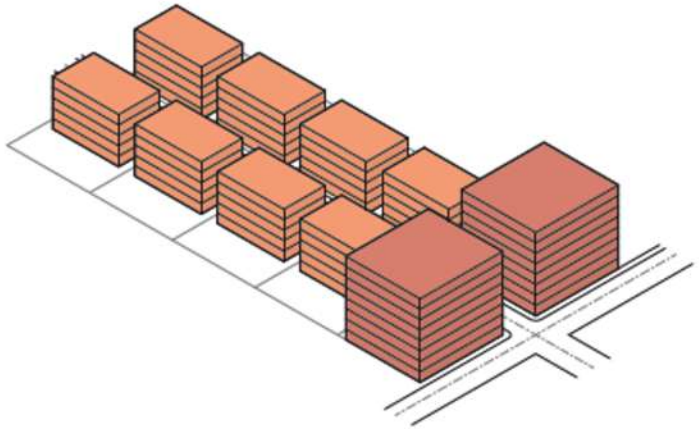
Low density residential



Medium density residential



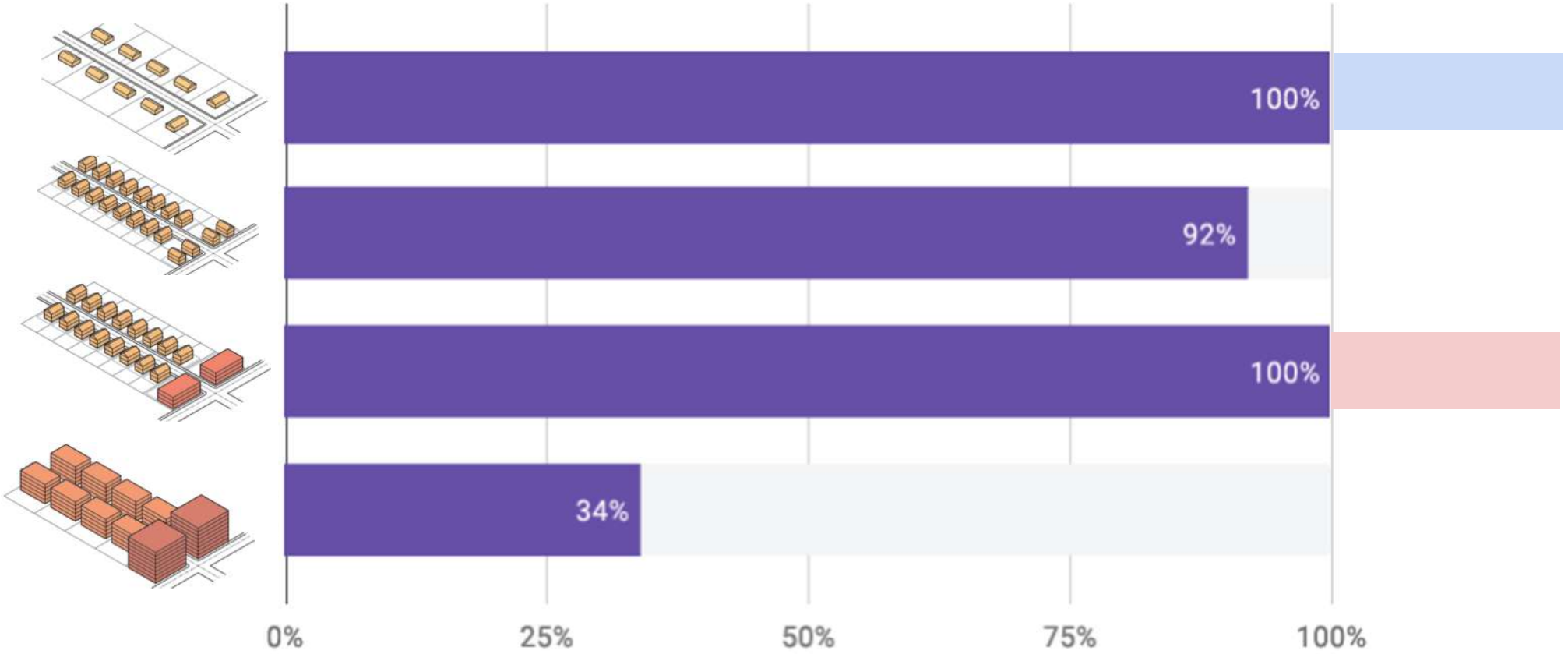
Medium density mixed-use



High density mixed-use

Technical Feasibility (by street segment)

Ability to meet energy demand through ‘shallow’ boreholes in the street only



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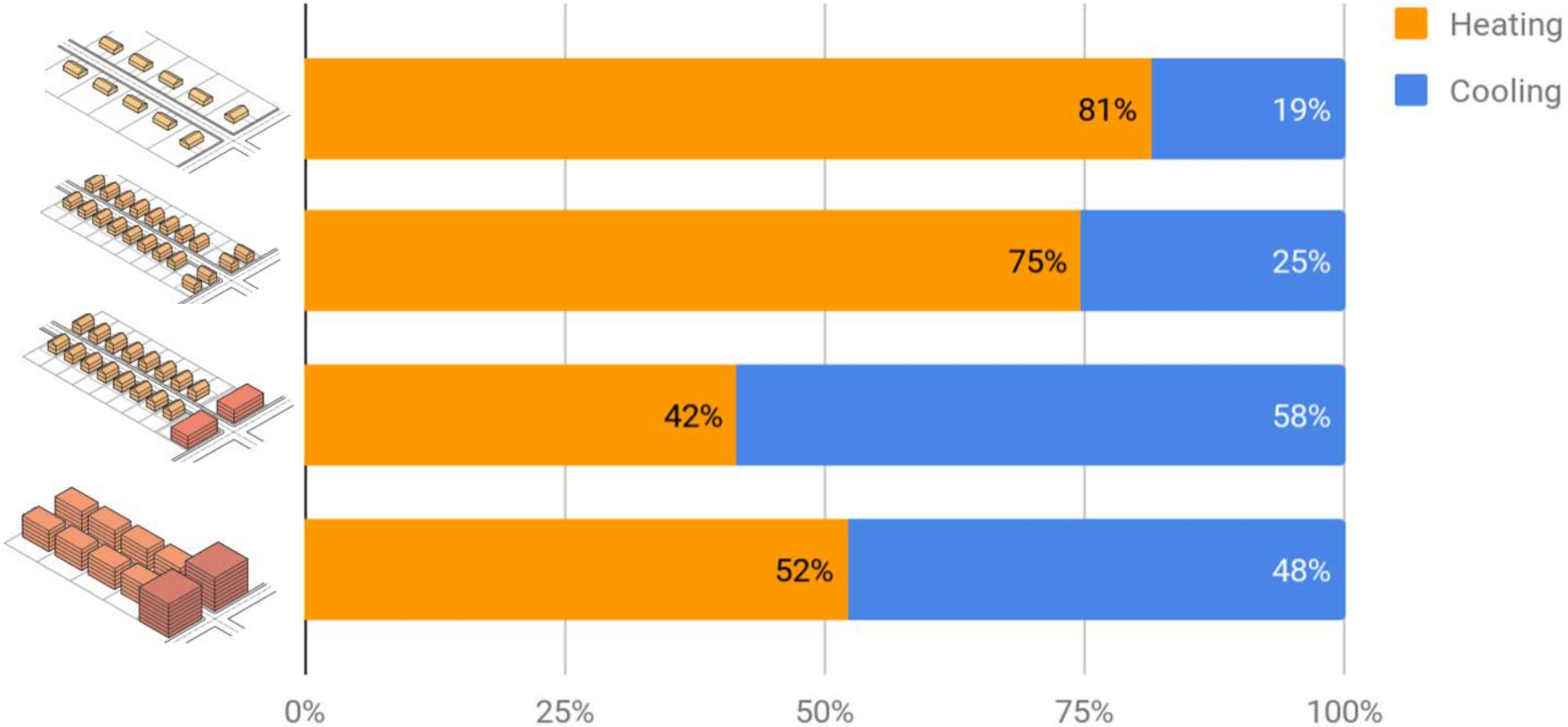
Opportunity in Annual Load Balancing

Dense urban areas have best balance of heating & cooling use



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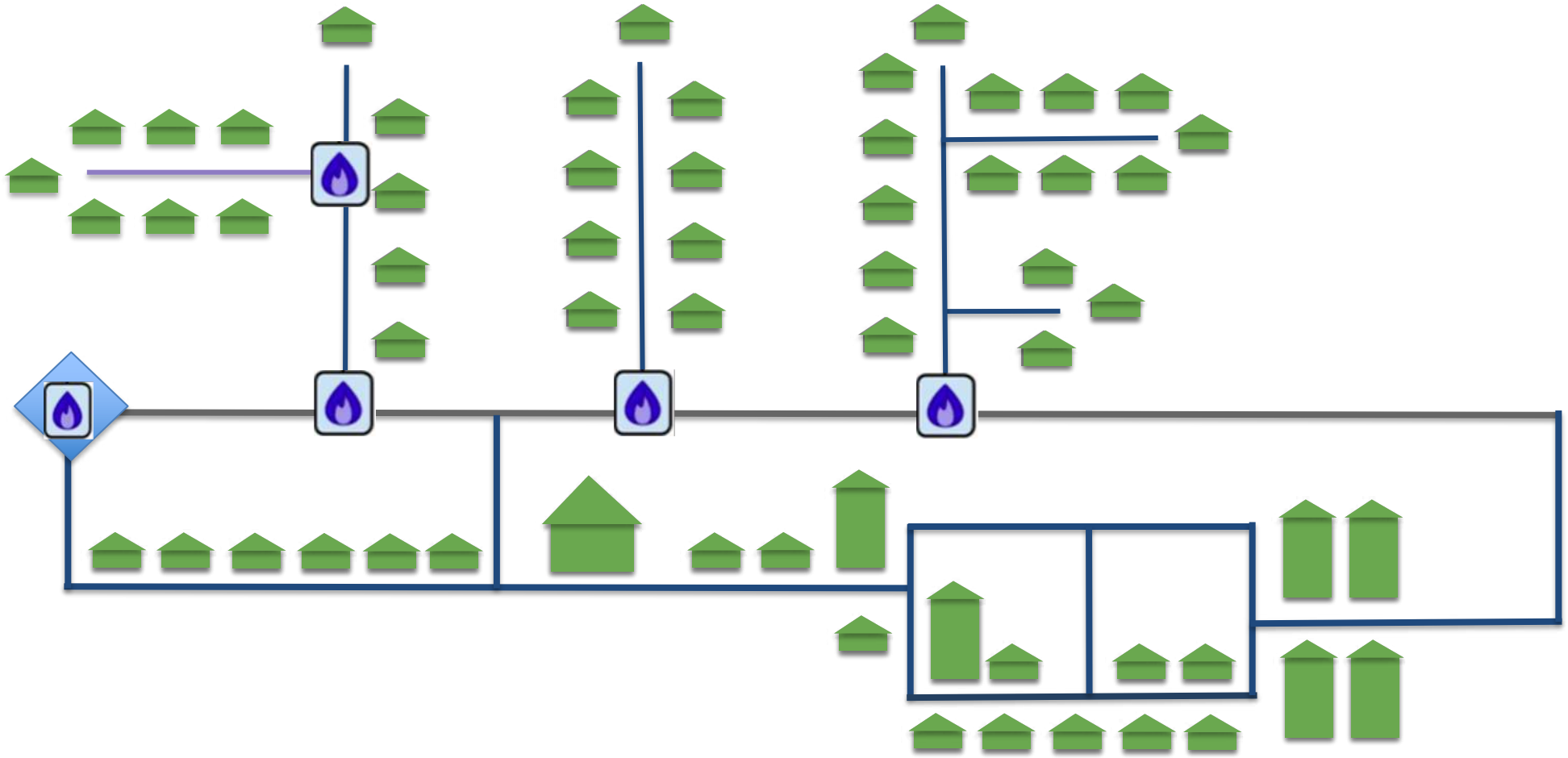
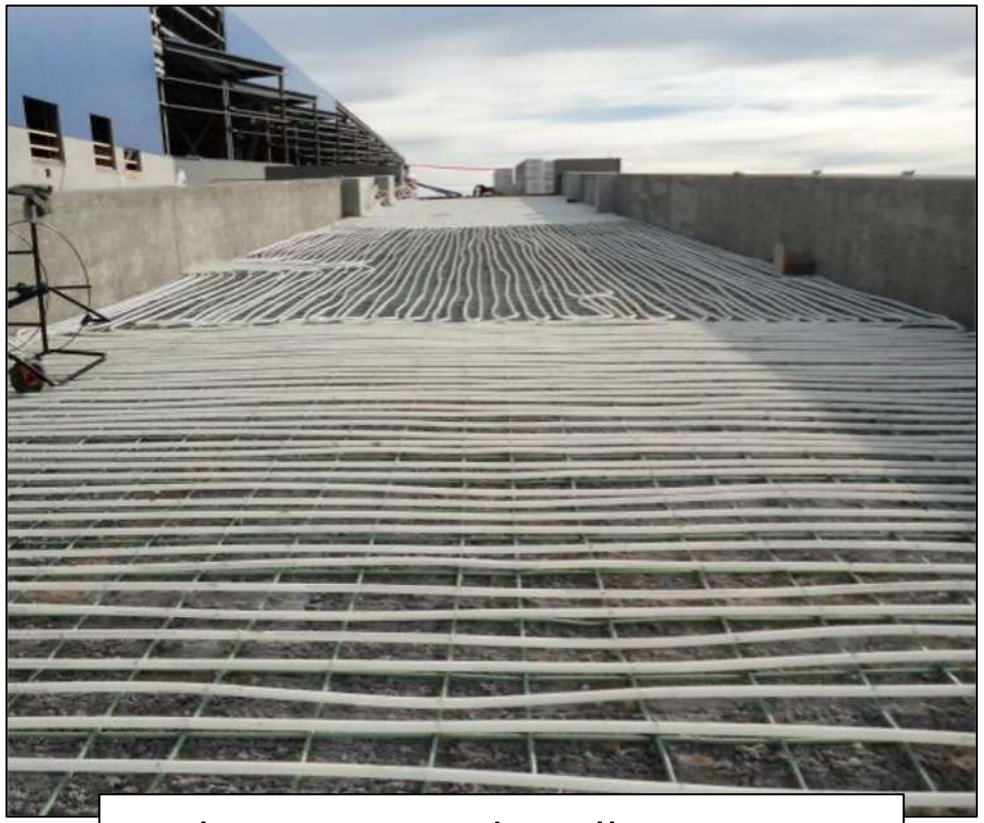
HEET's GeoGrid



Thermal Management

Cool Irrigation Water



Melt Snow on Sidewalks

Courtesy of The GreyEdge Group©

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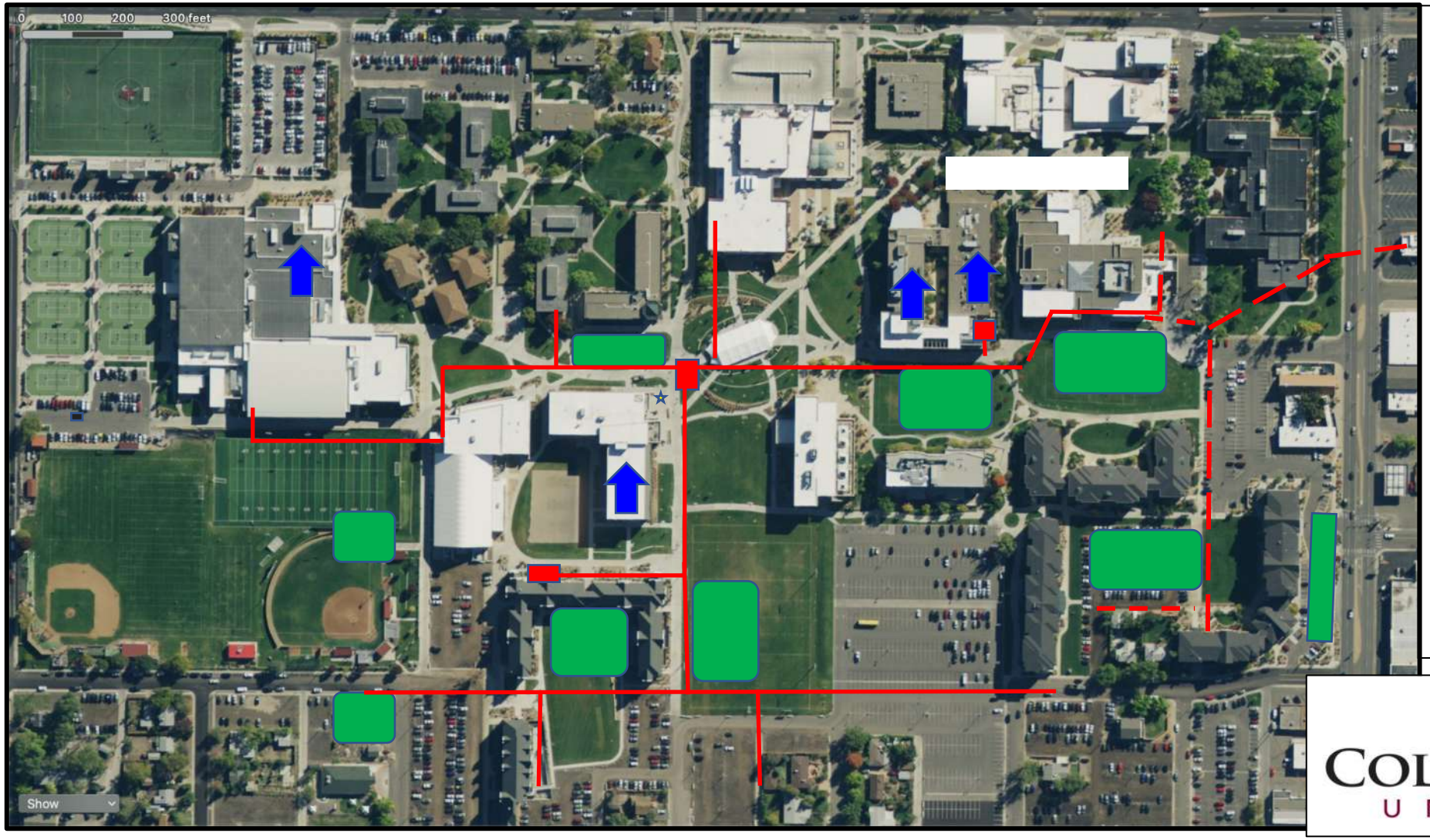
Case Study



Borefields
(121,000 ft)

Vaults &
Mechanical Rooms

Cooling Towers
(750 tons)

Shared loop:

18” Pipes

12” & 10” Pipes

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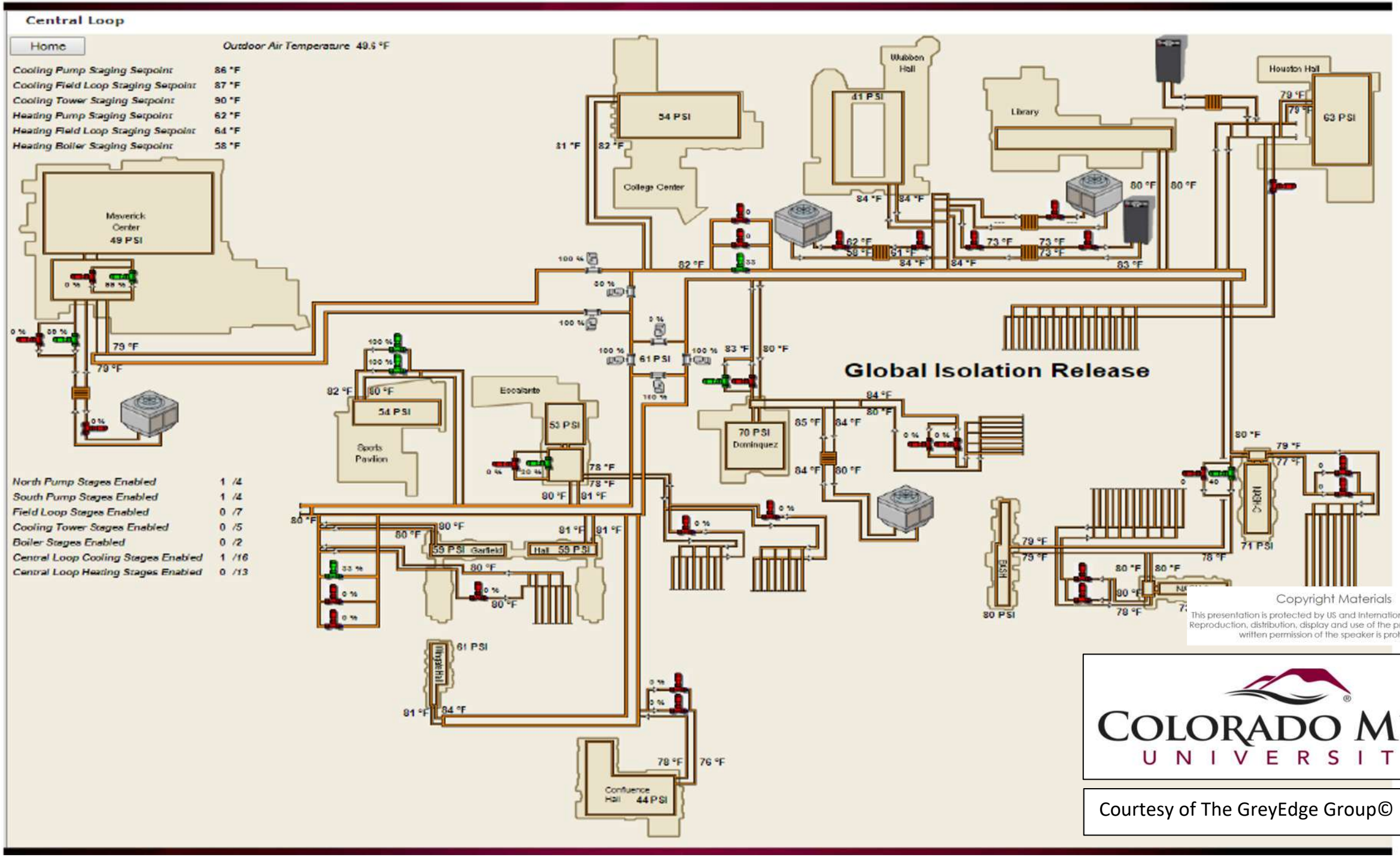
Courtesy of The GreyEdge Group©



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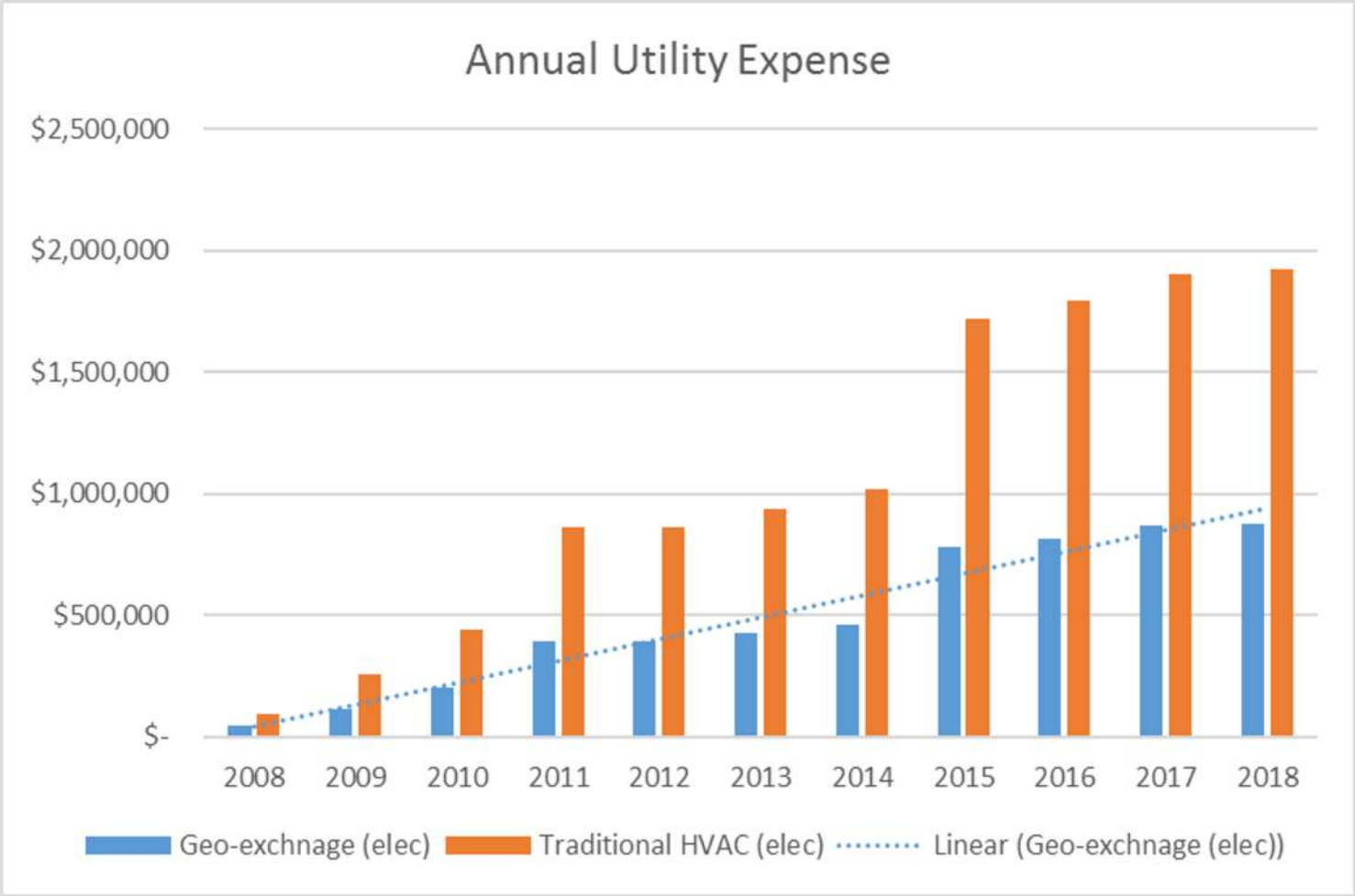
Energy & Money Savings



System cost:
$8.5 Million

Energy savings:
$1 Million/yr

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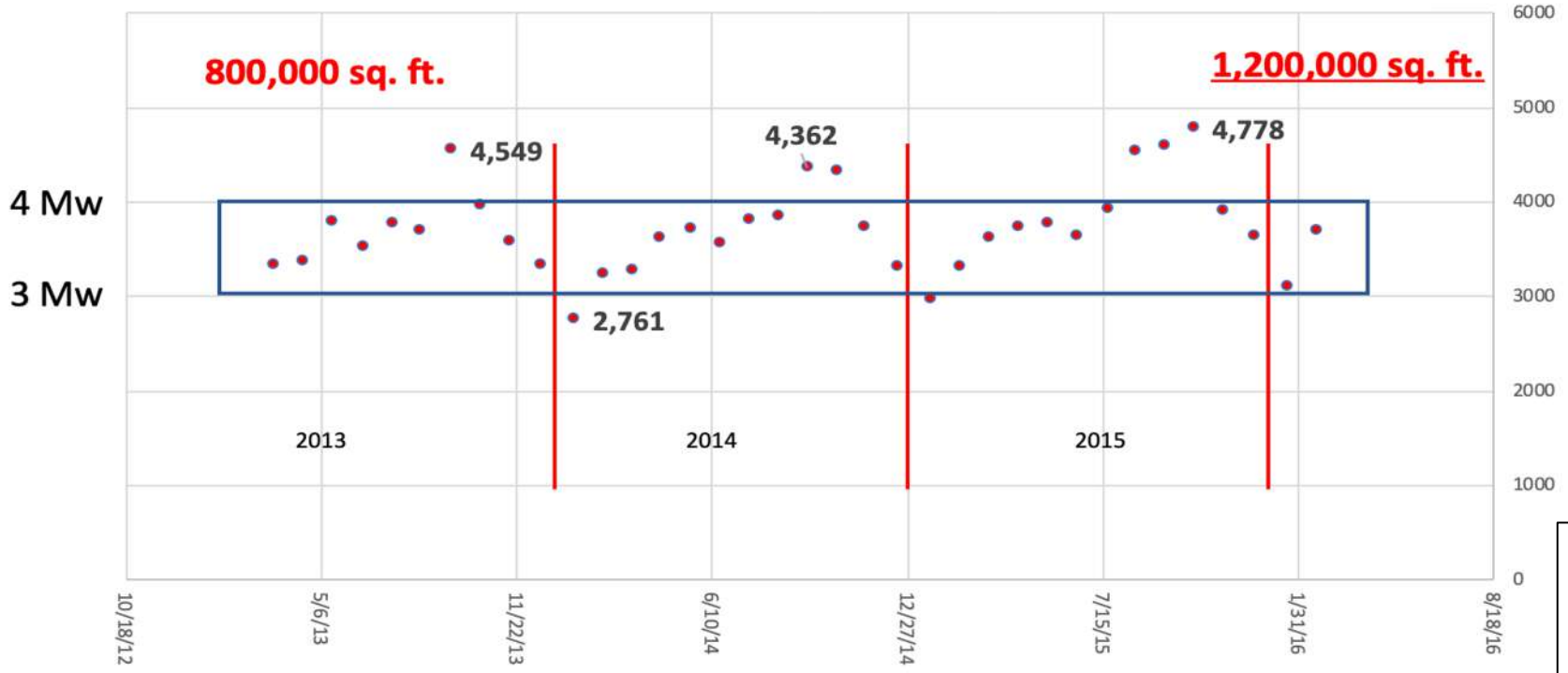
Flattening the Grid Load

PEAK kW Monthly as Shared Geo Grows

2013 (800,000 ft^2) – 2016 (1,200,000 ft^2)



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BENEFITS of Gas Utilities building a GeoGrid

- SAFETY
- Cuts GHG 90% by 2050 in MA
- Resilient and reliable
- Scalable & Adaptable
- Provides cooling
- Flattens grid loads
- Cheap energy storage
- **Equitable & Low Cost**
- **Keeps gas workers in jobs**
- **SPEED**

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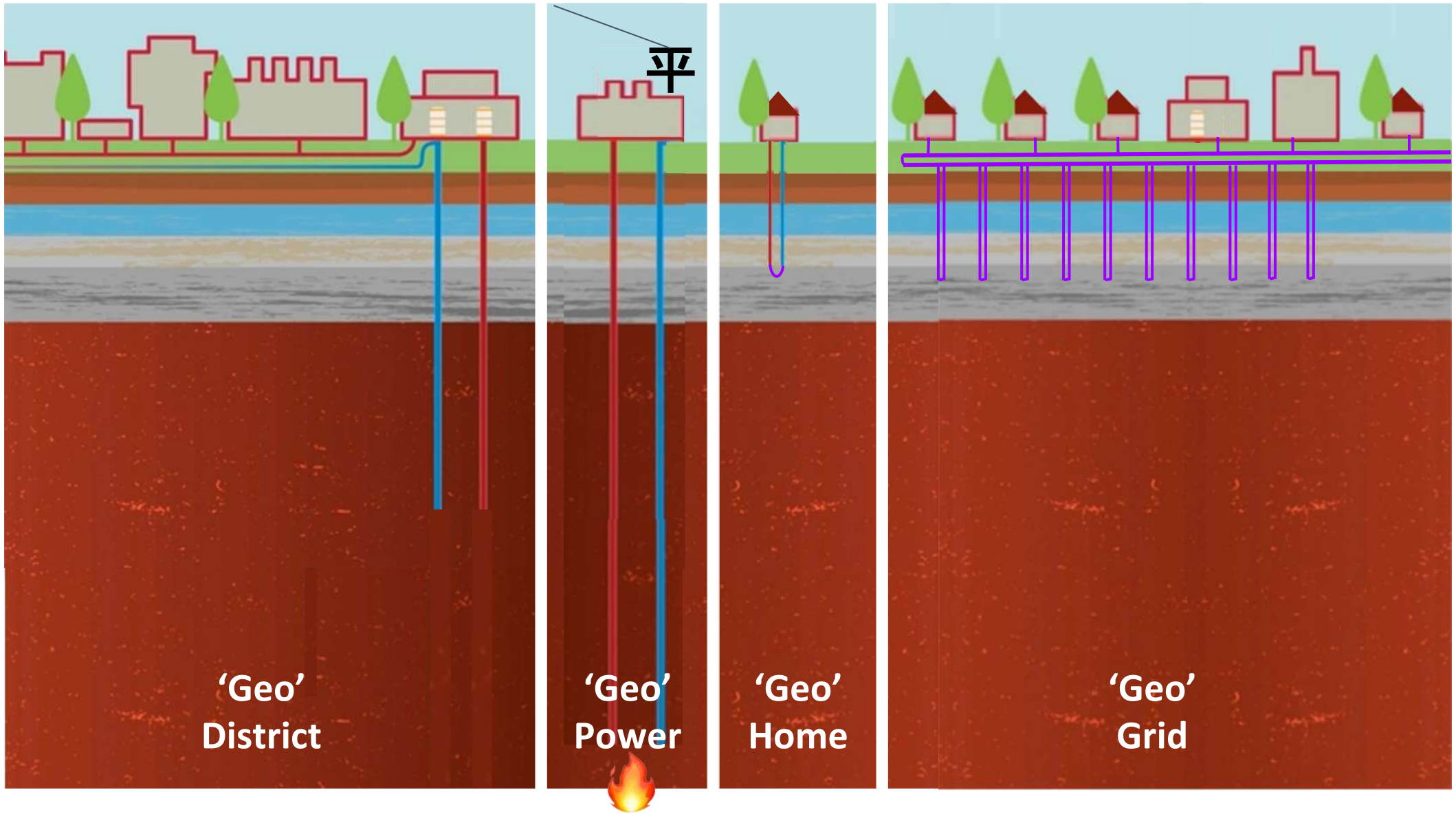
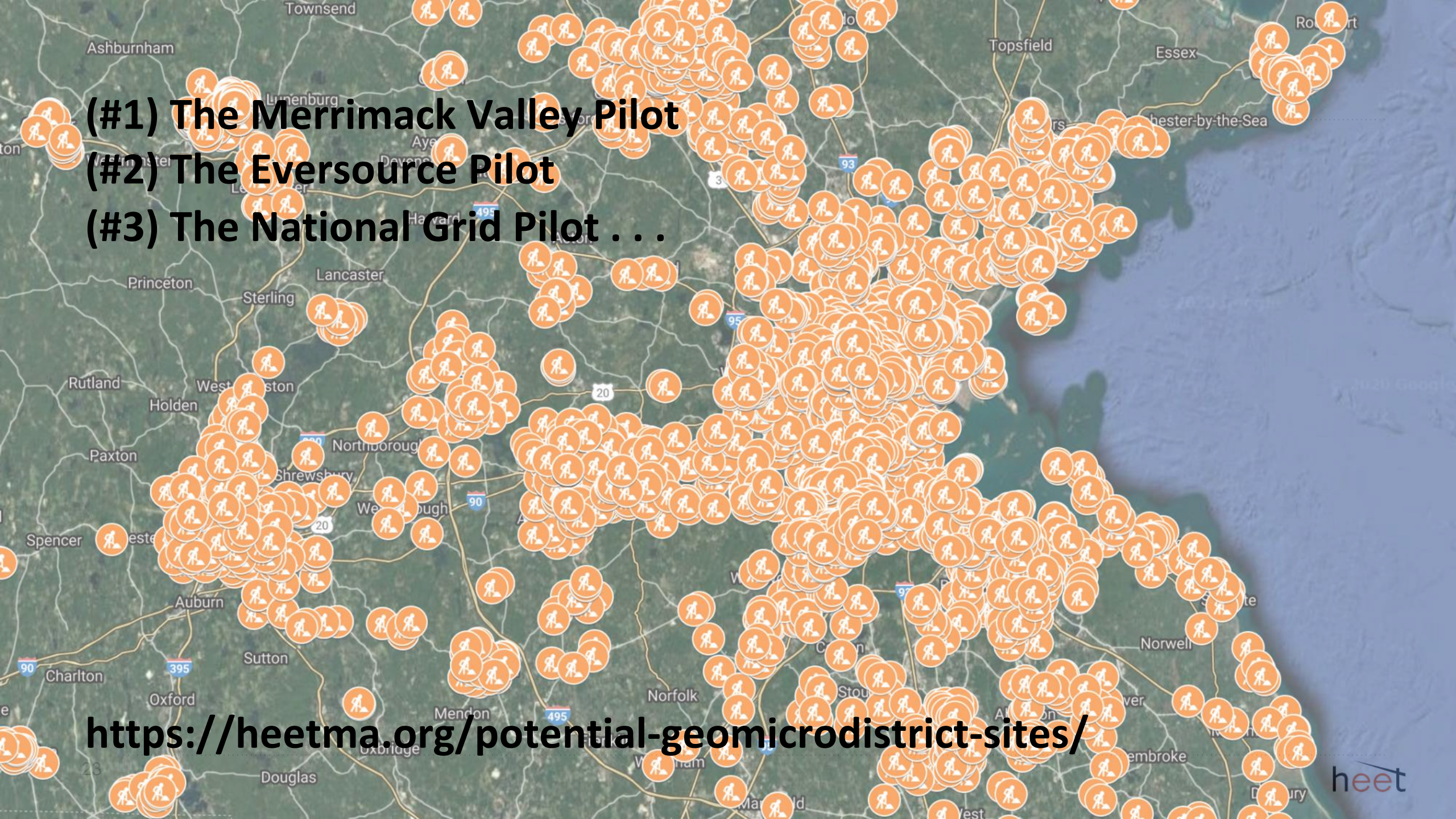
Is this NOVEL technology?





(#1) The Merrimack Valley Pilot

(#2) The Eversource Pilot

(#3) The National Grid Pilot . . .

https://heetma.org/potential-geomicrodistrict-sites/

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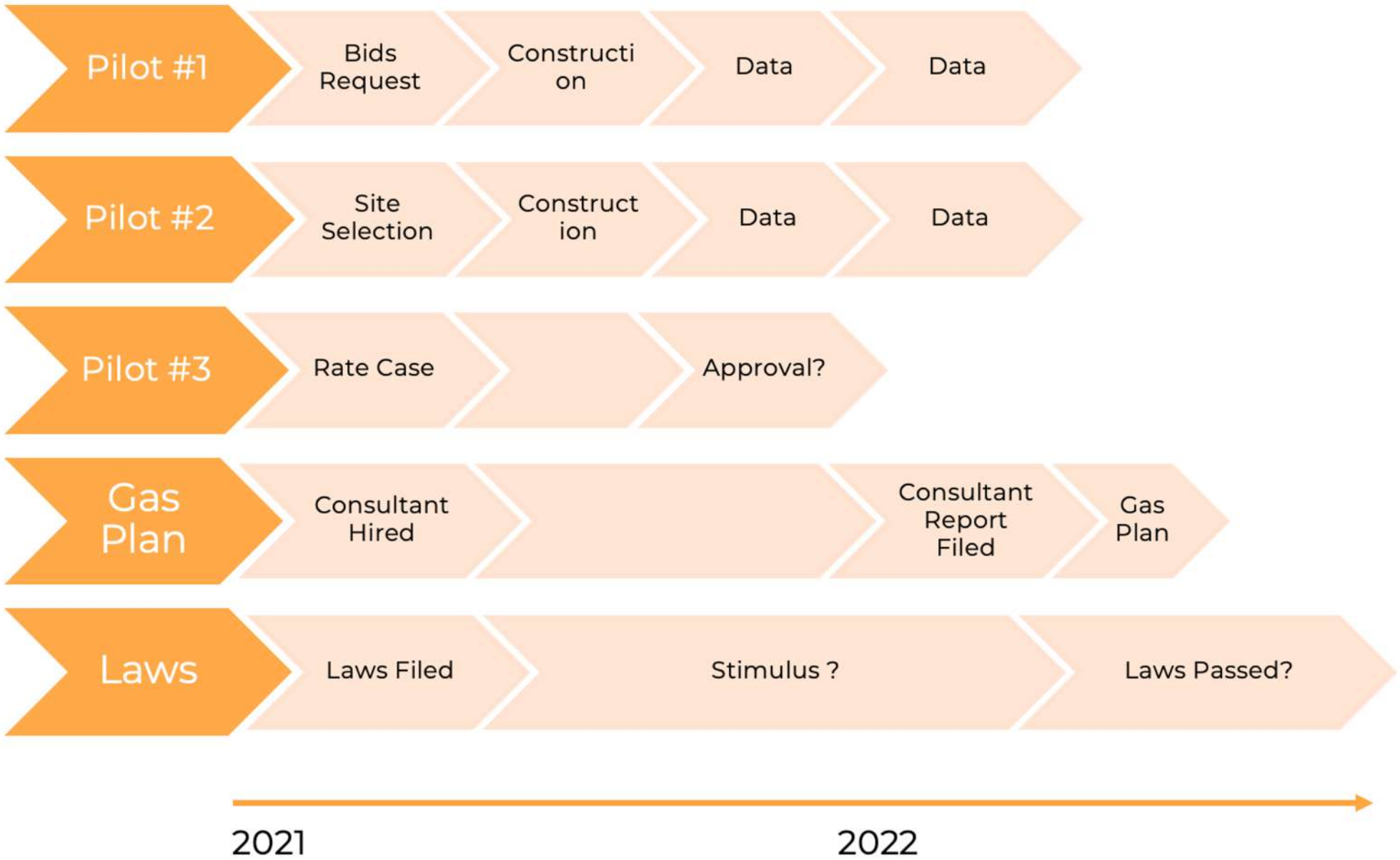
Pilot #1
Bids Request
Constructi on
Data
Data
Pilot #2
Site Selection
Construct ion
Data
Data
Pilot #3
Rate Case
Approval?
Gas Plan
Consultant Hired
Consultant Report Filed
Gas Plan
Laws
Laws Filed
Stimulus ?
Laws Passed?
2021
2022

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Legislative & Regulatory Challenges & Possibilities:

- Expand definition of ‘gas company’ in Chpt. 164
- Include gas companies in Renewable Thermal Credit Market
- Limit gas infrastructure depreciation past 2050
- Allow GSEP to include renewable thermal infrastructure

- Alter obligation to serve to include thermal delivery or remove
- Ensure equity & good jobs are prioritized in new system
- Assess securitization as a transition mechanism when ready

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HEET's 'Learning from the Ground Up' Research Team:

MIT Sloan School , System Dynamics
Harvard T.H.Chan School of Public Health, C-CHANGE Institute
BuroHappold Engineering
Massachusetts **DEP** (Department of Environmental Protection)
Berkeley National Lab, Earth and Environmental Science
University of California, **Berkeley**, Civil & Environmental Engineering
National Renewable Energy Laboratories

HEET's Quarterly Charrettes:

Jan '21 - Utilities, unions, regulators, advocates, municipalities, academics, geothermal experts, etc.

References & Resources

1. "GeoMicroDistrict Feasibility Study", Buro Happold & HEET, 2019
2. Eversource Gas geothermal pilot ratecase DPU 19-120
3. AG Healey's Petition to Consider the Future of Gas
4. Applied Economic Clinic policy brief
5. 'Energy Shift — A Utility-Scale Path From Gas To Renewable Thermal,' Zeyneb Magavi and Audrey Schulman, Building Energy Magazine, Nov. 2019.
6. Schulman, A., 2020. Pipes or Wires, Rocky Mountain Institute blog.
7. AG Healey deal with Columbia Gas & Transfer to Eversource Gas
8. Skarphagen, H. et al, 2019. 'Design Considerations for Borehole Thermal Energy Storage (BTES): A Review with Emphasis on Convective Heat Transfer,' *GeoFluids, Hindawi.* *https://doi.org/10.1155/2019/4961781.*
9. Bunning, F. et al, 2018. 'Bidirectional low temperature district energy systems with agent-based control: Performance comparison and operation optimization.' *Applied Energy.* https://doi.org/10.1016/j.apenergy.2017.10.072
10. Buffa, S. et al, 2019. '5th generation district heating and cooling systems: A review of existing cases in Europe.' *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2018.12.059

Eversource Geothermal Pilot Project

Clean Heat – The Potential of Networked Geothermal

November 19, 2020, 8:30-10:00 am

Our Commitment to Carbon Neutrality

EVERSOURCE

Eversource has been recognized as one of the most sustainable energy companies in the nation. We are committed to leading the way in environmental, social and governance performance, demonstrated in part by our ambitious Carbon Neutrality goal.

CLIMATE LEADERSHIP

Eversource aims to be carbon neutral by 2030 by reducing our carbon footprint from corporate operations and increasing resiliency to climate change impacts.

CLEAN ENERGY

We are committed to bringing more clean and affordable energy to the region.

ACCOUNTABILITY

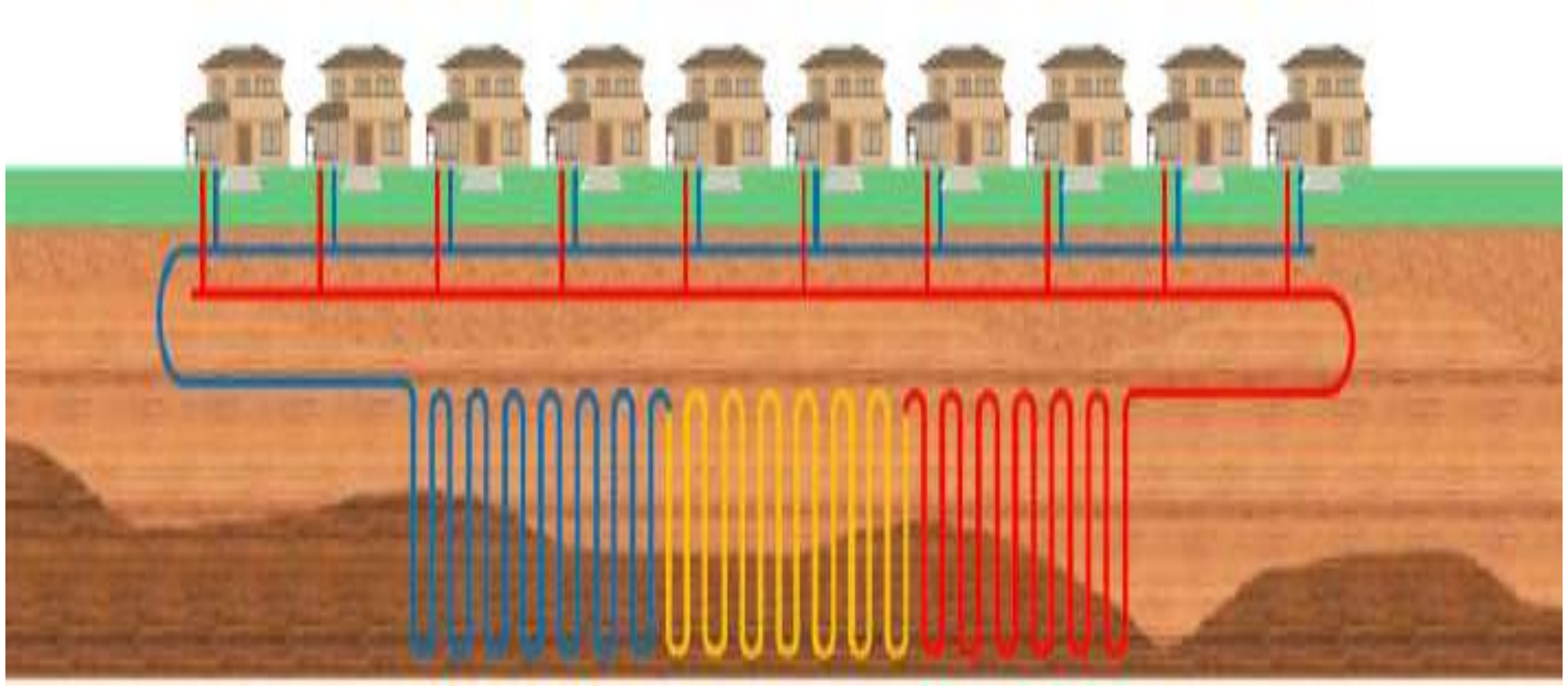
We meet and, in many cases, exceed all environmental laws and regulatory commitments and requirements.

STEWARDSHIP

We take great care to promote conservation and protection of wildlife, natural and cultural resources.

What is Geothermal?

EVERSOURCE



Example of a Closed Loop, Vertical System

- Ground source heat pump **(GSHP)** system is a heating and cooling solution for customers
- Use the **relatively stable temperature of the ground** to provide heating and cooling
- **Very efficient systems**, with Coefficients of Performance (COP) of 300-600%

Benefits of a Geothermal System

EVERSOURCE

Benefits	
Low operating cost	Simplicity
No required exposed outdoor equipment	No supplemental heat and cooling required
Level seasonal electric demand	Reduced Carbon
No on-site combustion	Safety
Long life expectancy	

Geothermal Networks

EVERSOURCE

Program Structure

The demonstration project seeks to test the viability of geothermal networks in three different scenarios.

MULTI-FAMILY

of HVAC Units: 30
Tons Per Unit: 2
Overall Tons: 60
Well Capacity: 75 Tons
Estimated Budget: $2.2M

MIXED USE/DENSE URBAN

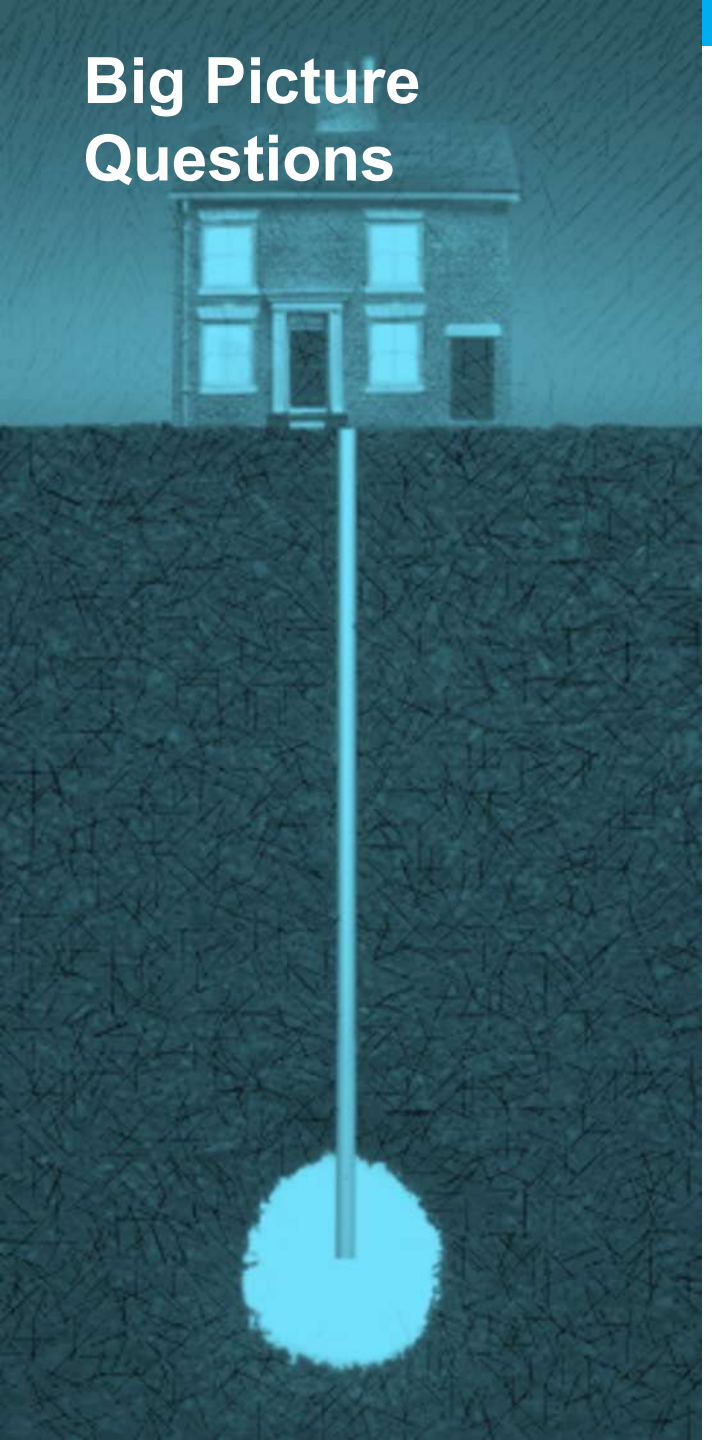
of HVAC Units: 100
Tons Per Unit: 3
Overall Tons: 300
Well Capacity: 375 Tons
Estimated Budget: $10.2M

RESIDENTIAL NEIGHBORHOOD

of HVAC Units: 10
Tons Per Unit: 3
Overall Tons:30
Well Capacity: 37.5 Tons
Estimated Budget: $1.2M

Budget estimates are inclusive of: Construction costs, staff costs, O&M, energy, water/glycol, performance monitoring

Big Picture Questions



EVERSOURCE

- Is it feasible to provide geothermal wells/loops and GSHPs as an **alternative/complement to delivered fossil fuels and gas service**?
- What is the **appropriate financial and business model**?
- What is **required to maintain a GSHP** system of wells?
- What are the **efficiencies that can be gained from shared loop system?**

Data Points We Want to Capture to Answer Big Picture Questions

EVERSOURCE

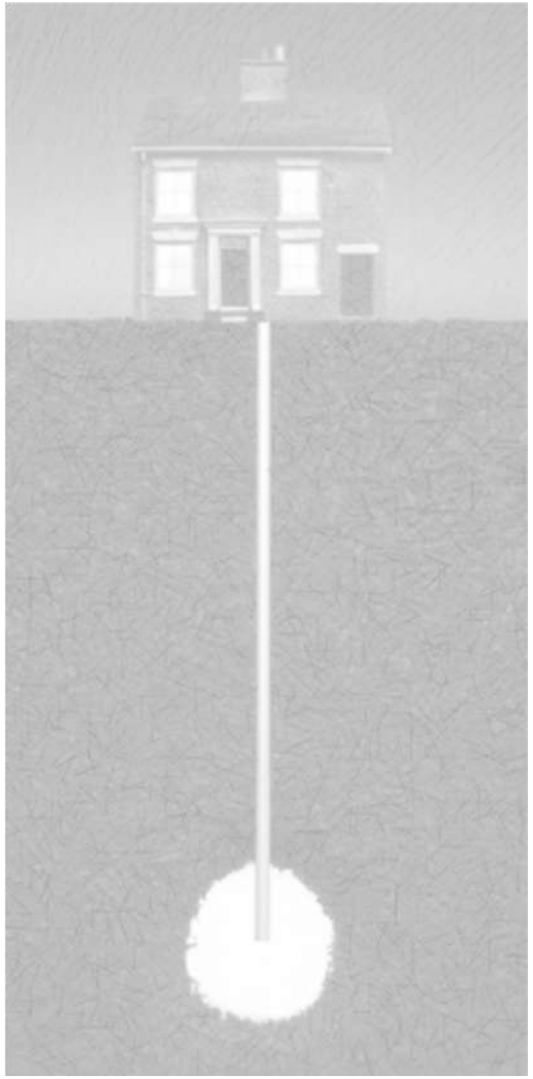
Questions	Data Points to Collect
Validated installation and operating costs	• System installation costs • Ongoing O&M costs
Customer acceptance of technology	• Customer Satisfaction surveys • Customer comfort
Carbon reductions	• Emission reductions • System performance
Technology performance	• System performance • Changes in customer energy consumption
Cost savings	• Changes in customer heating and cooling costs

The pilot project is an opportunity to answer key technical and financial questions that would enable the Company to decide whether to roll out a larger offering

Many Similarities Exist Between Geothermal and Natural Gas Business

EVERSOURCE

From a big picture perspective, geothermal and natural gas businesses share many common aspects



- Capital Intensive
- Buried/Underground Infrastructure
- Long Lived Assets
- Regulated Service
- Monitoring System Conditions
- Similar Customer Barriers
- Similar Point of Common Coupling

Existing Gas Business Model Addresses Common GSHP Concerns

EVERSOURCE

Existing gas business model and operations may be conducive to building, owning, and operating ground source heat pump networks

COMMON OBSTACLES TO GSHPS	EXISTING GAS BUSINESS OPERATIONS
Large upfront capital costs	Utility makes investment in capital projects and rate bases those assets across customers
Reluctance to spend money on infrastructure when customer might be in space for limited time period	Utility amortizes long lived assets over many years
Maintaining infrastructure outside of the customer's structure	Utility owns, operates, and maintains infrastructure in public/private ROWs

Benefits for Different Stakeholders

EVERSOURCE

Utility

- Provide customers an additional choice/alternative for heating
- Possible new business line
- Capitalize on existing gas company core competencies
- Flatter load profiles, higher utilization of infrastructure

Customer

- Provide low-cost heating where gas is not available
- Cleaner, safer, quieter, reliable system
- Provides both heating and cooling
- GSHP equipment is located inside the building so there is an ease of repair/maintenance and no aesthetic impacts

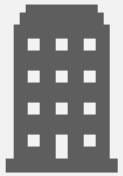
State

- Provides state with another way to meet to climate goals
- Estimated 60%+ reduction in carbon emissions from combined heating and cooling for an average residence by installing GSHP

Determining the Way Ahead

EVERSOURCE

Recent Order from the Department of Public Utilities helps chart a path forward



LOW INCOME/MULTI-FAMILY

DENSE URBAN ENVIRONMENT

COMMUNITY/SUBDIVISION

Determining the Way Ahead

EVERSOURCE

Recent Order from the Department of Public Utilities helps chart a path forward

LOW INCOME/MULTI-FAMILY

DENSE URBAN ENVIRONMENT

COMMUNITY/SUBDIVISION

The Department finds that the intent of the Company's proposal is consistent with the GWSA [Global Warming Solutions Act] and the Commonwealth's energy climate policies, including the statewide emissions limit for 2050.

…the experience of developing and maintaining a company-owned geothermal network could inform the potential regulatory policies related to broad scale geothermal deployment and the role of LDCs in the future.

Utility-Owned Geothermal

Owen Brady-Traczyk
Manager, Future of Heat

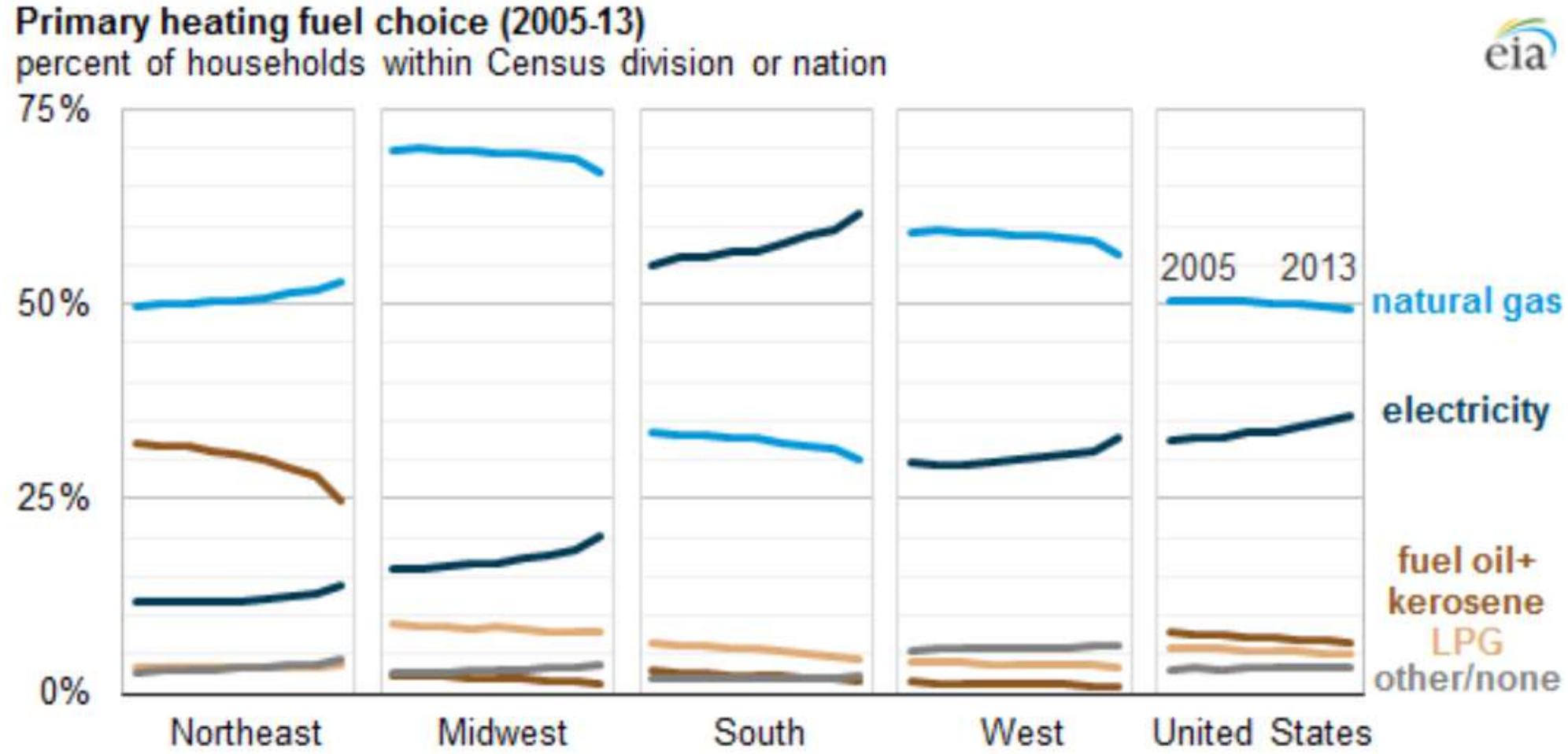
nationalgrid

A gas utility interested in geothermal?

Strong demand for natural gas over the past few decades, driven by convenience, social momentum, and low relative price, has created the need for significant gas resources in the Northeast.

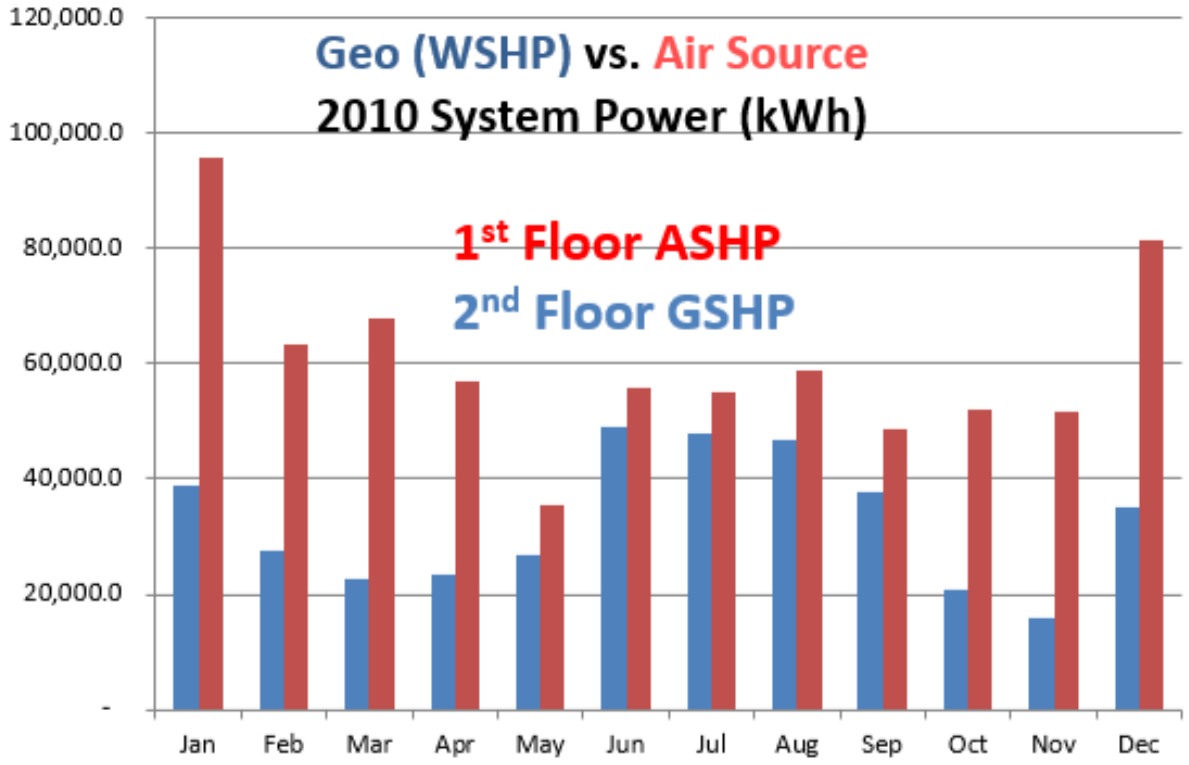
- Limited pipeline infrastructure available to deliver supply
- State policy that requires reduction in emissions/fossil fuel consumption
- Desire from all stakeholders, including the gas industry, to improve efficiency and reduce GHG emissions
- Customers desire simplicity; one system that meet year-round needs
- Price tends to be the most important factor for customers
  - High electric rates in northeast have made the economics for electrification more challenging
  - Usually the purchase price of new equipment rather than the lifetime cost

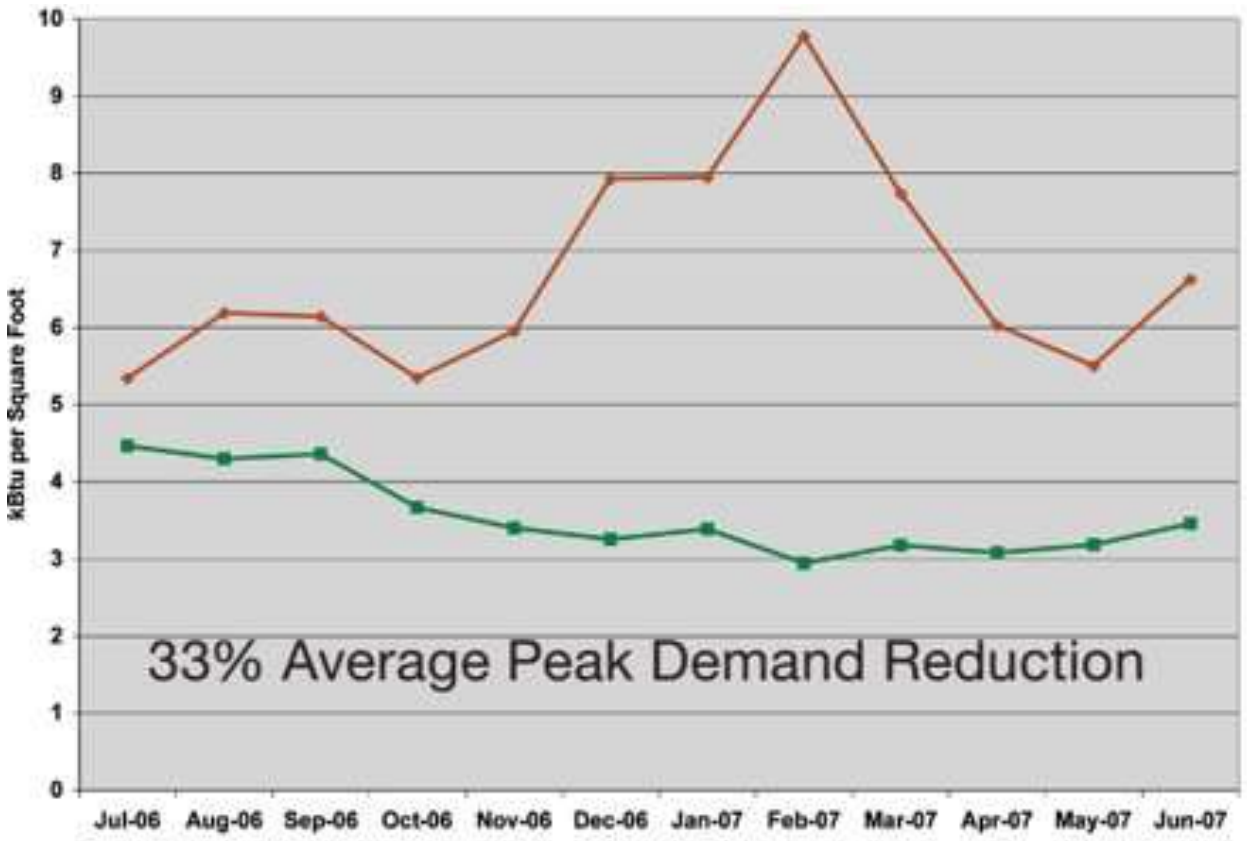
The Northeast is unique



Source: U.S. Energy Information Administration, based on Census Bureau American Community Survey
Note: Geographic areas based on Census regions. LPG is liquefied petroleum gas.

Utility Perspective: Geothermal provides grid benefits





Charts: EggGeo, LLC

VAV System Geothermal

REV Demo – Shared-loop in Riverhead, NY

- Test and learn pilot approved in 2016 rate case
- 55+ retirement community with homes located 1000'-1500' from gas network
- 10 homes connected to a 30-ton common loop field beginning in Dec 2017
  - No central pumping
  - Replaced kerosene and propane heating systems
- Energy efficiency upgrades were made in some homes, typically based on the vintage of the home
- Close coordination with NYSERDA & PSE&G-LI for installation, system impacts, EM&V, and incentives
- All system costs paid for by the project
  - Participants paid $21.66/month, which is the minimum gas customer charge for LI

Riverhead, NY Geothermal Pilot – Results

Project was successful and utility ownership merits further investigation

- Load diversity resulted in a peak load that was 80% of nominal load
  - Shared loop capacity could have been reduced by 20% compared to individual loops
- Met year-round heating and cooling needs for these customers
- Could potentially be a viable alternative to expanding gas infrastructure
- Customers experienced positive qualitative benefits
  - Improved indoor air quality
  - Reduced equipment noise
  - More consistent temperature in the home
- Customers saved 43% compared with previous heating and cooling systems

NMPC Gas – Future of Heat Geothermal Proposal

- Installing 2,600 tons of capacity over 3 years
  - ~86 Riverhead projects
  - Exclusively shared-loop projects for this pilot
  - Exploring a mixture of projects for customers not connected to the gas system and customers who are being served by gas assets that will be replaced, including leak-prone pipe
- Installations will occur “in partnership with the competitive suppliers of geothermal heat pumps, with the Company owning the shared loop infrastructure and supplying thermal energy to connected customers under a long-term contract rate.”
- Customers will be charged a fixed monthly rate based on their connected capacity using identical financial model used for gas infrastructure
  - Weighted average cost of a ton (“WACOT”)
  - $22.69/ton/month (e.g. 4-ton system = $90.76/month)
  - No subsidy from gas customers (share of general/overhead expenses)

MA Gas – Future of Heat Geothermal Proposal

- Installing 876 tons of capacity over 3 years
  - ~29 Riverhead projects
- Similar to Eversource's proposal, all costs will be covered as part of this demonstration
- Exploring a mixture of projects for customers not connected to the gas system and customers who are being served by gas assets that will be replaced, including leak-prone pipe
- Focused exclusively on shared-loop, mixed-use systems
  - Goal is to understand how to optimize the value of shared loops by increasing load diversity
    - Will hire EM&V consultant
- Will seek to install projects within gas service territory
  - Exploring best practices for coordinating multiple underground assets

MA Gas – Future of Heat Geothermal Proposal (cont.)

- Will shared loops provide operational efficiency because peak demand on the shared loop is less than the nominal peak demand of connected customers?
- How does the actual installed cost per ton for a district energy system compare with the cost per ton for individual geothermal systems?
- Can shared loops satisfy peak day needs for connected customers without backup heating and cooling systems?
- Is it feasible to develop geothermal networks in lieu of leak-prone pipe replacement in an area or neighborhood?
- Will connecting more customers to a shared loop add enough excess heat to the system to decrease the amount of energy required to operate the system and create cost savings for all customers on the system?
- When is it feasible and cost-effective to connect incremental customers to an existing shared loop?
- What are the minimum thresholds for heat capacity, total load, number of connected customers, and other factors below which it is inefficient or too costly to use a shared loop?
- What are effective ways to make existing or potentially new gas customers aware of a new heating and cooling solution like shared geothermal loops?

Owen Brady-Traczyk

Manager, Future of Heat
Owen.brady@nationalgrid.com

nationalgrid

Thank You!

Join Our Next GRCx Program:

Procuring Renewable Energy to Maximize Emissions Reductions

December 1st, 2020, 8:30am – 10:00am

GRCx | GREEN RIBBON COMMISSION Climate Action Exchange