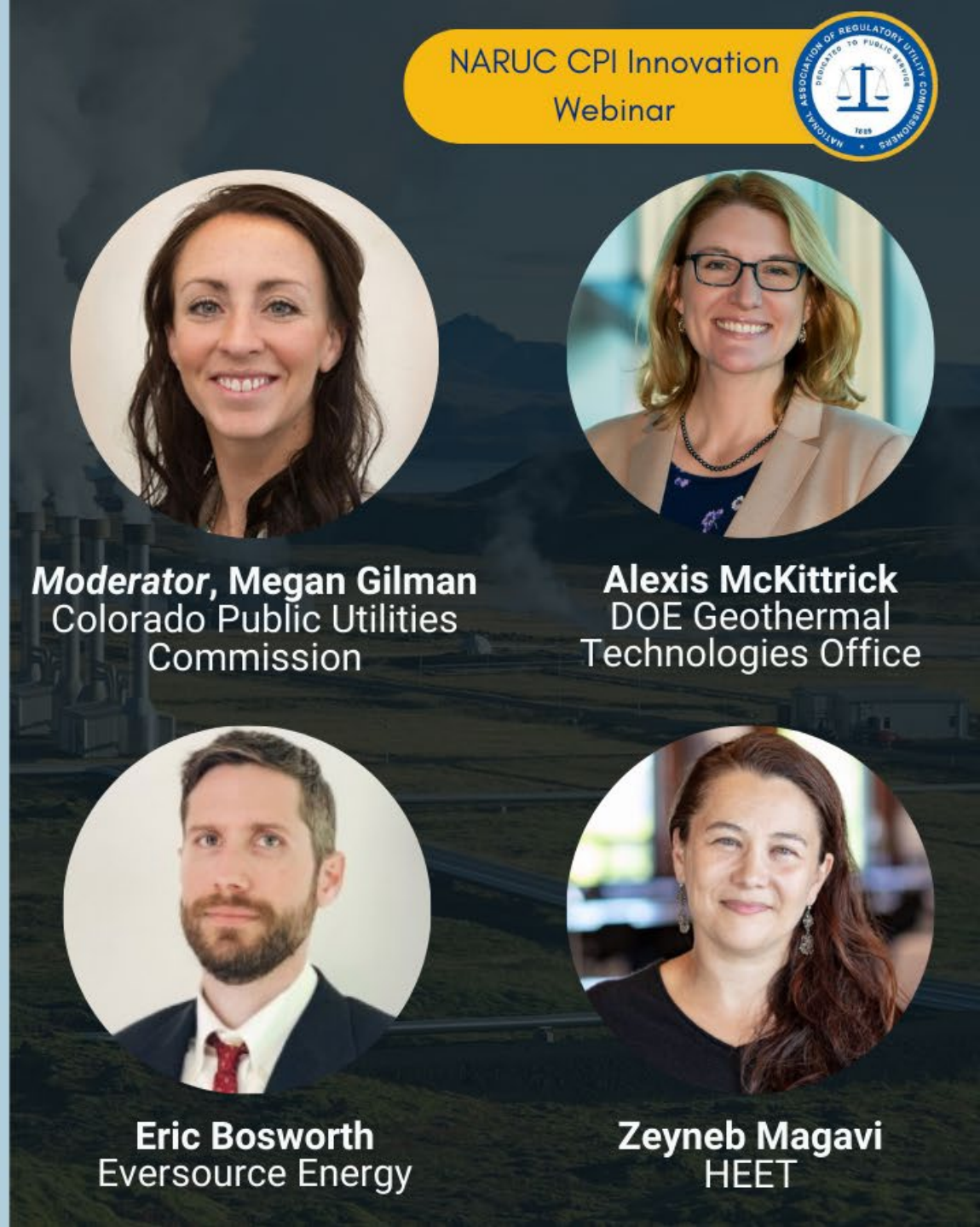
UNEARTHING OPPORTUNITIES: ADVANCES IN NETWORKED GEOTHERMAL SYSTEMS TO MEET TODAY'S CUSTOMER HEATING NEEDS

INNOVATION WEBINAR

August 22, 2024

3:00 - 4:00 p.m. ET



About NARUC

- Founded in 1889, the National Association of Regulatory Utility Commissioners (NARUC) is a non-profit organization dedicated to representing the state public service commissions who regulate the utilities that provide essential services such as energy, telecommunications, power, water, and transportation.
- NARUC's members include all 50 states, the District of Columbia, Puerto Rico, and the Virgin Islands.
- Our mission is to serve the public interest by improving the quality and effectiveness of public utility regulation.

About CPI

- The NARUC Center for Partnerships & Innovation (CPI) builds relationships, develops resources, and delivers training to assist state commissions contending with complex current and emerging issues.
- CPI is funded by cooperative agreements with the U.S. Department of Energy (DOE) and the U.S. Department of Commerce's National Institute of Standards and Technology (NIST).
- NARUC CPI conducts work across five key energy areas and many topics within each: generation; transmission; distribution; customers; and critical infrastructure preparedness, response, and resilience.
- For more information, visit: https://www.naruc.org/cpi/cpi-home/

Upcoming Events

Virtual Events:

- **NASEO-NARUC Grid-interactive Efficient Buildings (GEB) Working Groups Forum: RMI Virtual Power Plant (VPP) Flipbook** – Sept. 4
- **Workforce Development Webinar on Interagency Dialogue -** Sept. 9
- **Innovation Webinar on AI and Energy Demands -** Sept. 19
- **Regulators' Roundtable Series: Wildfires and Affordability: Financial, Regulatory, and Policy Issues for Regulator Part Three of Three** – Oct. 8

September & October In-Person Events:

- **Central Energy Equity Roundtable**, Kansas City, MO, Sept. 10 – 11
- **Cybersecurity Training, Philadelphia**, PA, Sept. 24 – 25
- **Natural Gas Task Force Workshop,** Atlanta, GA, Oct. 18 – 19
- **NCEP Annual Meeting**, Phoenix, AZ, Oct. 29 – 30

See our full list of events: https://www.naruc.org/cpi/cpi-events/

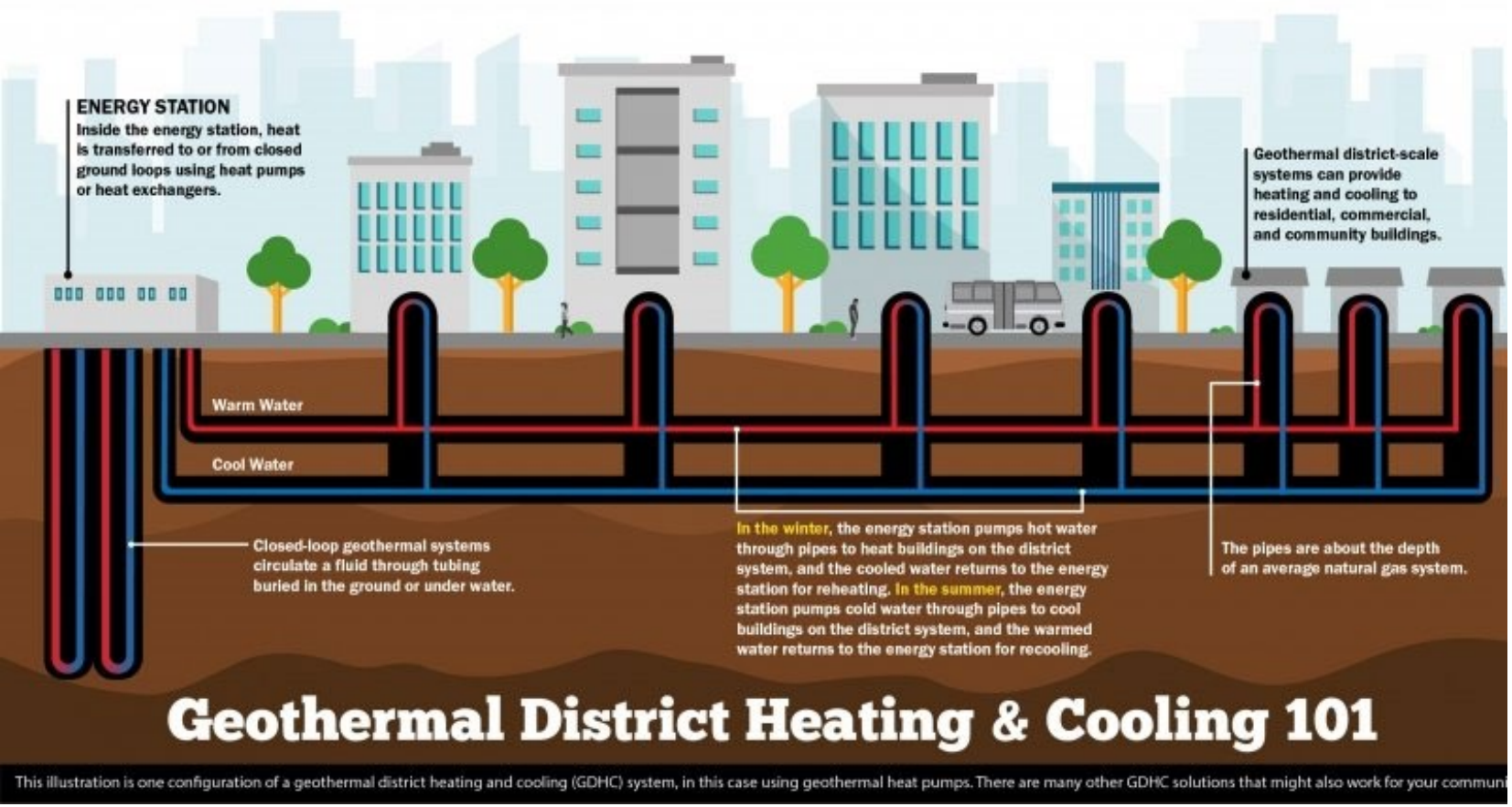
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Networked Geothermal Heating and Cooling

Alexis McKittrick, Ph.D.
Program Manager
Geothermal Technologies Office
August 22, 2024

Geothermal District Heating and Cooling Systems

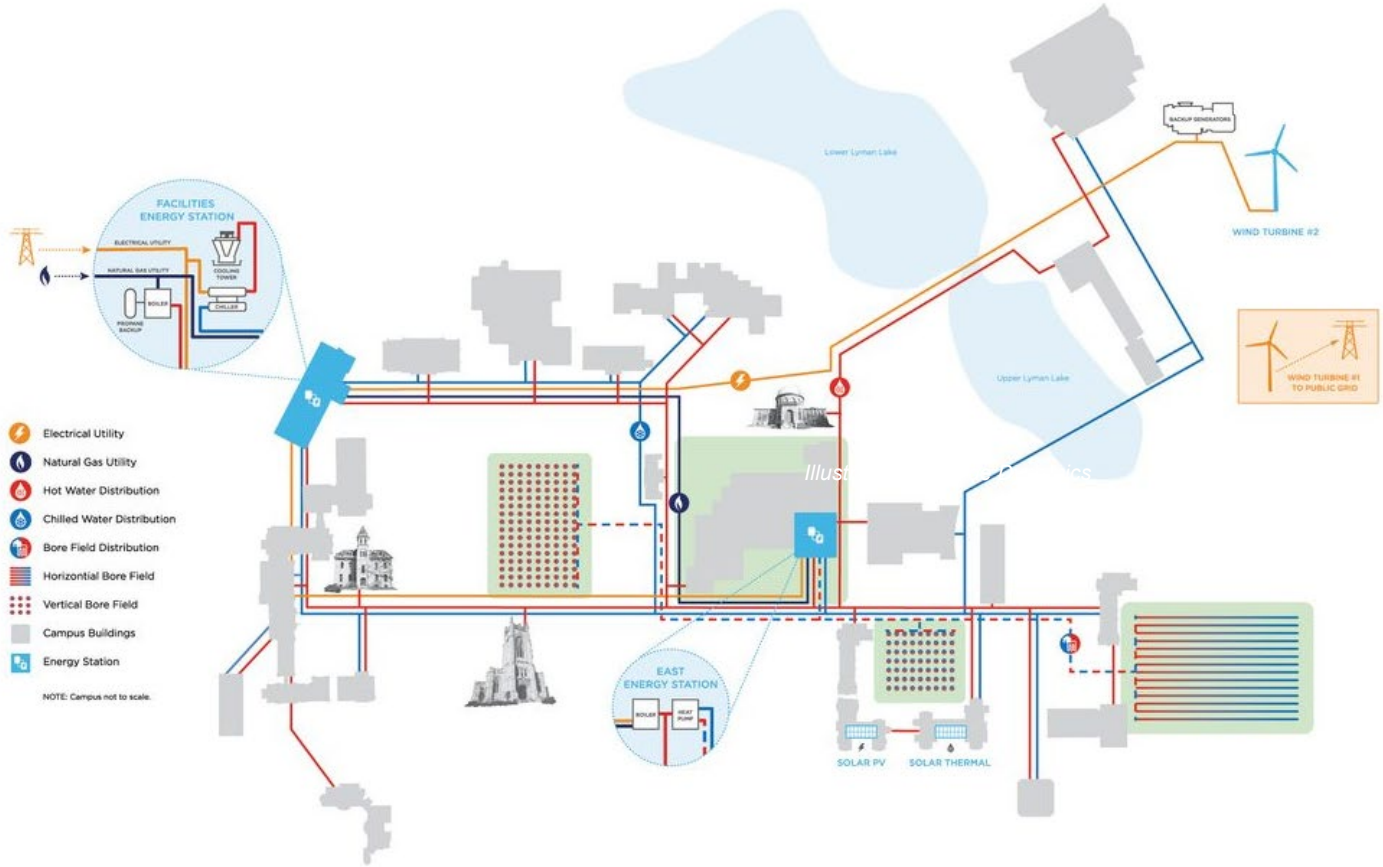


- Low-temperature, shallow systems
- Hundreds to thousands of boreholes connected to district energy stations
- Central loops distribute hot and cold water to buildings
- Major trends:
  - Replace existing district systems
  - Often hybrid systems
  - Buildings slowly retrofitted and added to system
  - Interest in shifting towards utility-scale

Icons via Flaticon.com

Geothermal District Heating and Cooling Variations

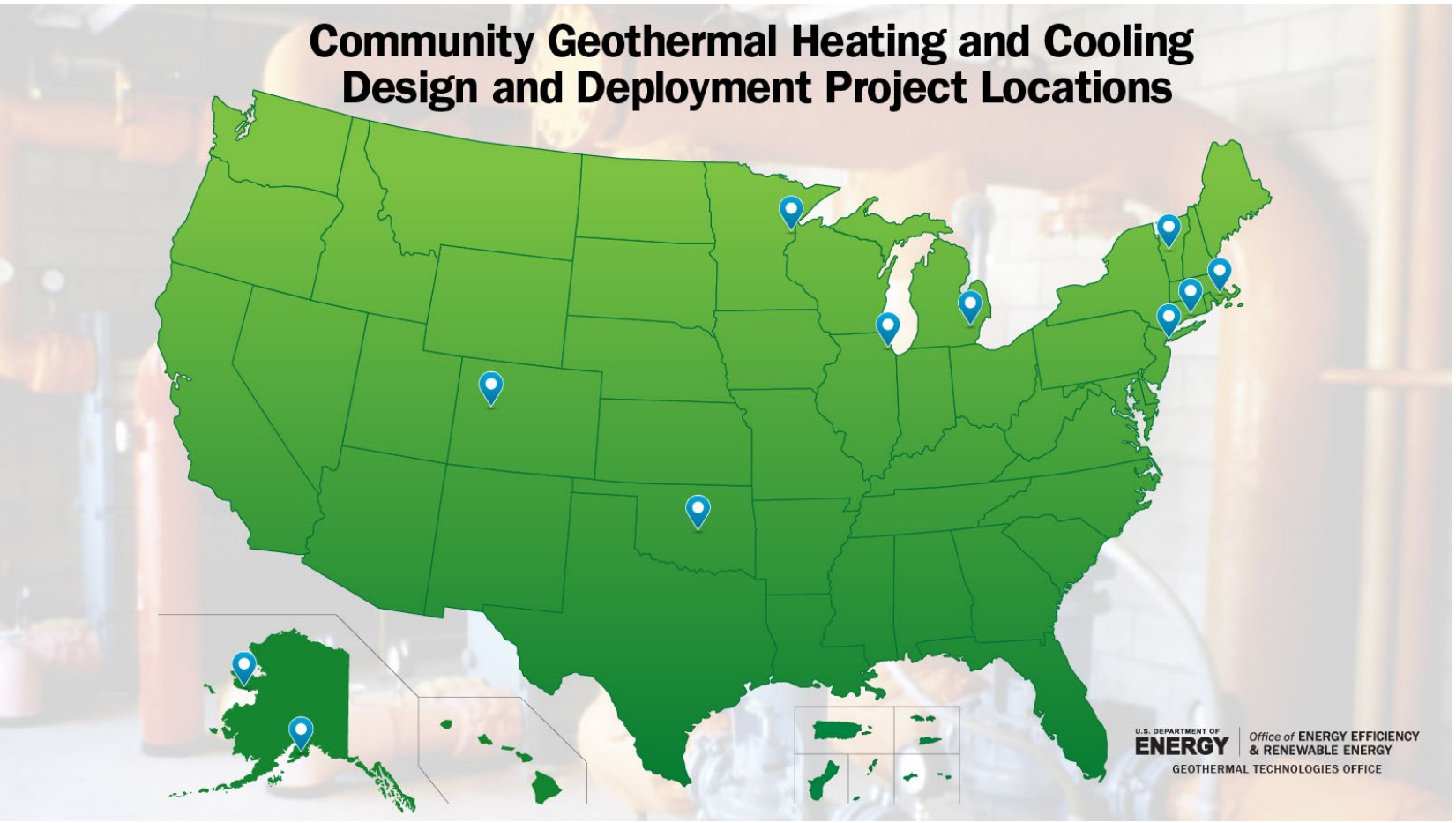
- Different stakeholders may have different conceptual structures for “district energy” or "thermal energy networks."
- Geothermal district heating and cooling (GDHC) systems have many variations, including:
  - Stand-alone or coupled with other energy systems or stranded thermal assets (e.g., wastewater or sewer heat)
  - Systems with an underground thermal loop connecting the system
  - System using GHPs, direct use of geothermal heat, or both
  - Systems that provide heating only, and systems that provide both heating and cooling.



Campus energy system including borefields and hot and chilled water distribution at Carlton College in Northfield, Minnesota, completed in 2021

Icons via Flaticon.com

Community Geothermal



Selected 11 communities in 10 states to assess and design community-scale geothermal heating and cooling systems

Urban
- Ann Arbor, MI
- Chicago, IL
- Duluth, MN
- Framingham, MA
- New York City, NY
- Wallingford, CT

Rural
- Carbondale, CO
- Middlebury, VT
- Seward, AK
- Shawnee, OK

Remote
- Nome, AK

energy.gov/eere/geothermal/community-geothermal-heating-and-cooling-design-and-deployment

Icons via Flaticon.com

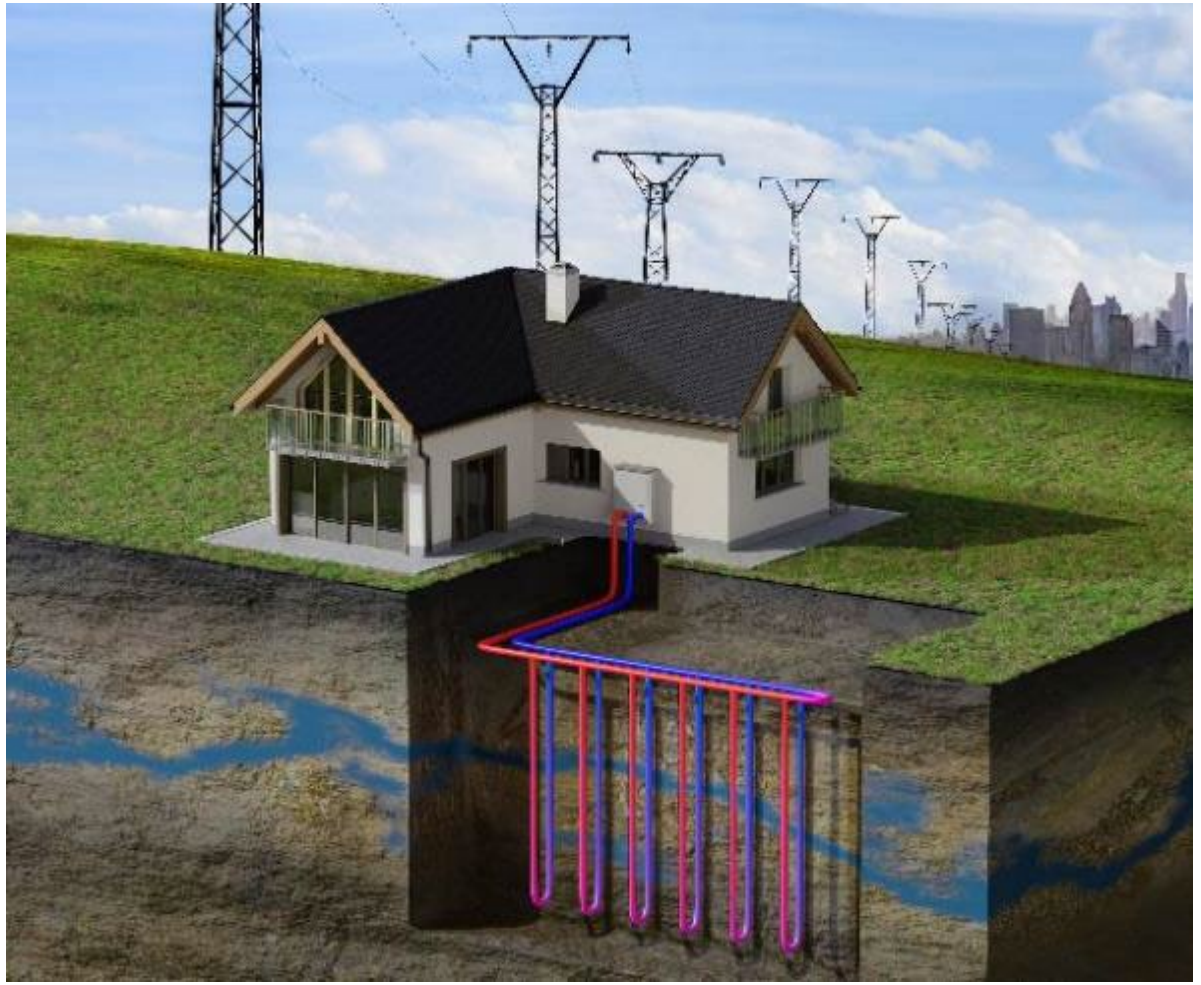
GHP Impacts Analysis

GTO-funded analysis by Oak Ridge National Lab and National Renewable Energy Lab to assess how mass deployment of geothermal heat pumps (GHPs) can provide cost and carbon reductions at the grid.

Aimed to quantify:

- Effects on building electricity use and emissions resulting from mass deployment of GHPs
- Impacts to the bulk power system under various carbon policy, electrification, and sensitivity scenarios.

Assessment considered GHPs at the individual building level, so networked deployment in community-scale systems could likely provide even greater benefits.



https://www.osti.gov/biblio/2224191

GHP Impacts Analysis

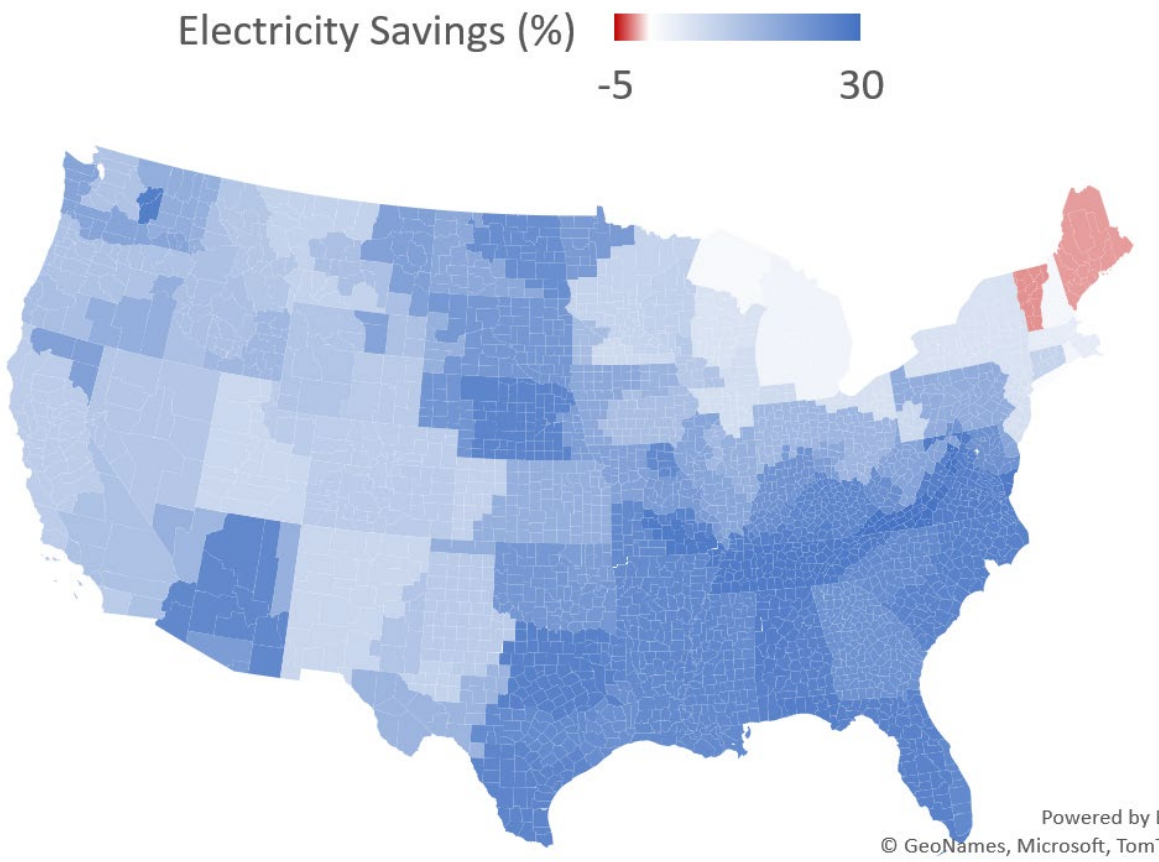
Eliminate the need for up to 43,600 miles of new interregional transmission infrastructure – equivalent of up to 44 SunZia transmission projects

Reduce up to 410 GW of nationwide generation capacity requirements – bolstering seasonal U.S. grid resilience

Eliminate more than 7 gigatons of carbon – equivalent to all U.S. emissions produced in 2022

https://www.osti.gov/biblio/2224191

GHP Impacts Analysis



Based on the analysis, mass GHP deployment:

- Electrifies heating in all climate zones at high efficiency
  - Electrification increases grid winter electrical demand; HOWEVER, in aggregate, increases are offset by summer cooling savings
- In combination with building envelope improvements, reduces annual electric consumption in 132 of the 134 Balancing Authority Areas
- By 2050, reduces national generation requirements by 11% and 13% for Decarb and Electrification Future scenarios
- Can reduce the cost of grid power and provide environmental benefit even to those who do *not* have GHPs installed.

https://www.osti.gov/biblio/2224191

Pathways to Commercial Liftoff: Geothermal Heating and Cooling

- Cross-office collaborative DOE report; all Liftoff Reports take a technology or suite of technologies and build a common understanding with the private sector and broader ecosystem around the current state, pathways to commercial liftoff, and challenges and solutions to unlock scale
- Late 2024 release of Liftoff Report focused on geothermal heating and cooling technologies

Geothermal heating and cooling system at the University of Utah. Photo courtesy University of Utah.

energy.gov/lpo/pathways-commercial-liftoff-reports

Incentives and Resources

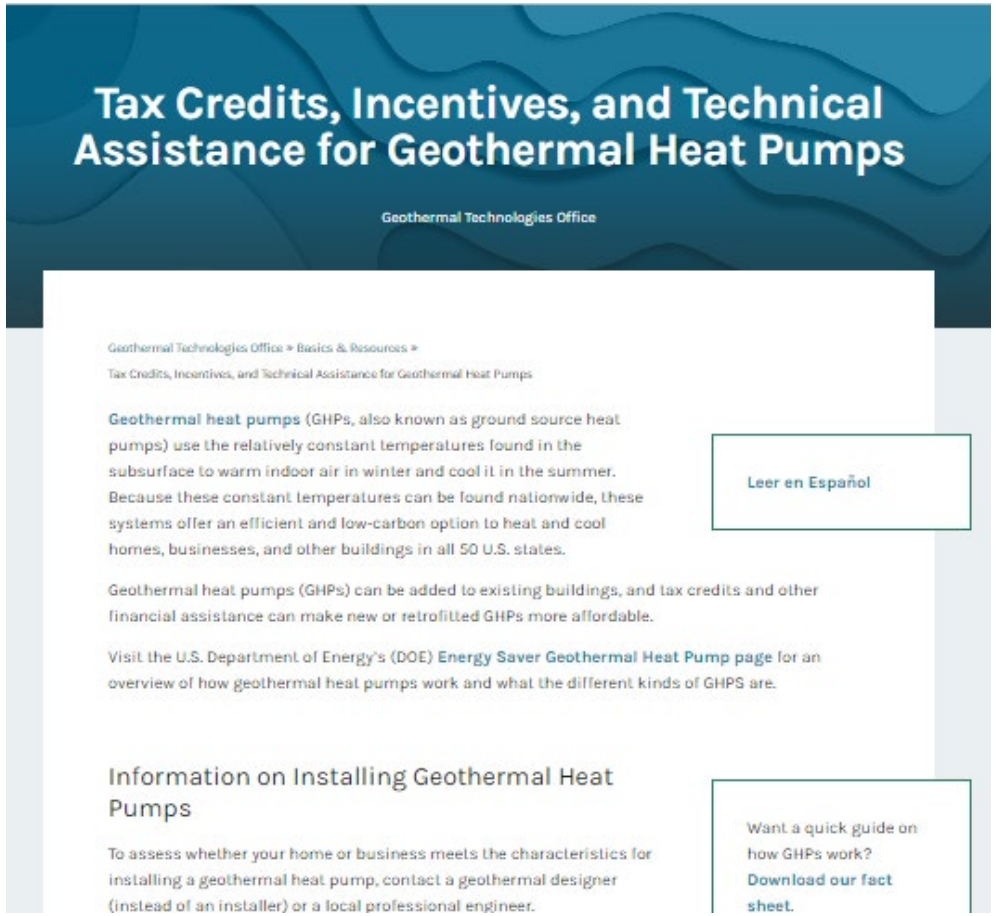
GHPs in the Inflation Reduction Act

- **Residential:** 30% tax credit for ENERGY STAR-rated GHPs through 2032

- **Commercial:** Investment Tax Credit (ITC) for renewable energy projects beginning construction before 1/1/25. For geothermal, base ITC is 6% for the first 10 years; credit increases for projects meeting labor, content, and locations parameters

Building Decarbonization Coalition

Maintains a web page of states that have implemented legislation advancing or promoting thermal energy networks
buildingdecarb.org/resource-library/tens-state-leg



GTO's website features numerous resources, including a tax credits, incentives, and technical assistance web page with more information!

energy.gov/eere/geothermal/tax-credits-incentives-and-technical-assistance-geothermal-heat-pumps

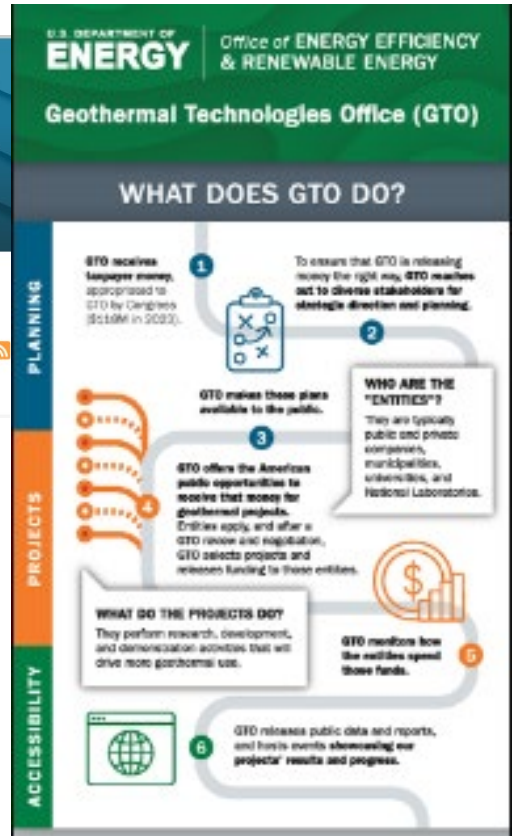
More Resources and Thank You!

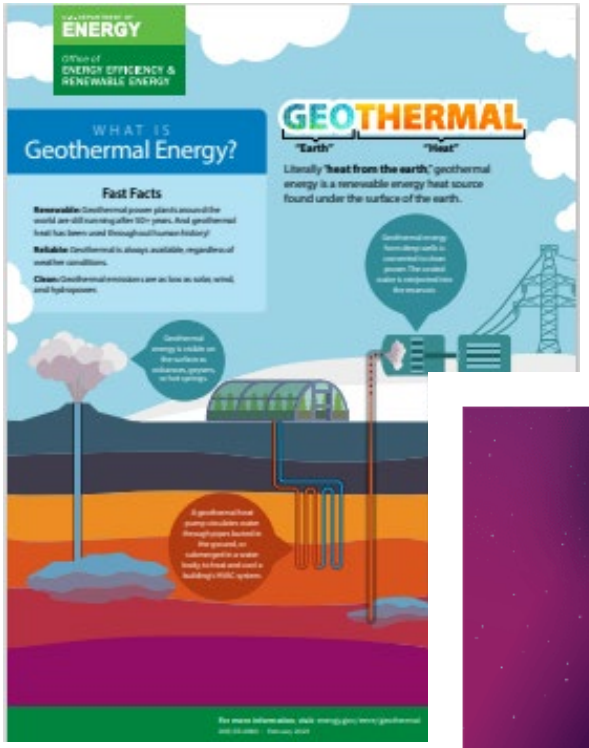
GTO has additional tools and resources available to learn about geothermal energy, find funding opportunities, and more.

- Funding Opportunities
- Fact Sheets
- The Drill Down Newsletter
- Stakeholder Toolkits
- Infographics
- Project Postcards

Get the hottest geothermal news from ***The Drill Down***, GTO's monthly newsletter!

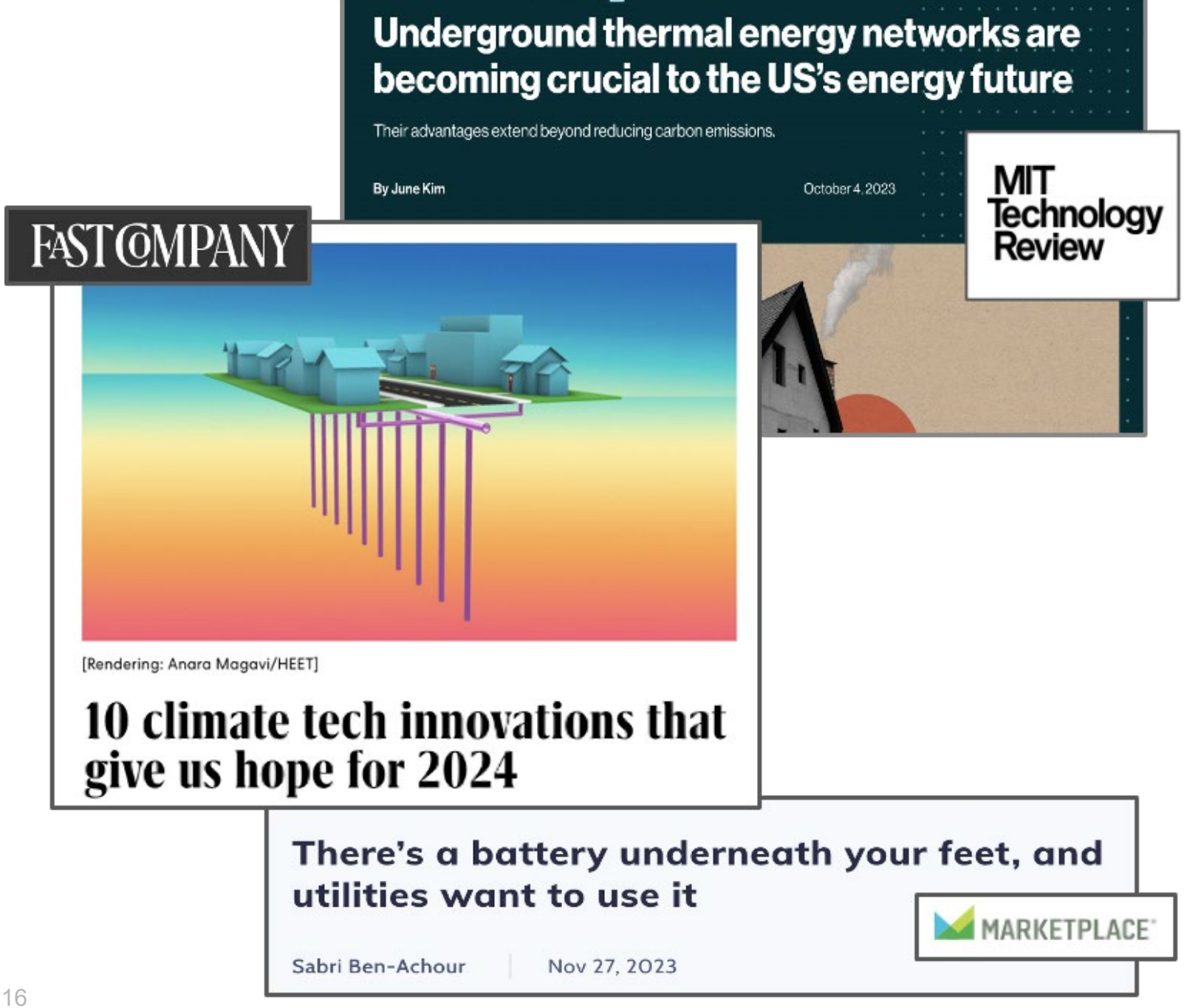
Sign up today: geothermal.energy.gov





Delivering Decarbonization

Zeyneb Magavi | August 2024



Thermal Energy Networks or Geothermal Networks are apparently one of the hottest (and coolest!) new climate tech innovations . . .

So WHAT are they?

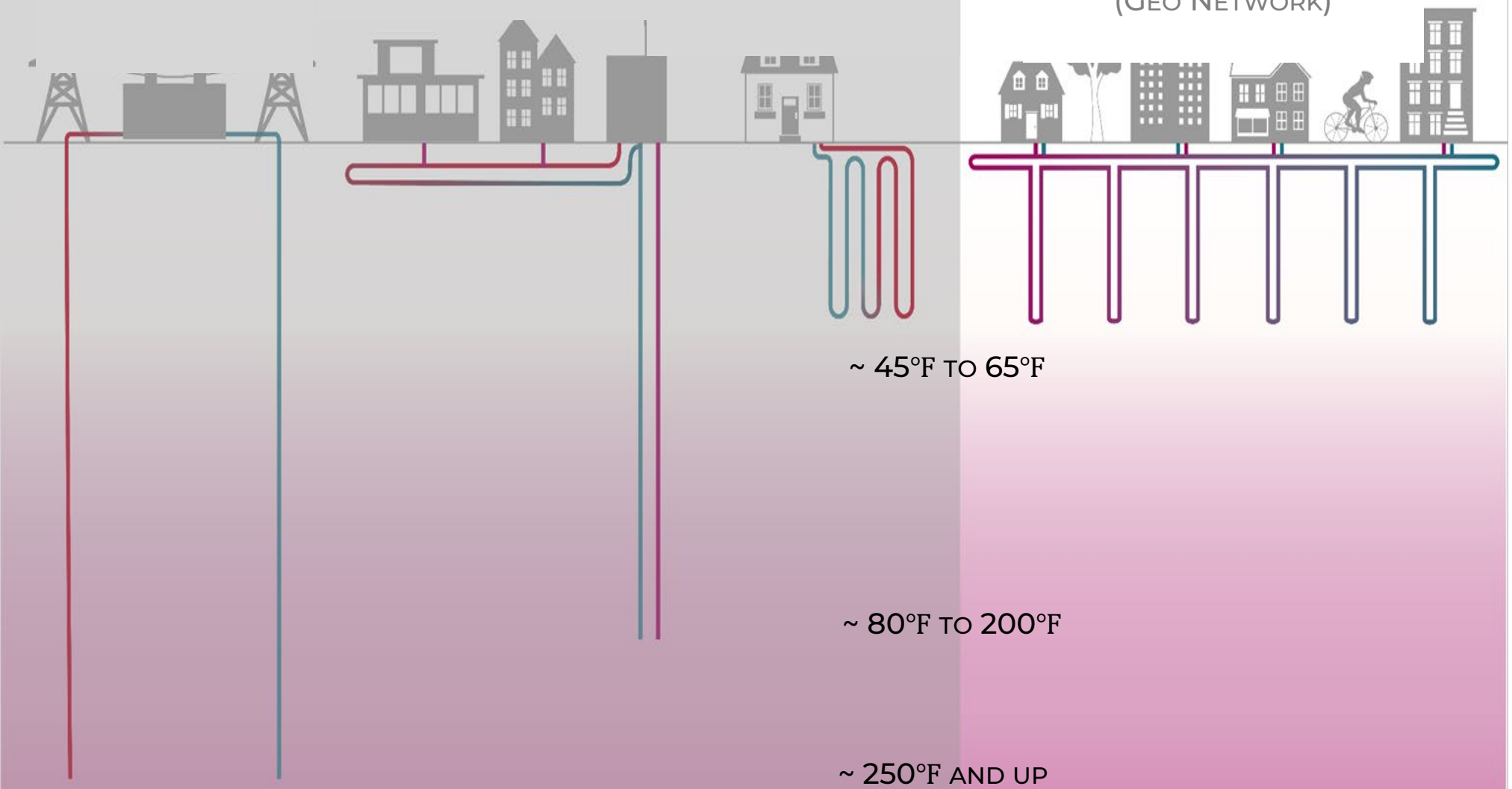
heet

ELECTRICITY
(Geo Power)

DISTRICT HEAT
('Direct Use' Geo)

HEAT & A/C
(Geo Building)

UTILITY-SCALE HEAT & A/C
(Geo Network)



All Geothermal Technologies provide STABLE non-intermittent energy

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BUILDINGS :
(GROUND SOURCE HEAT PUMP)
(AKA GEOTHERMAL HEAT PUMP)

THERMAL ENERGY NETWORK
(AKA AMBIENT TEMP LOOP - ATL)
(AKA THERMAL HIGHWAY)

THERMAL RESOURCES :

- GEOEXCHANGE (BOREHOLES, ETC)
- WASTEWATER EXCHANGE
- INDUSTRIAL WASTE HEAT
- BUILDINGS
- THERMAL ENERGY STORAGE, SOLAR THERMAL, LAKES & THE OCEAN

What's in a Geothermal Energy Network ?

A.k.a. Community Geothermal, Thermal Energy Network, TEN, CTEN, UTEN, 5GHCD, District Geothermal, and GEN!!

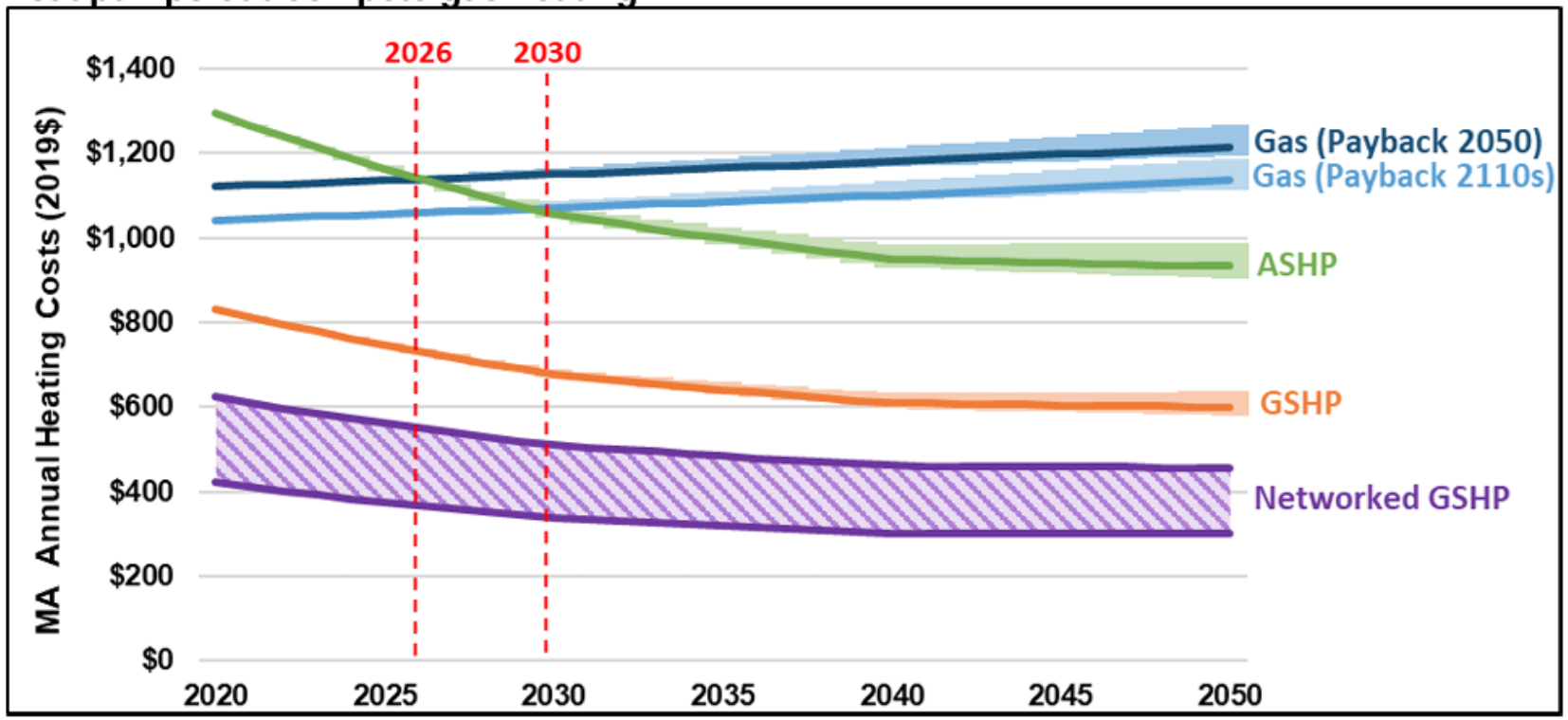
- ☐ High Safety & Security
- ☐ Reliable & Resilient
- ☐ Affordable for consumer
- ☐ Gets us to zero emissions
- ☐ Just workforce transition
- ☐ Equitable access & impact
- ☐ Scalable & Adaptable
- ☐ Economic sense for utility
- ☐ Speed & scale needed

HEET's initial collection of Gas System Decarbonization Requirements

GAS to GEO

heet

Figure ES-1. Inflection points for an average-sized Massachusetts home: When do electric heat pumps out-compete gas heating?



Castigliego, J., Alisalad, S., Stanton & E. (2021). When heating with gas costs more. Applied Economics Clinic. https://aeclinic.org/publicationpages/2021/01/13/inflection-point-when-heating-with-gas-costs-more

MA Energy Bill Projection

Geothermal Heat Pumps are the lowest monthly energy cost today

The cost question we are tackling is the question of the up front infrastructure cost.

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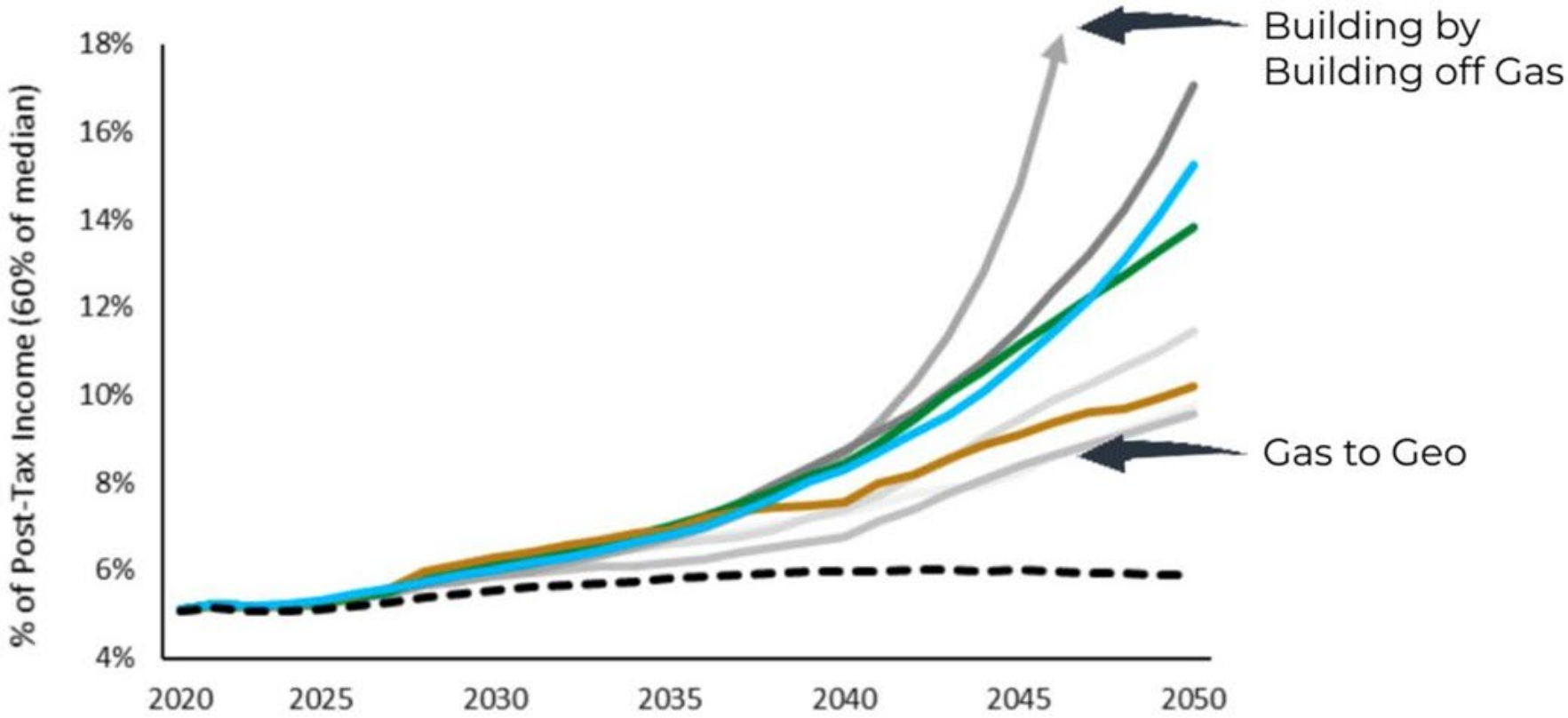
Future Energy Burden for Low-Income Customers



Source: E3, Report for Massachusetts Gas Utilities, 2022

A Gas to Geo pathway can minimize energy burden for the low-income

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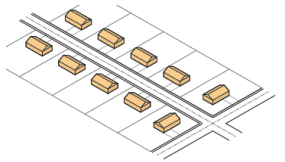
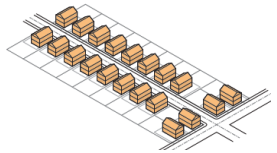
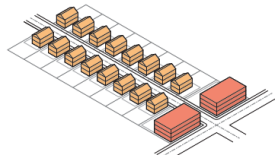
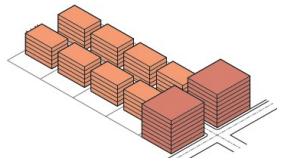
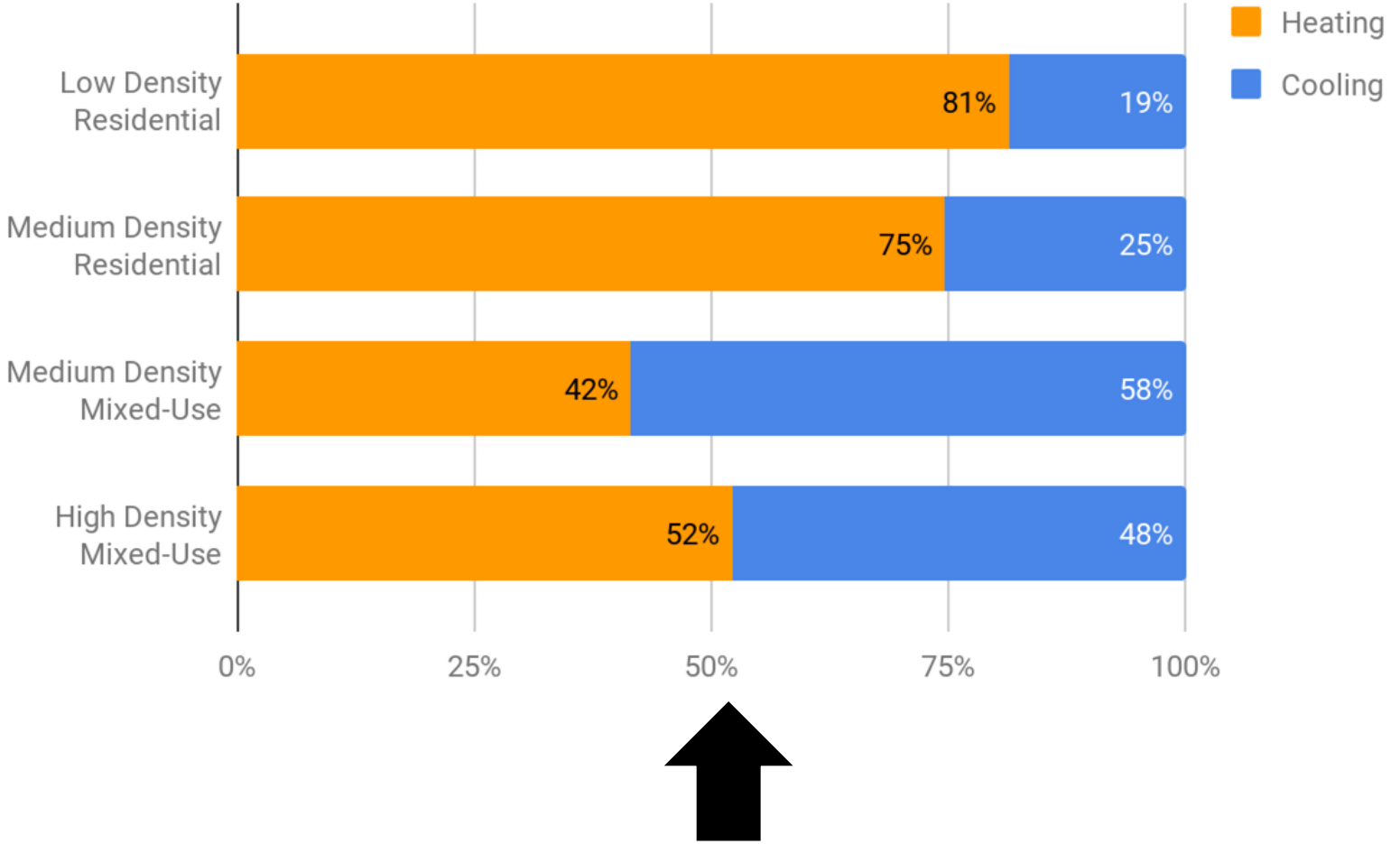
Technical Feasibility: Opportunity in Annual Load Balancing



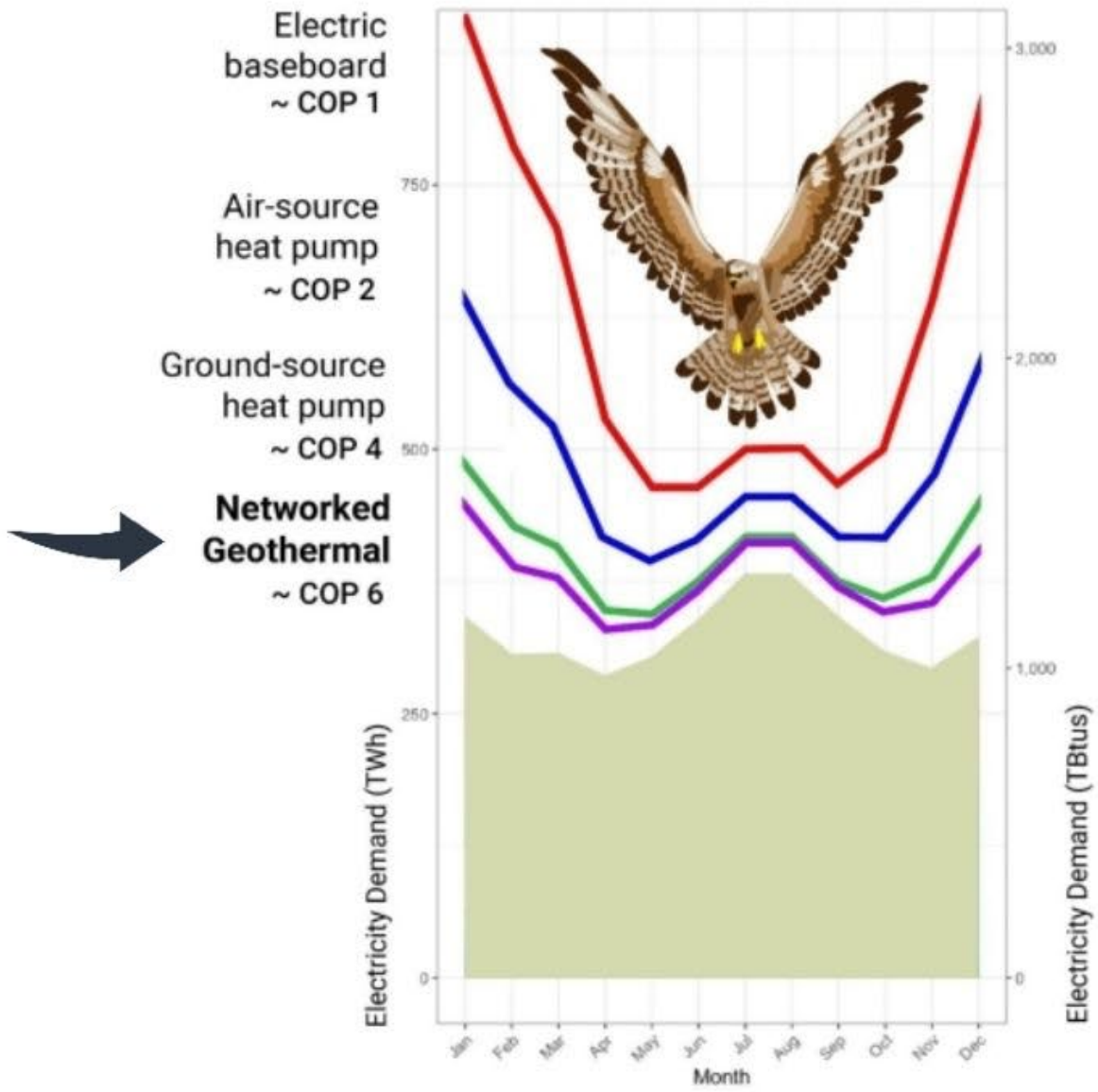








BUROHAPPOLD ENGINEERING heet



Buonocore, J. J., Salimifard, P., Magavi, Z., & Allen, J. G. (2022). Inefficient Building Electrification Will Require Massive Buildout of Renewable Energy and Seasonal Energy Storage. *Scientific Reports*, *12*(1), 11931–11931. https://doi.org/10.1038/s41598-022-15628-2

Networked Geothermal minimizes the GRID IMPACT:

The Falcon Curve Showing future U.S. Building Electric Use

heet

- ~ 10-year payback
- ~ $1M per year energy savings
- ~ 7.9 MMt CO_2 per year reduction
- 100% of heating covered
- Water use cut by 60%
- **Average annual system efficiency of 570%, with a winter peak efficiency of 890%**

Colorado Mesa University 'Living Lab'

Outcomes for Colorado Mesa University installation:

2008 - present

Courtesy of The Grey Edge Group©, Michaels Energy, Xcel Energy, & Colorado Mesa University

Gas System Decarbonization Requirements

- ☑ High Safety & Security
- ☑ 100% Renewable
- ☑ Reliable & Resilient
- ☑ Scalable & Adaptable
- ☑ Just workforce transition
- ☑ Equitable access & impact
- ☑ Affordable for consumer
- ☑ Economic sense for utility
- ☑ Speed & scale needed
- ☑ Electric grid savings

A gas utility and climate advocates in Framingham offer a vision for the future: cleaner, cheaper energy

An unusual partnership could speed decarbonization efforts in Massachusetts

By **Phil McKenna** Inside Climate News, Updated June 4, 2024, 3:22 p.m.

Geothermal pipes were ready for installation in 2023 for Eversource's geothermal networking pilot program in Framingham. JONATHAN WIGGS/GLOBE STAFF

These benefits - meeting core needs of diverse stakeholders - are why networking buildings has created unusual partnerships and alignment.

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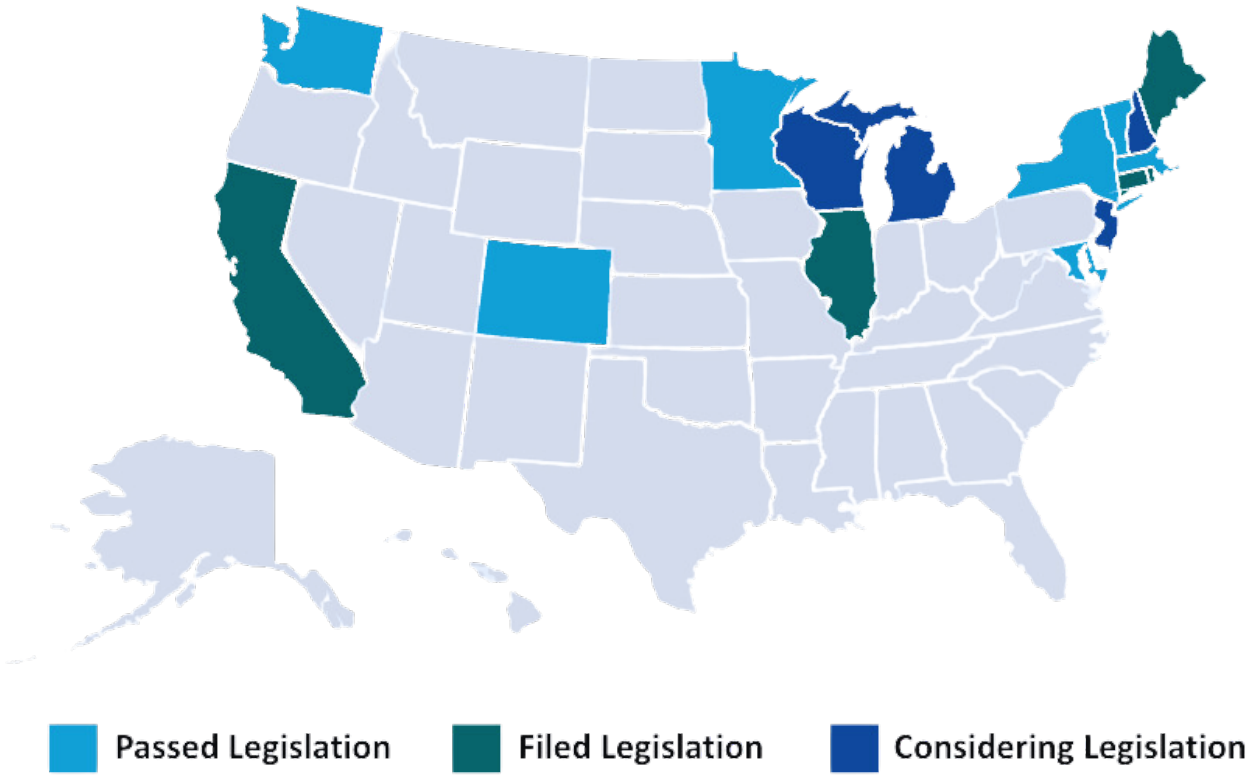

MA: An Act Driving Clean Energy (2021-2022)

MN: Natural Gas Innovation Act (2021) + 7 TENs bills in 2024

NY: Utility Thermal Network & Jobs Act (2022)

CO: Thermal Energy Act (2023)

WA: Promoting the Establishment of Thermal Energy Networks (2024)

MD: WARMTH Act (2024)

VT: Act relating to Thermal Energy Networks (2024)

BUILDING DECARBONIZATION COALITION

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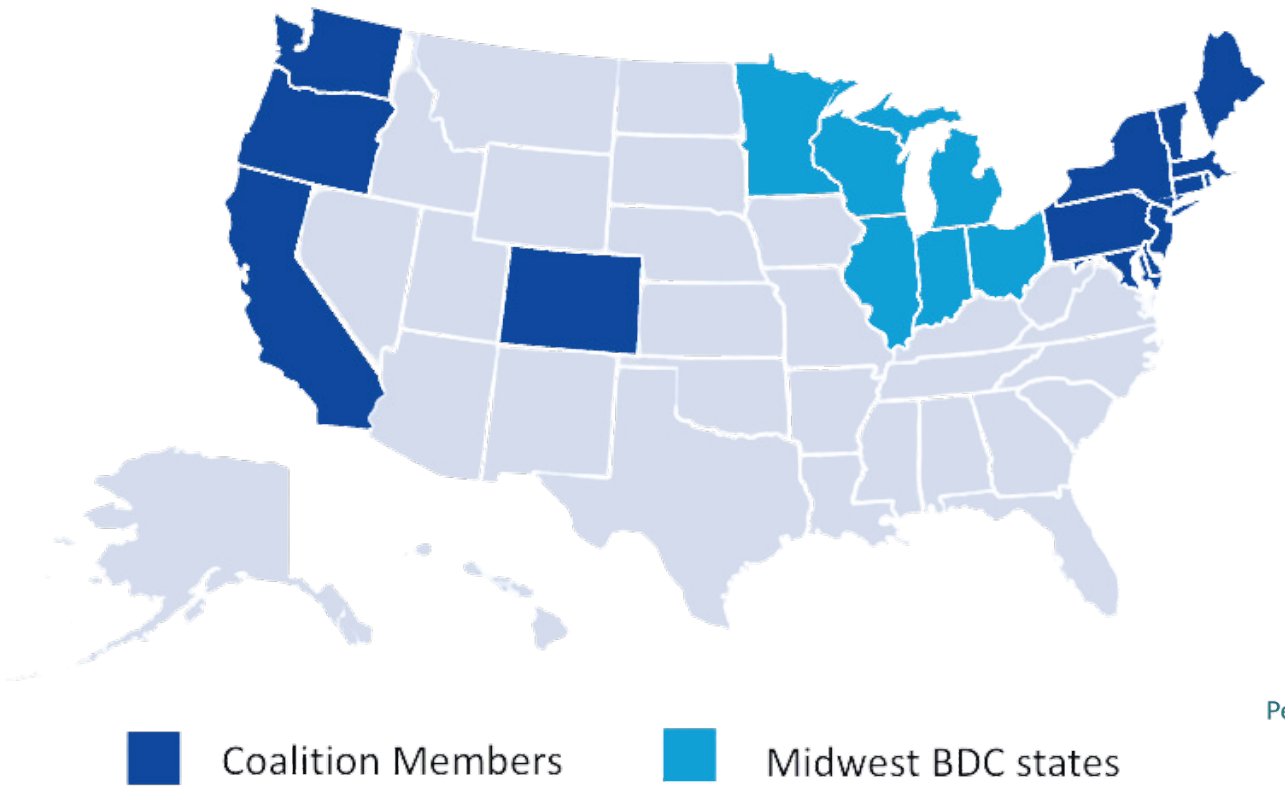
U.S. Geothermal Network Advocacy Coalition



100%

100% Renewable Thermal

Acadia Center

BUILDING DECARBONIZATION COALITION

GAS TRANSITION ALLIES

GEOEXCHANGE®

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INTERFAITH Power & Light
DC.MD.NoVA
Our religious response to climate change.

Midwest Building Decarbonization Coalition

New Jersey Conservation FOUNDATION

PennFuture

POWER

SIERRA CLUB MAINE CHAPTER

Sightline INSTITUTE

slipstream
Accelerating climate solutions. For everyone.

YAMPA VALLEY SUSTAINABILITY COUNCIL

VERMONT COMMUNITY THERMAL NETWORKS

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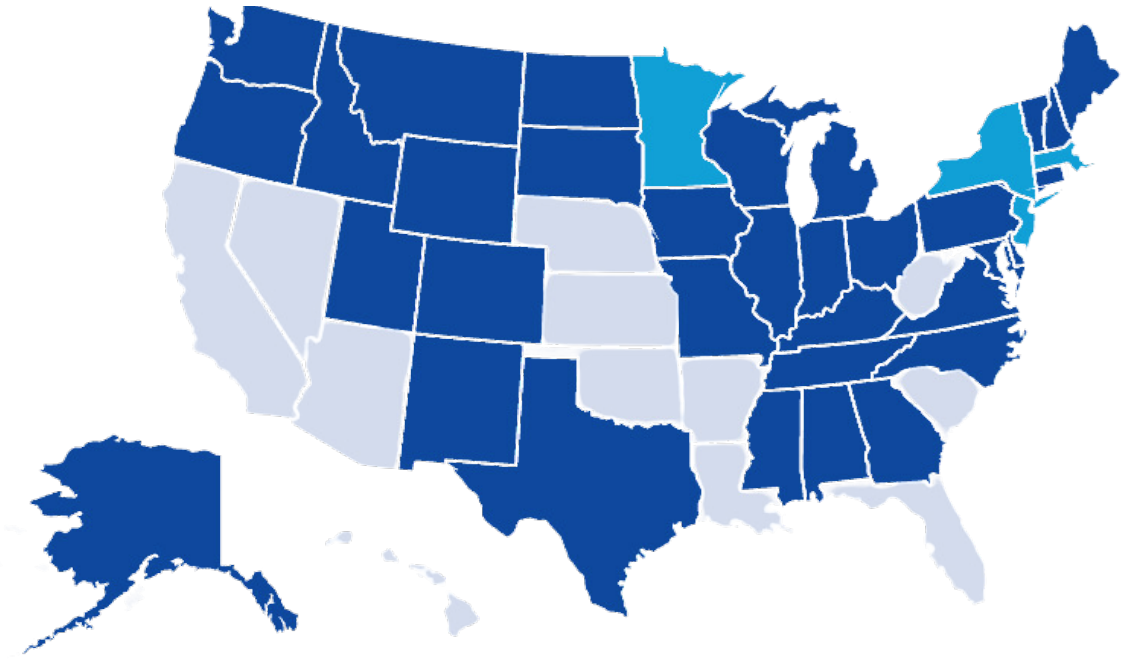
U.S. Gas Utility Engagement in 'UNGC' (Utility Networked Geothermal Coalition)



Gas Utility Pilots Utility NetGeo Collaborative

FORTIS BC
AVANGRID
nationalgrid
National Fuel
spire
Avista
PGW
Xcel Energy
CenterPoint Energy
Southern Company Gas
conEdison
BGE
An Exelon Company
NiSource
Consumers Energy
Count on Us
Liberty
PSE
PUGET SOUND ENERGY
Unitil
Washington Gas
CASCADE NATURAL GAS
NW Natural
New Jersey Natural Gas
CMS ENERGY
Nicor Gas
VGS
EVERSOURCE ENERGY
RICHMOND GAS WORKS
ENBRIDGE

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OPEN database of projects using normalized data to compare & learn

OPEN library of resources and tools including predictive system models for design and evaluation

Scaling & Impact Projections & Potential Studies

LeGUp RESEARCH TEAM:

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

BERKELEY LAB

SOGA RESEARCH GROUP
BERKELEY ENGINEERING

MIT
MANAGEMENT
SLOAN SCHOOL

BURO HAPPOLD

BOSTON UNIVERSITY
SCHOOL of
Public Health

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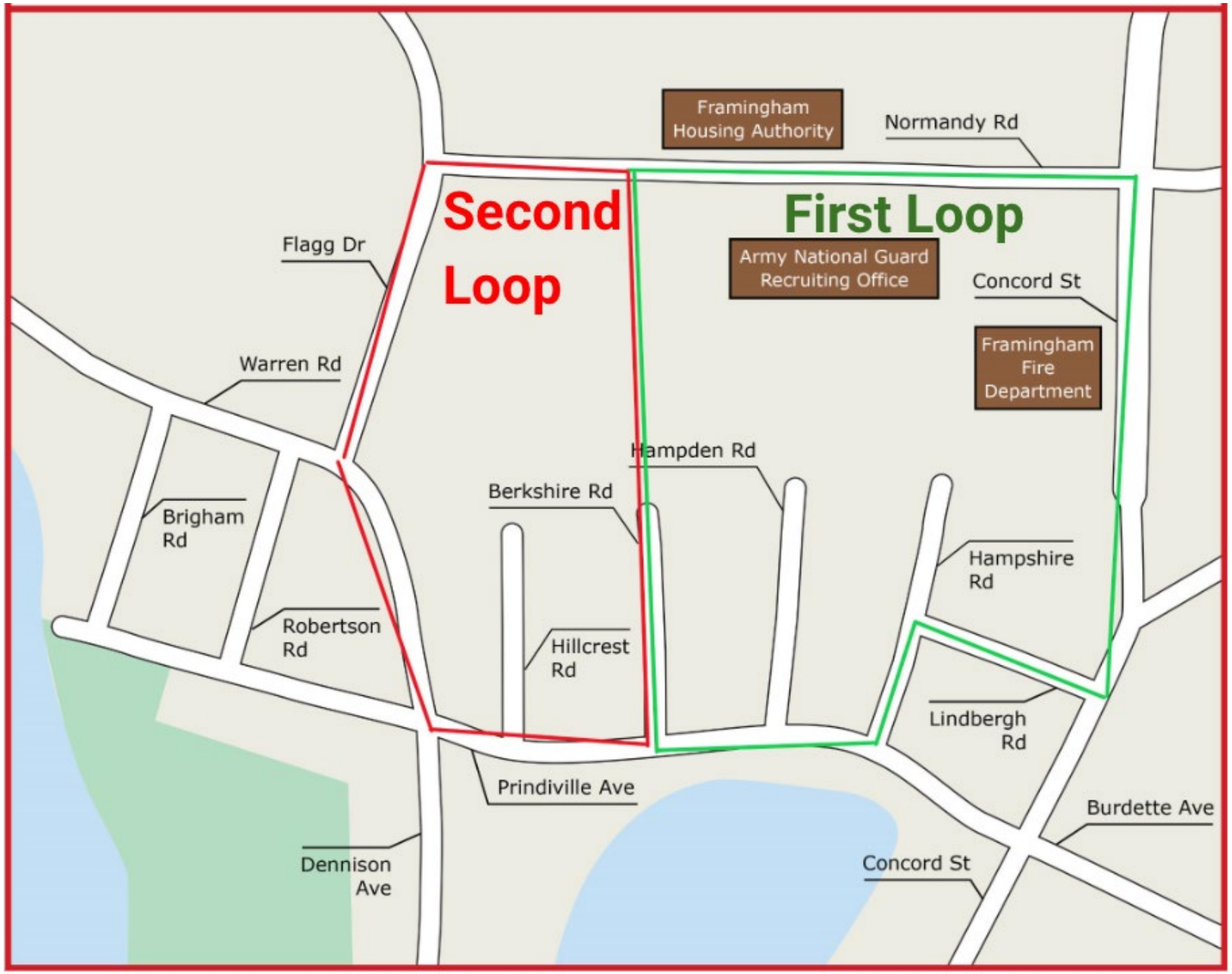


Framingham Second Loop Design:

Moving from Demonstration to Development.

INFO@heet.org

heet

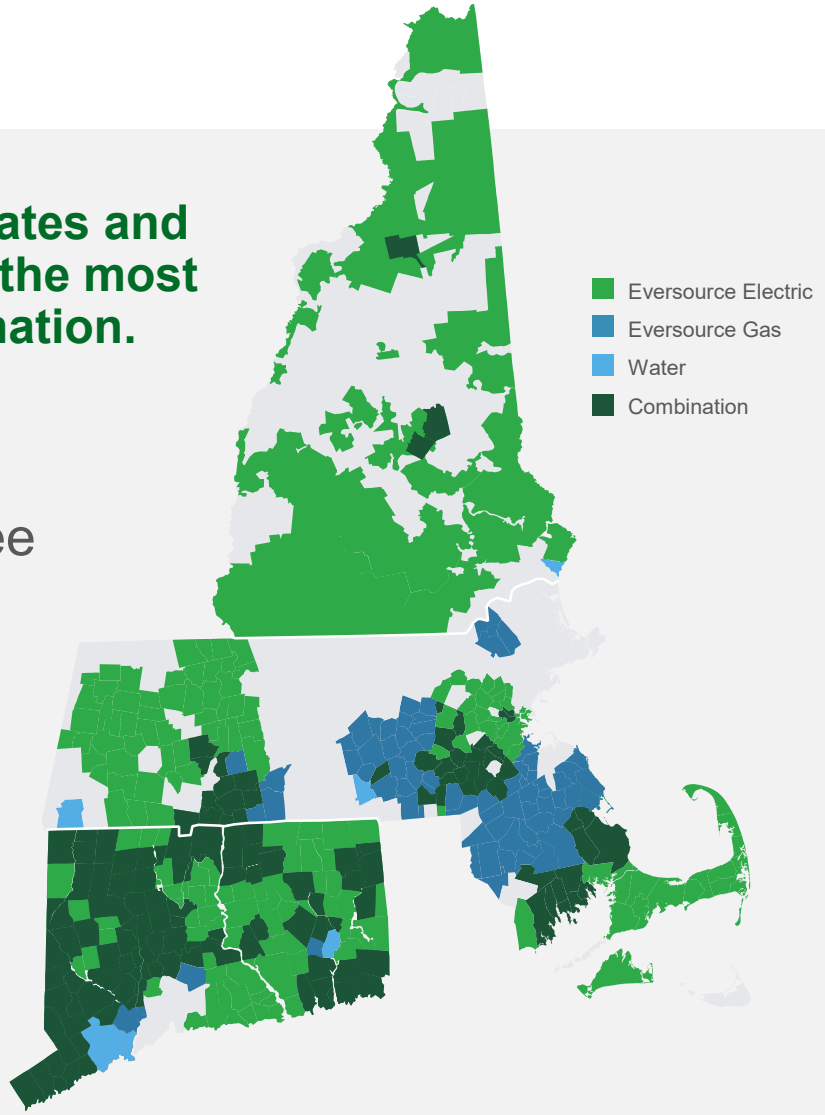
EVERSOURCE

Clean Technologies – Geothermal Pilot

Overview

Eversource operates across three states and has been recognized by Barron's as the most sustainable energy company in the nation.

- Approximately 4.4 million total energy customers across the three states
  (Gas, Electric, and Water)
- Internally set a science based target for net zero
- Working towards broader climate goals in each of the operating states



Project Background

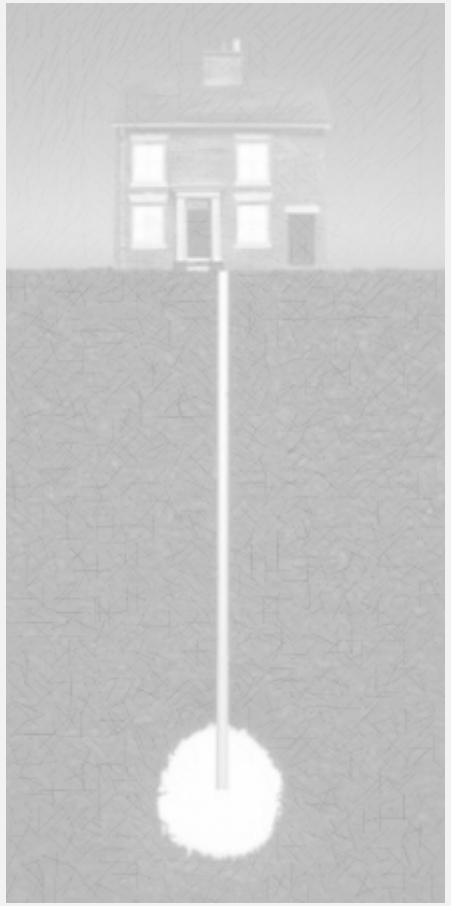
- Initial pilot proposed in a 2020 gas rate case
- Massachusetts regulators approved a mixed use project case with an approximate total load of 300 tons of heating / cooling
- Feasibility and site selection work took place to establish Framingham as host community
- Specific neighborhoods were identified with balanced loads that met the proposal requirements
- Detailed design work was performed to determine loads, pipe routing, and borefield requirements

Geothermal Pilot Project Overview

- Project began in 2021 with site selection. Commissioning and operation targeted for later this year
- One pipe system of approximately 1 mile of main
- 37 buildings with 140 individual customers throughout
- 90 boreholes to provide capacity of approximately 375 tons of peak load

Why the Gas Utility

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

Gas Work Similarities

- HDPE pipe used for installation
- Trenching, fusing, pressure testing, and fittings very similar to gas work
- Mark outs and GIS on the same systems
- Fixed facilities similar to regulator stations and pits in the public ROW
- Instrumentation and SCADA system with the same hardware
- O&M work involves pump maintenance, flushing, and system monitoring

Main and Service Installation

- 100% of main installation complete as of Nov 2023.
- HDPE pipe is being used for the distribution loop
- Installation method similar to water or gas line work in the public right of way
- Installation depth of 5 feet underneath roadways

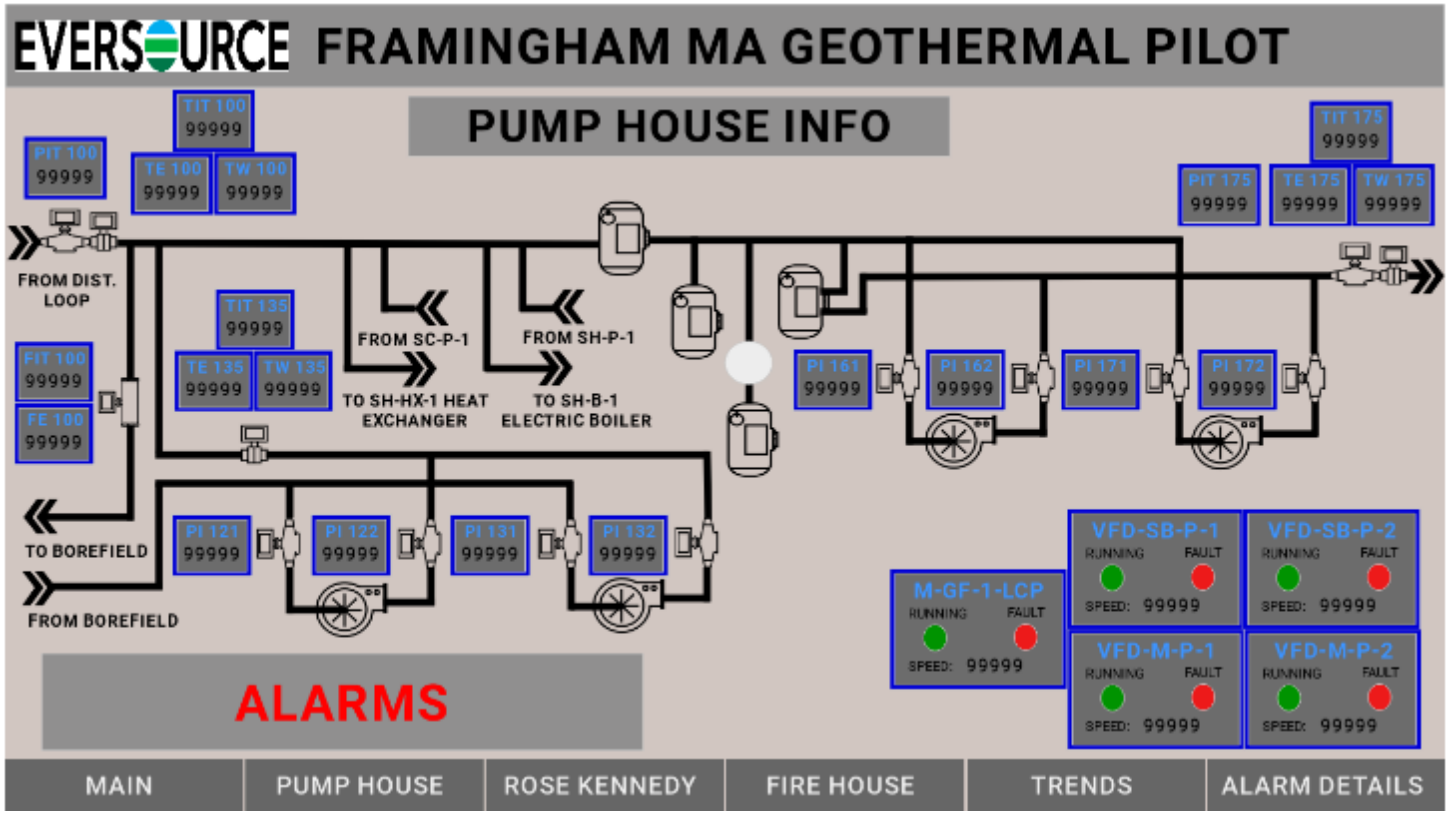
Borehole Drilling

- Drilling completed at all three sites
- Deviated drilling being used at one to keep work zone as small as possible and reduce total number of boreholes.
- Traditional drilling at the 2nd and 3rd site

Building Conversions

- Conversions are a critical portion of converting to geothermal
- Depending on the existing system and building, it can be complex
- Domestic water and appliances can be converted or left on original energy source

Operations and Monitoring



- Pilot run length is planned for 2x heating and 2x cooling seasons
- Backup heat and cooling will be available for the loop (electric boiler and dry cooler)
- Data will be gathered on costs to operate as well as frequency of maintenance events
- Pilot operation will be an opportunity to train internal workforce on unique aspects of geothermal and identify crossover skills

Stakeholder Engagement

- Customer adoption is critical to decarbonization efforts
- Education is an important first step
- Allowing customers to make informed choices
- Community engagement and outreach

Geothermal Value Proposition

Utility

- Provide customers an additional choice/alternative for heating
- Potential 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, quieter and reliable system
- Provides both heating and cooling
- Geothermal customer 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 geothermal

What Does Success Look Like?

Success Factors	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
Environmental Benefits	• Emission reductions • System efficiency
Technology performance	• System performance • Changes in customer energy consumption
Cost savings	• Changes in customer heating and cooling costs

Discussion & Questions