Tactical Thermal Transition

heet
ENERGY FOUNDATION
building a new energy future
Barr Foundation
PUTNAM FOUNDATION
MASSACHUSETTS CLEAN ENERGY CENTER
E4 THE FUTURE
WINSLOW FOUNDATION

Community Activist

Utility Executive

Steelworkers Union Leader

MIT academic

HEET Networked Leadership

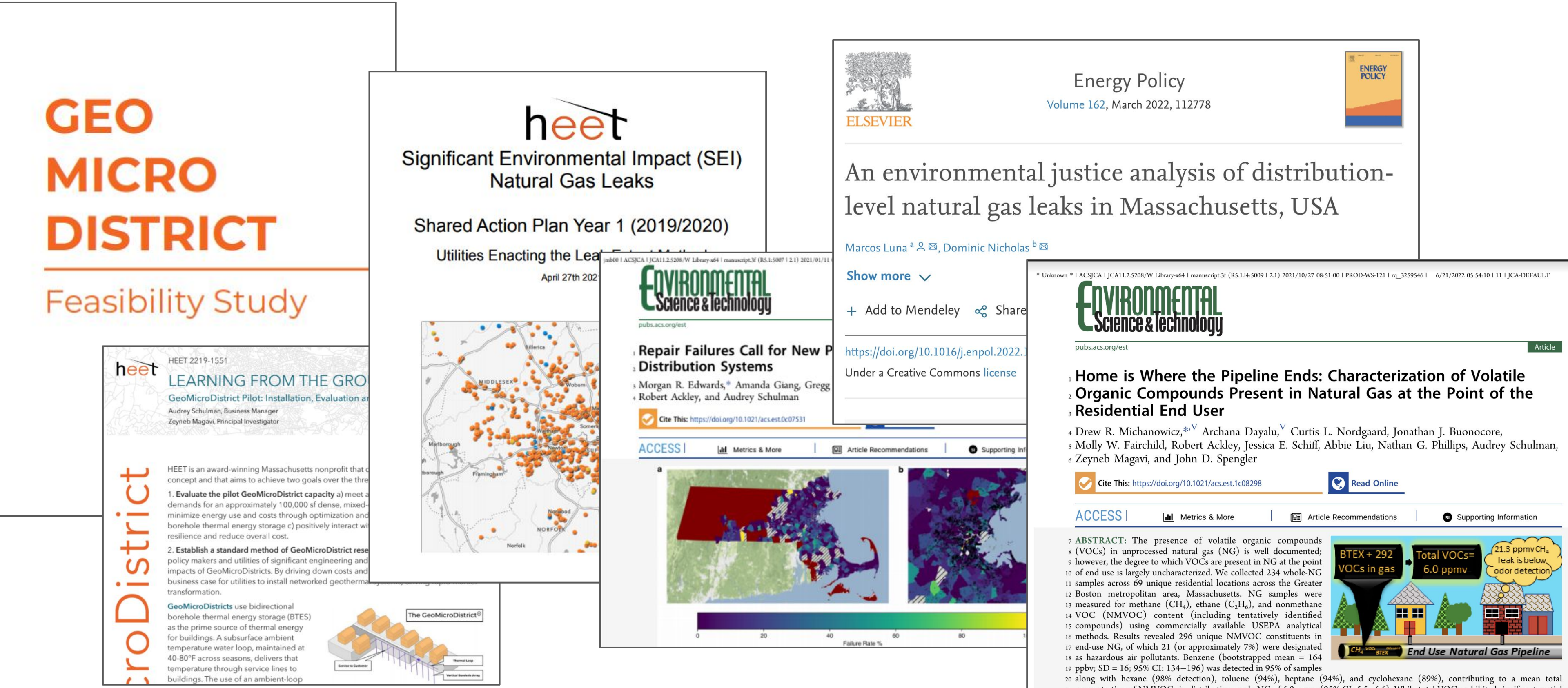
State Regulator

Geothermal Expert

Governor’s Office

“Gas is the Bridge Fuel” originator

Research


GEO
MICRO
DISTRICT
Feasibility Study
heet
HEET 2219-1551
LEARNING FROM THE GRO
GeoMicroDistrict Pilot: Installation, Evaluation ar
Audrey Schulman, Business Manager
Zeyneb Magavi, Principal Investigator
croDistrict
HEET is an award-winning Massachusetts nonprofit that c
concept and that aims to achieve two goals over the thre
1. Evaluate the pilot GeoMicroDistrict capacity a) meet a
demands for an approximately 100,000 sf dense, mixed-
minimize energy use and costs through optimization and
borehole thermal energy storage c) positively interact wi
resilience and reduce overall cost.
2. Establish a standard method of GeoMicroDistrict rese
policy makers and utilities of significant engineering and
impacts of GeoMicroDistricts. By driving down costs and
business case for utilities to install networked geotherma
transformation.
GeoMicroDistricts use bidirectional
borehole thermal energy storage (BTES)
as the prime source of thermal energy
for buildings. A subsurface ambient
temperature water loop, maintained at
40-80°F across seasons, delivers that
temperature through service lines to
buildings. The use of an ambient-loop
The GeoMicroDistrict
heet
Significant Environmental Impact (SEI)
Natural Gas Leaks
Shared Action Plan Year 1 (2019/2020)
Utilities Enacting the Lea
April 27th 202
Environmental Science & Technology
pubs.acs.org/est
Repair Failures Call for New P
Distribution Systems
Morgan R. Edwards,* Amanda Giang, Gregg
Robert Ackley, and Audrey Schulman
Cite This: https://doi.org/10.1021/acs.est.0c07531
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ELSEVIER
Energy Policy
Volume 162, March 2022, 112778
ENERGY POLICY
An environmental justice analysis of distribution-level natural gas leaks in Massachusetts, USA
Marcos Luna [a], Dominic Nicholas [b]
Show more
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https://doi.org/10.1016/j.enpol.2022.1
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Environmental Science & Technology
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Article
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/acs.est.1c08298
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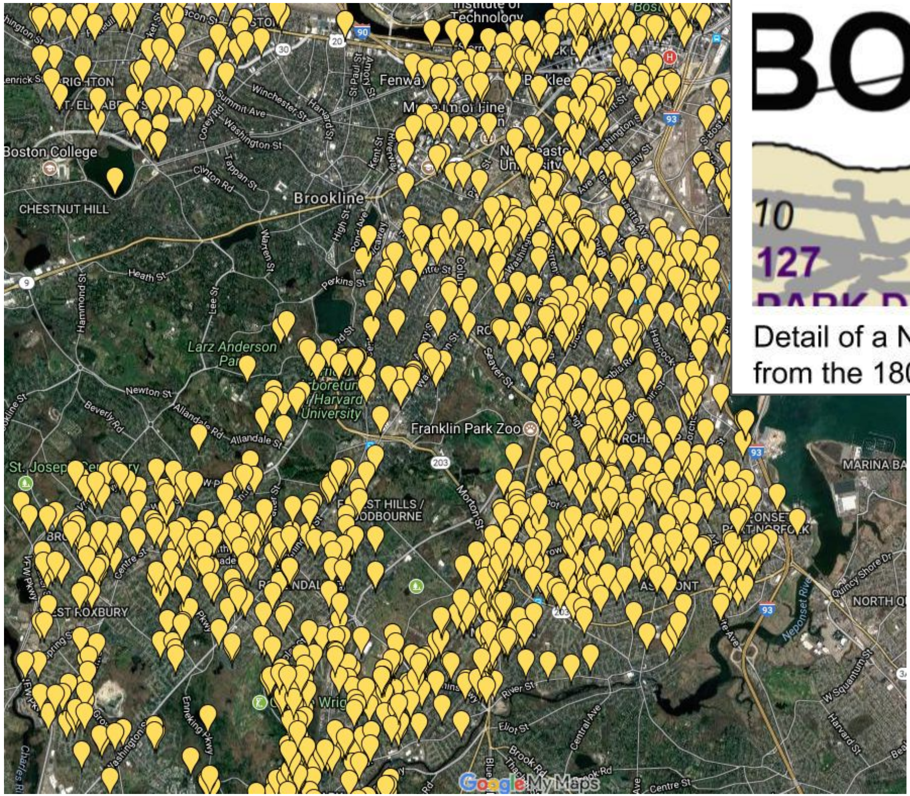
ABSTRACT: The presence of volatile organic compounds (VOCs) in unprocessed natural gas (NG) is well documented; however, the degree to which VOCs are present in NG at the point of end use is largely uncharacterized. We collected 234 whole-NG samples across 69 unique residential locations across the Greater Boston metropolitan area, Massachusetts. NG samples were measured for methane (CH4), ethane (C2H6), and nonmethane VOC (NMVOC) content (including tentatively identified compounds) using commercially available USEPA analytical methods. Results revealed 296 unique NMVOC constituents in end-use NG, of which 21 (or approximately 7%) were designated as hazardous air pollutants. Benzene (bootstrapped mean = 164 ppbv; SD = 16; 95% CI: 134−196) was detected in 95% of samples along with hexane (98% detection), toluene (94%), heptane (94%), and cyclohexane (89%), contributing to a mean total
BTEX + 292 VOCs in gas
Total VOCs= 6.0 ppmv
21.3 ppmv CH4 leak is below odor detection
End Use Natural Gas Pipeline

What We Like to Do

MA Gas System

MA Gas Leaks



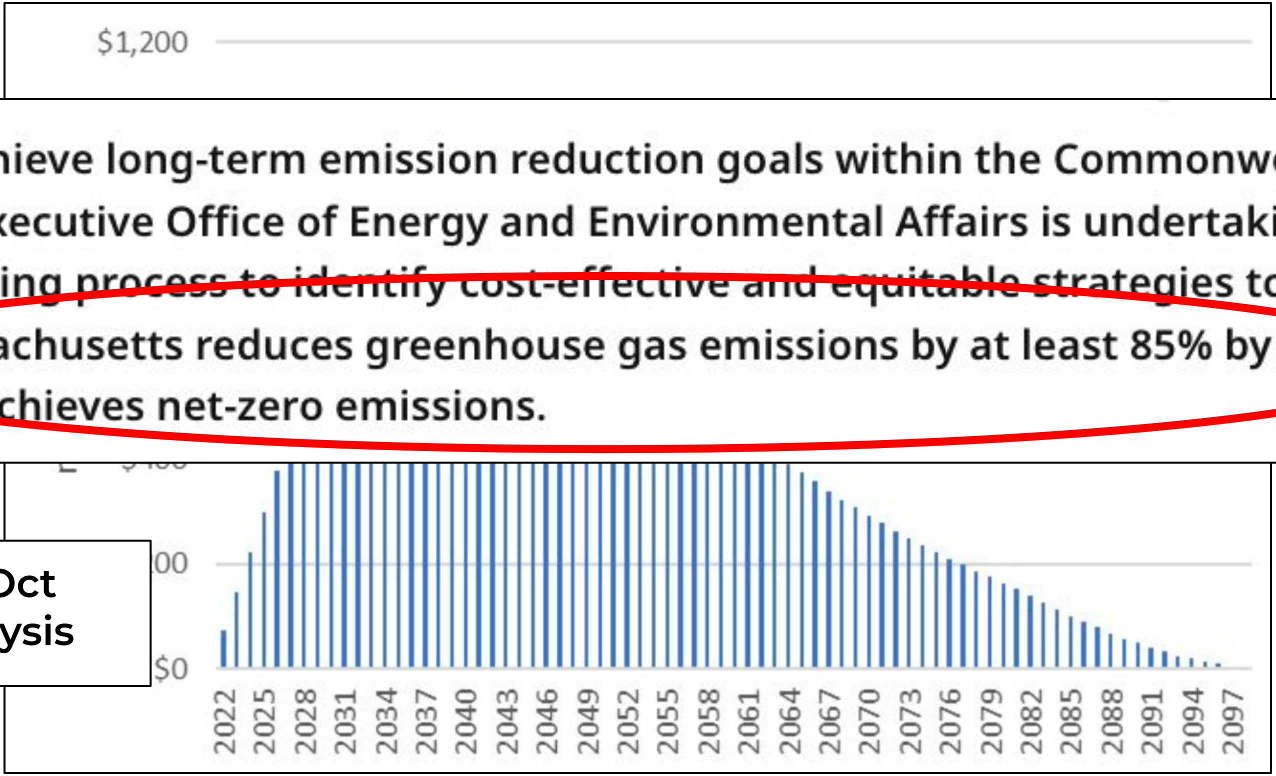
Utility reported gas leaks in Boston. https://heet.org

Detail of a National Grid gas infrastructure map of Back Bay showing two pipes from the 1800s still in use running down Beacon St and Comm. Ave.

Two Summers Ago..

heet

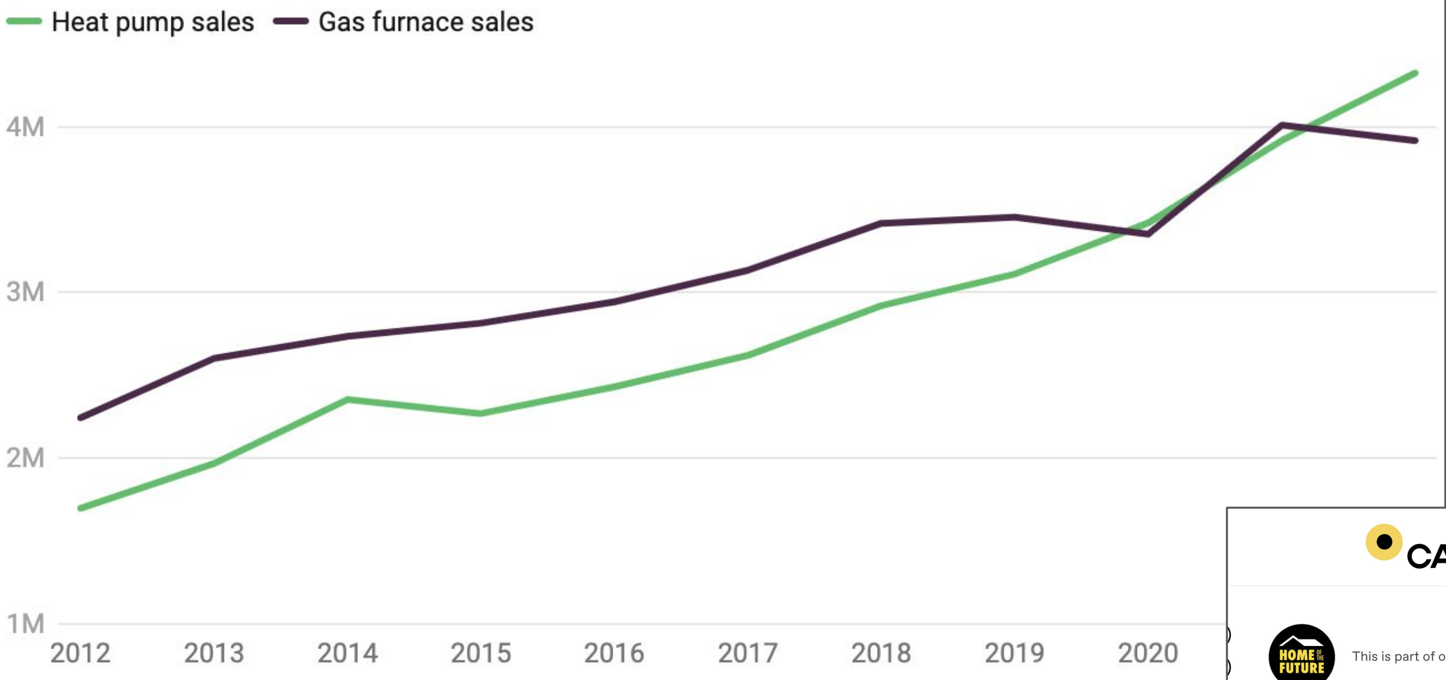
Stranded Assets



To achieve long-term emission reduction goals within the Commonwealth, the Executive Office of Energy and Environmental Affairs is undertaking a planning process to identify cost-effective and equitable strategies to ensure Massachusetts reduces greenhouse gas emissions by at least 85% by 2050 and achieves net-zero emissions.

Dorie Seavey's Oct 2023 GSEP Analysis

Heat pump sales in U.S. surged past gas furnaces in 2022



2022 figures include sales data for Jan–Nov and projected sales for Dec.

Chart: Canary Media • Source: Air-Conditioning, Heating, and Refrigeration Institute • Embed • Download image

CANARY MEDIA

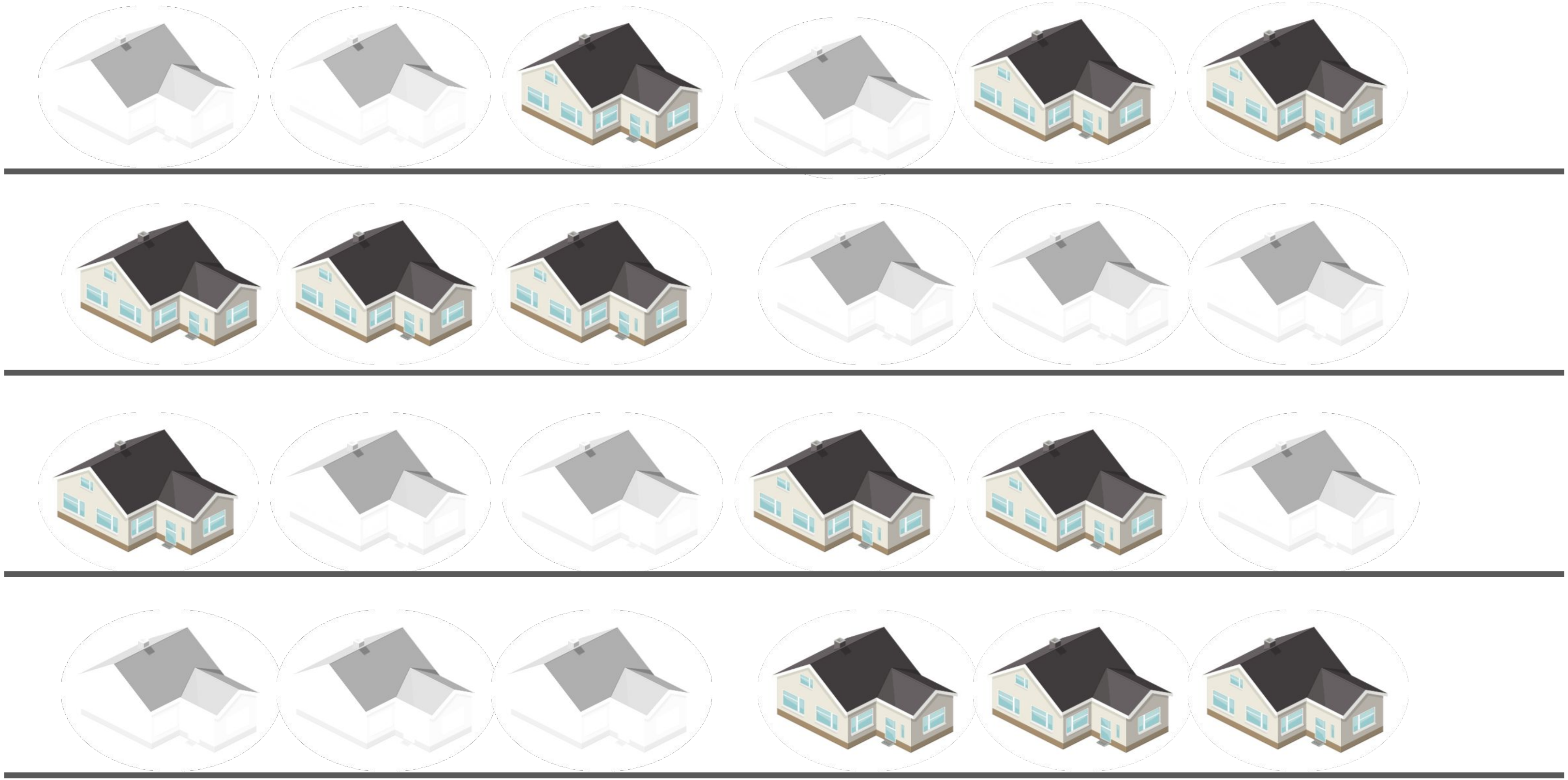
HOME OF THE FUTURE

This is part of our special series "Home of the Future." Read more.

Chart: Americans bought more heat pumps than gas furnaces last year

Even before Inflation Reduction Act incentives kicked in, Americans bought more heat pumps than ever before last year — well over 4 million.

The Way We Are Headed



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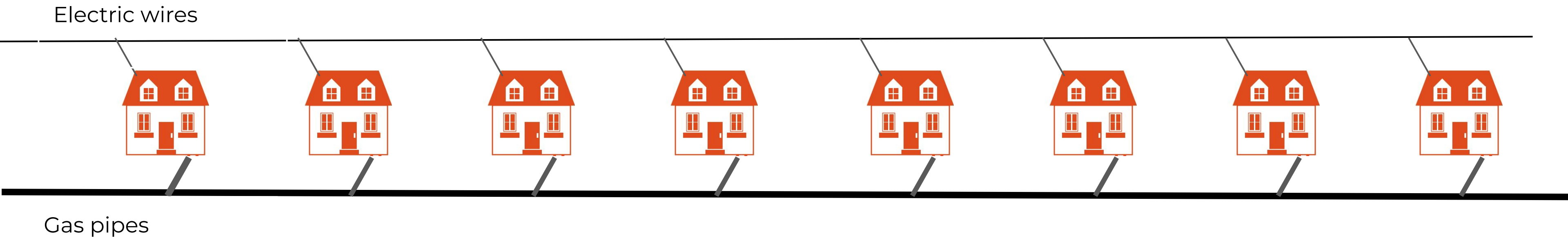
Decarbonization:
Impacts on Electric System

MA Current System

- Gas system at peak can contain 4x energy of electric system



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Proposed Plan

- Move off of gas for all but “hard to decarbonize”

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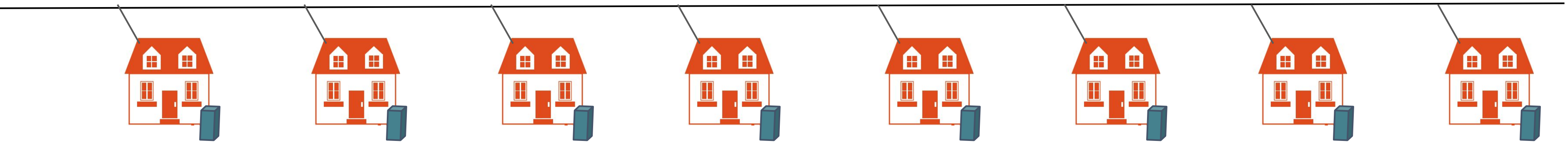
Proposed Plan

- Move off of gas for all but “hard to decarbonize”
- Electric HVAC



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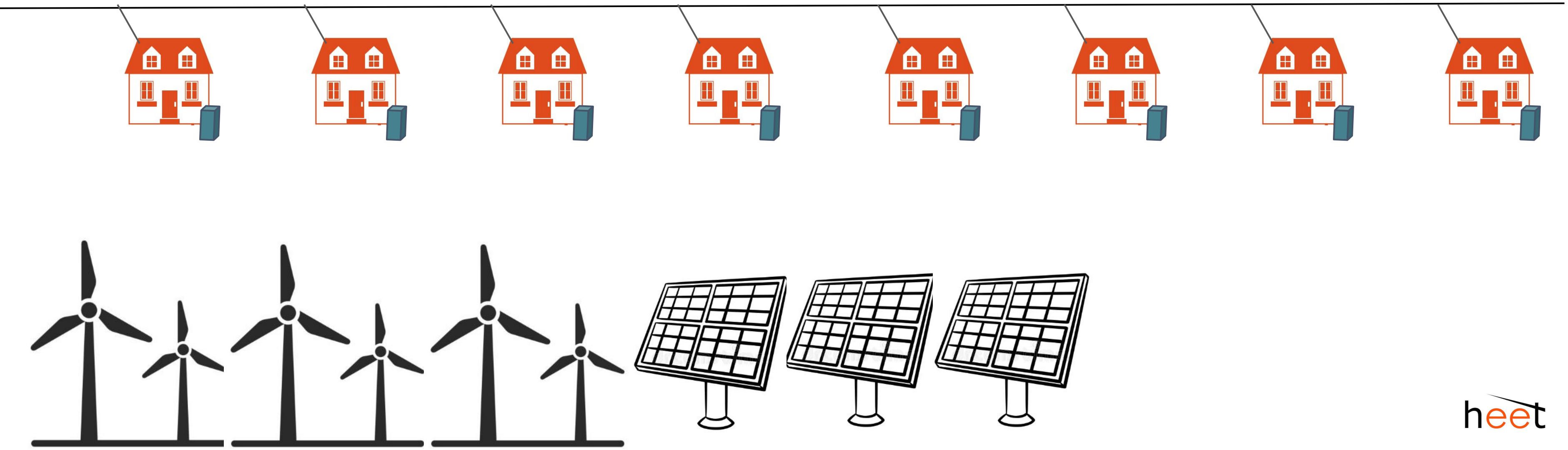
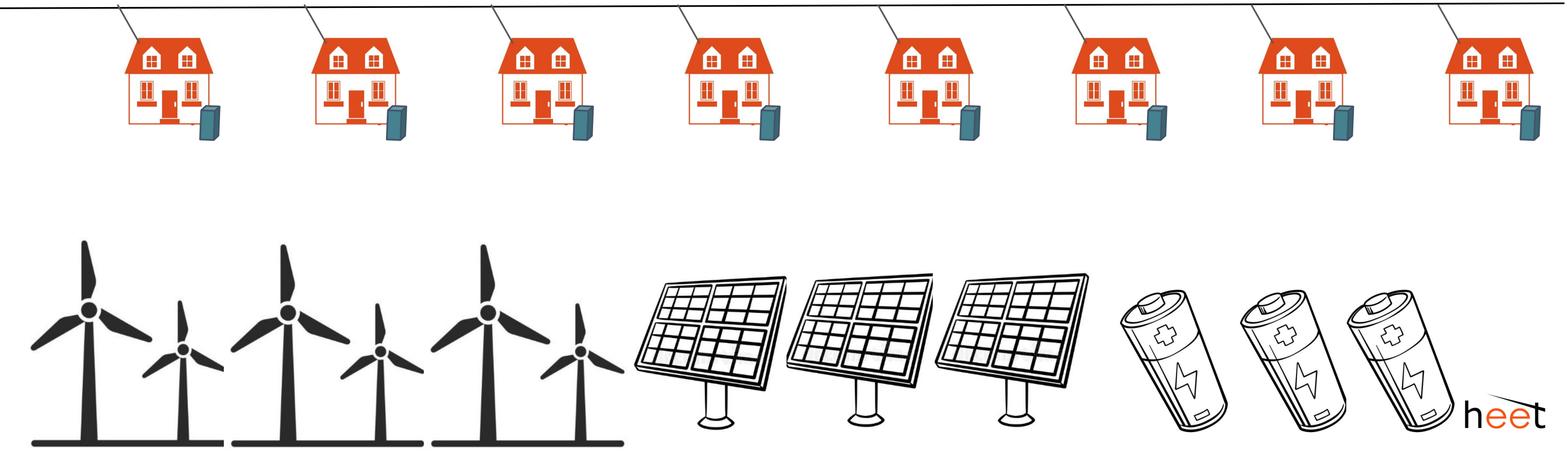
Proposed Plan

- Move off of gas for all but “hard to decarbonize”
- Electric HVAC
- 100% renewable energy



Proposed Plan

- Move off of gas for all but “hard to decarbonize”
- Electric HVAC
- 100% renewable energy
- Storage



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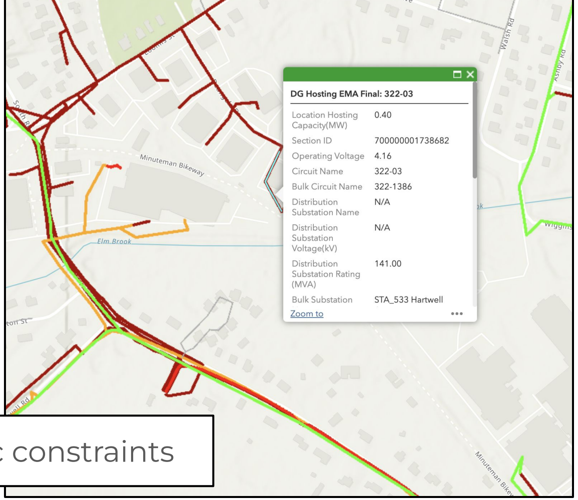
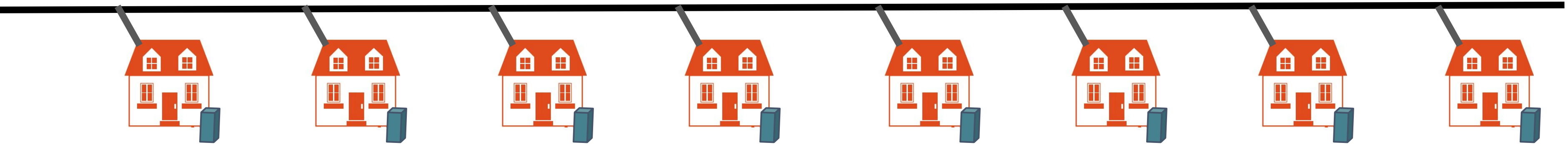
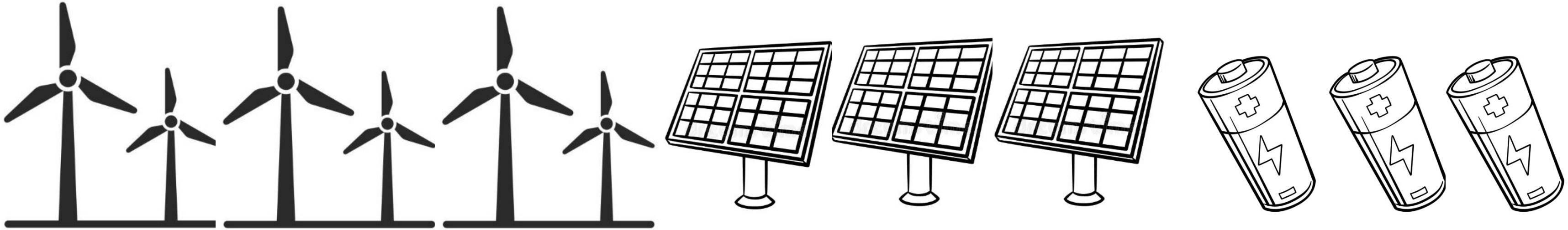
Proposed Plan

- Move off of gas for all but “hard to decarbonize”
- Electric HVAC
- 100% renewable energy
- Storage
- Local electric grid upgrades



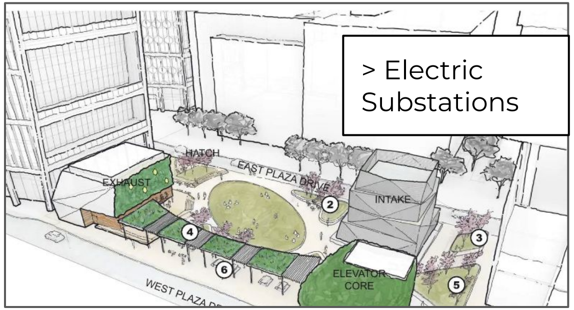
Local electric constraints

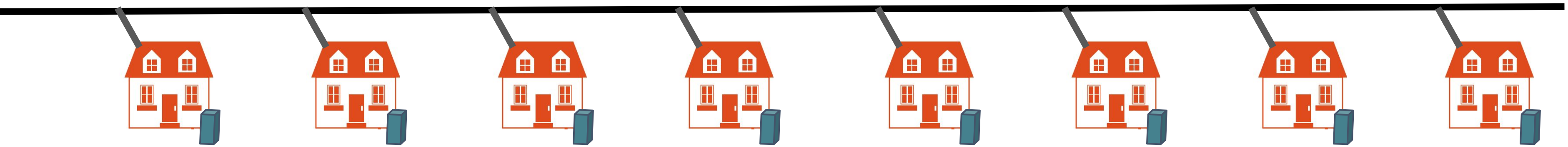


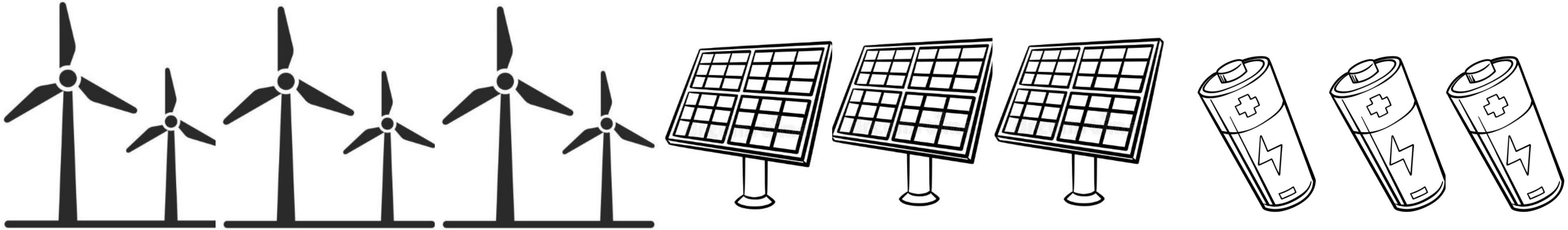


Proposed Plan

- Move off of gas for all but “hard to decarbonize”
- Electric HVAC
- 100% renewable energy
- Storage
- Local electric grid upgrades
- Substations







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Proposed Plan

- Move off of gas for all but “hard to decarbonize”
- Electric HVAC
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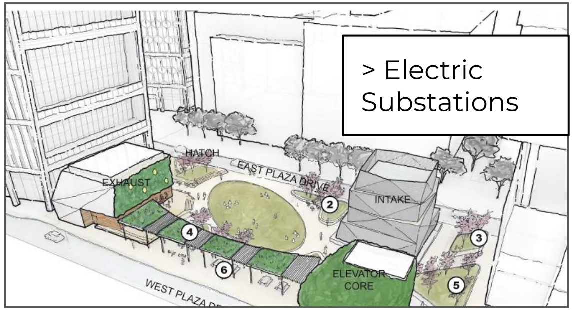

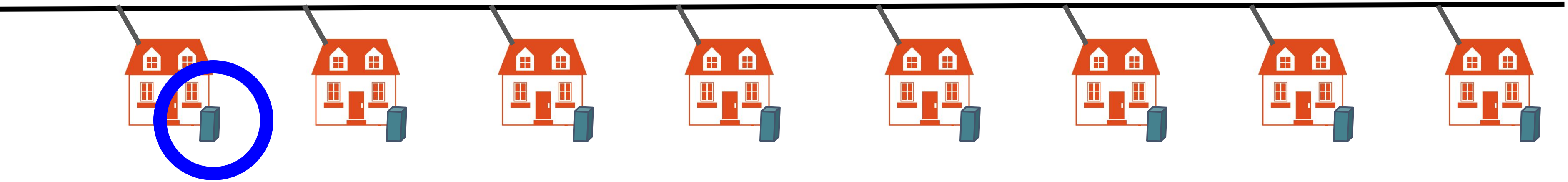

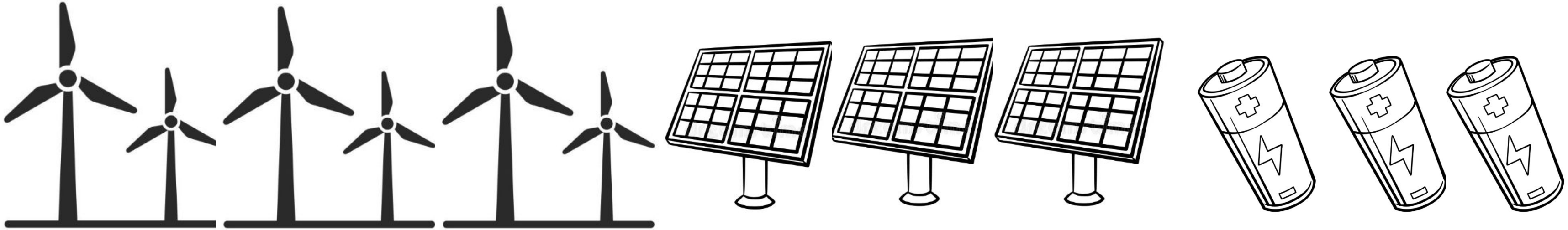

Prevailing Assumption

- Air source heat pump

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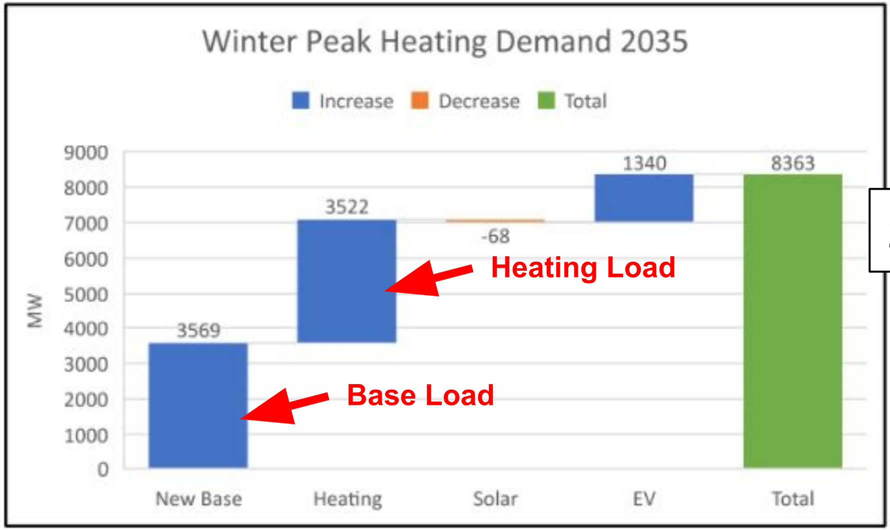
Winter Electric Peak (assuming most HVAC is air source heat pumps)

2050 Winter Peak Demand > 2X Current Summer Peak

National Grid ESMP Report, 2023

heet

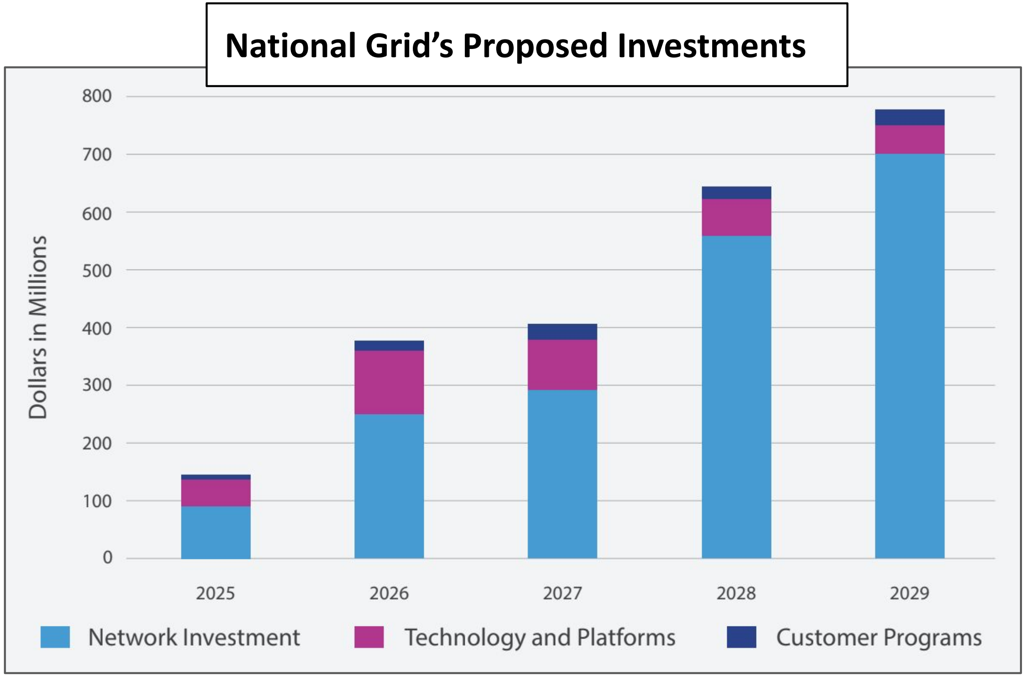
Driven by Heating



Eversource ESMP Report, 2023

2035 Winter Peak Electric Load

Will Cost a Lot



National Grid ESMP Report, 2023

Impacts of Each HVAC Method (MA)

Air source heat pump (4 ton)

- ~5 kW increase in electric peak*
- Max 300,000 homes with current electric grid

* According to Harvey Michaels, MIT Sloan

heet

Impacts of Each HVAC Method (MA)

Ground source heat pump

- 2.5 kW increase in electric peak *
- Max 600,000 homes with current electric grid

* According to Harvey Michaels, MIT Sloan

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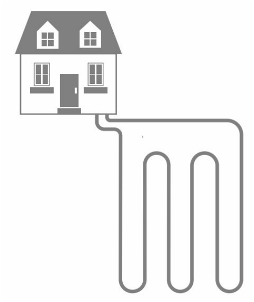
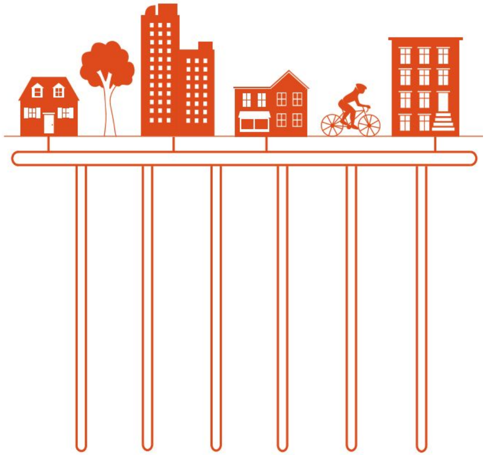
Impacts of Each HVAC Method (MA)

Networked Geothermal (per home)

- ~1.2 kW increase in electric peak*
- ~750,000 homes with current electric grid*





* My rough assumption given Harvey's calculations

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Networked Geothermal

Networked Geothermal

- Infrastructure in the street
- “Shallow” boreholes
- Ambient temperature
- Single pipe

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The Most Efficient Heating System

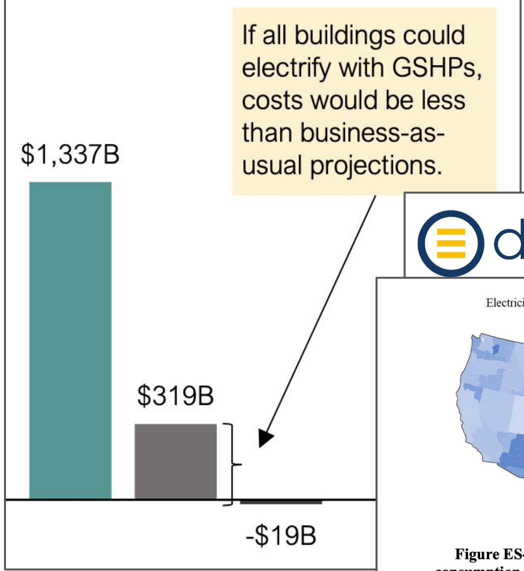


Table 1 CMU networked geothermal efficiency vs a standard system

	Networked Geo COP	Conventional COP
Spring	7.0	1.9
Summer	3.6	3.4
Fall	5.8	2.0
Winter	8.9	1.2
[illegible]	5.7	1.9

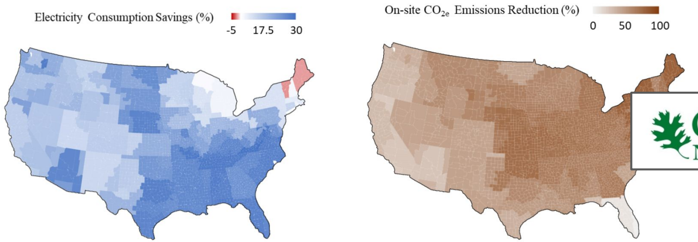
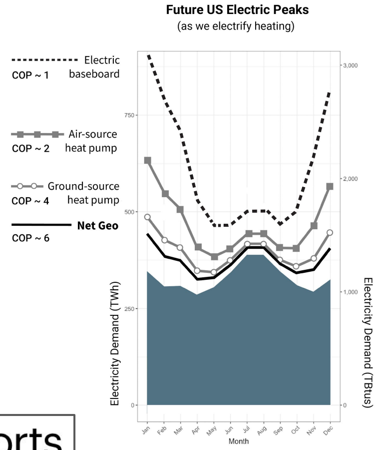


Figure ES-1. Geospatial representation of the percentage changes in (left) building annual electricity consumption and (right) carbon emissions (from on-site combustion in buildings) resulting from deploying GHPs into 68% of existing and new residential and commercial buildings in the United States, coupled with weatherization in single-family homes.

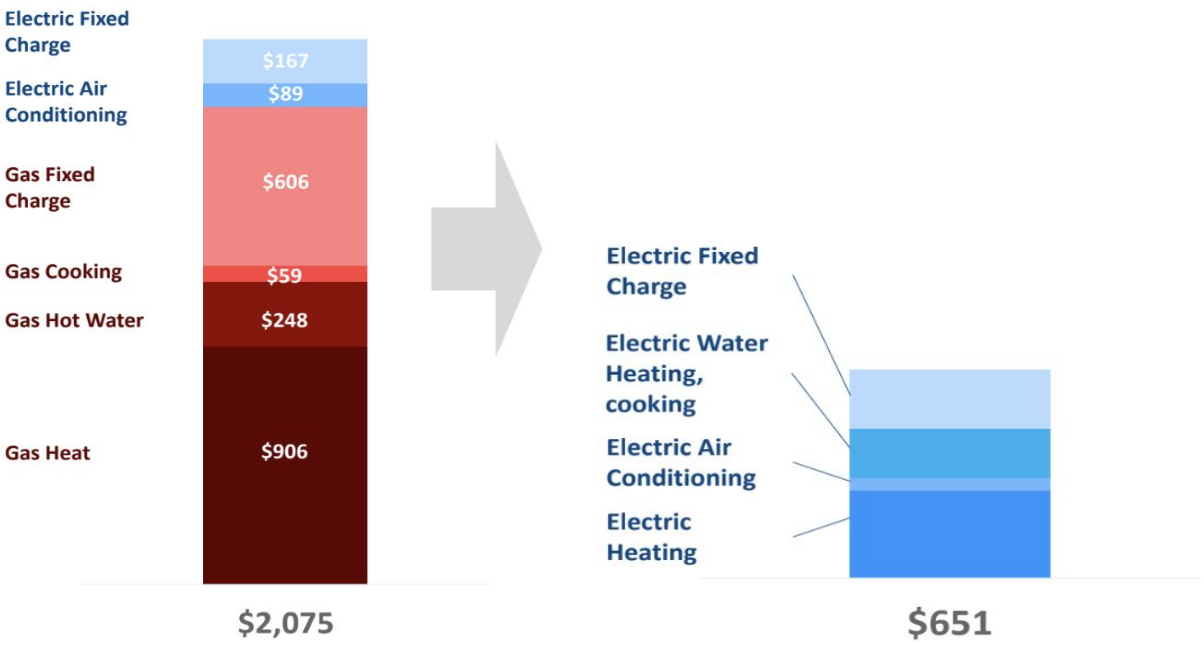


Buonocore, J.,Salimifard, P., Magavi, Z., Allen, J., ""The Falcon Curve: Implications of Seasonal Building Energy Use and Seasonal Energy Storage for Healthy Decarbonization" DOI:10.21203/rs.3.rs-1054606/v1

Networked geothermal systems reduce electric peak demands compared to pathways with larger reliance on ASHPs because these technologies are not sensitive to outside temperature.

- 20-80 Independent Consultant Report

Lower Energy Bill



Sustainable Chicago analysis, multi-unit apartment

Allows Gas Workers to Transition

Gas Pipes

Water Pipes

heet

MA Networked Geothermal - Gas Utility Installs

Eversource - Framingham

- 140 units, including residential & commercial buildings
- Turned on by spring

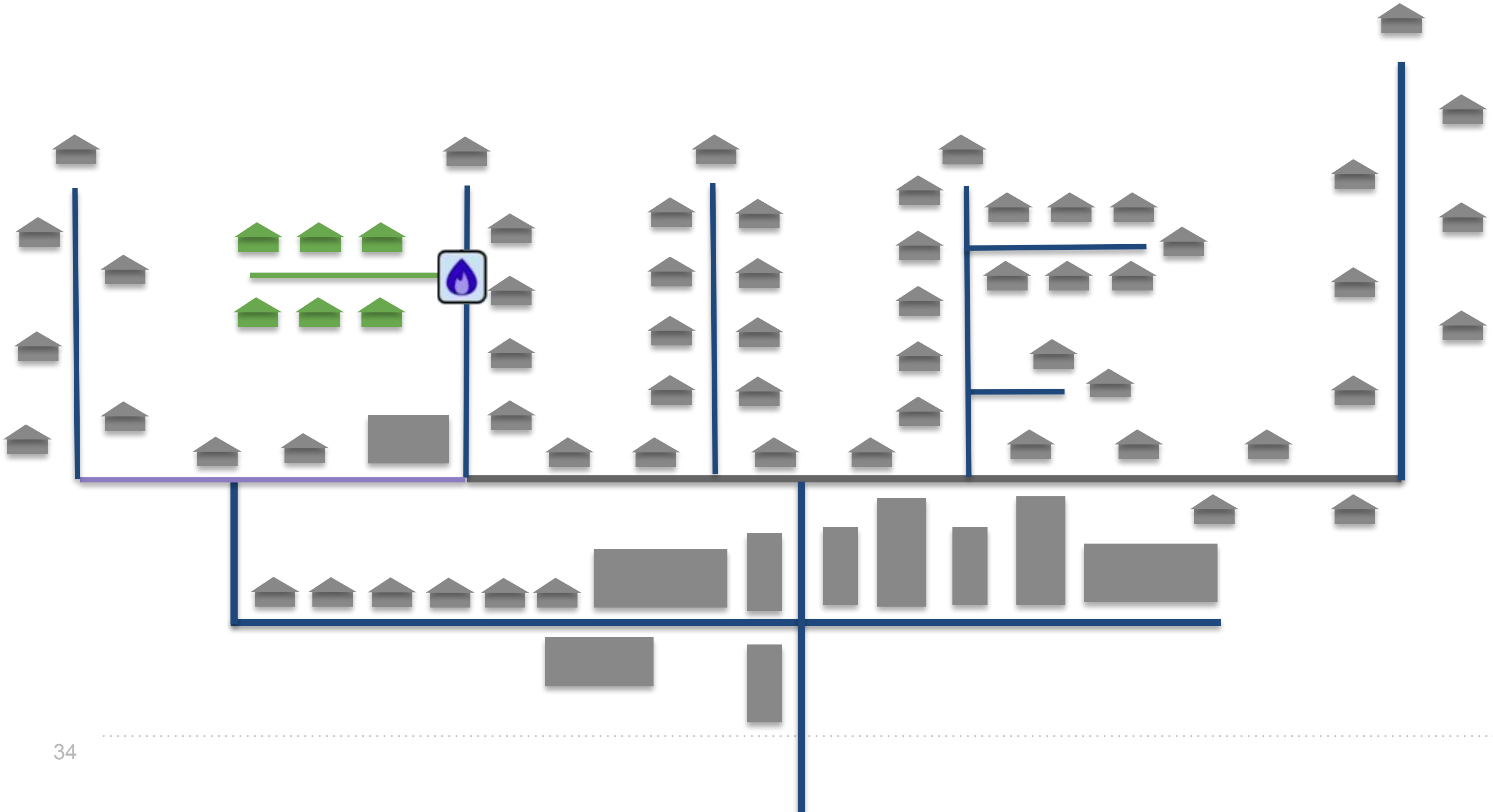
National Grid - Lowell & Dorchester

- @ 160 units total
- Full electrification

HEET Research Team

MIT
the GreyEdge group
MASSCEC
SOGA RESEARCH GROUP
BERKELEY ENGINEERING
EMERGENT URBAN CONCEPTS
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
nationalgrid
FRONTIER ENERGY LTD
OAK RIDGE National Laboratory
EVERSOURCE
MassDEP
Commonwealth of Massachusetts Department of Environmental Protection
BURO HAPPOLD
BOSTON UNIVERSITY SCHOOL of Public Health
BERKELEY LAB
Salem STATE UNIVERSITY
Energy Solutions
SALASO'BRIEN

Grafting Networked Geothermal onto the Gas System



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Grafting Networked Geothermal onto the Gas System

Tactical Thermal Transition

(The mapping part)

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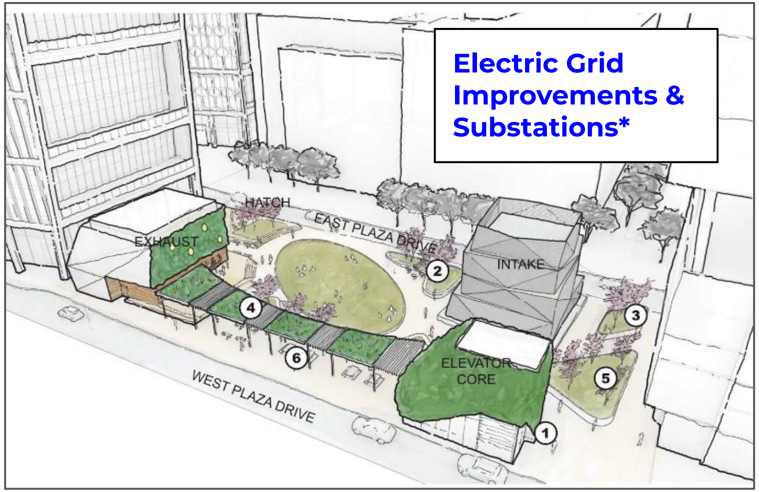
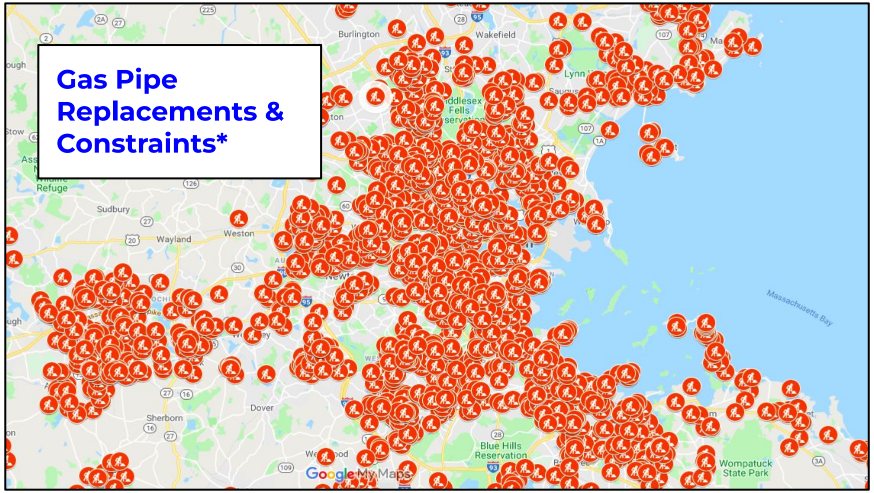
Use Networked Geothermal When Possible

- To minimize unnecessary costs (avoided costs pay for customer retrofits?)



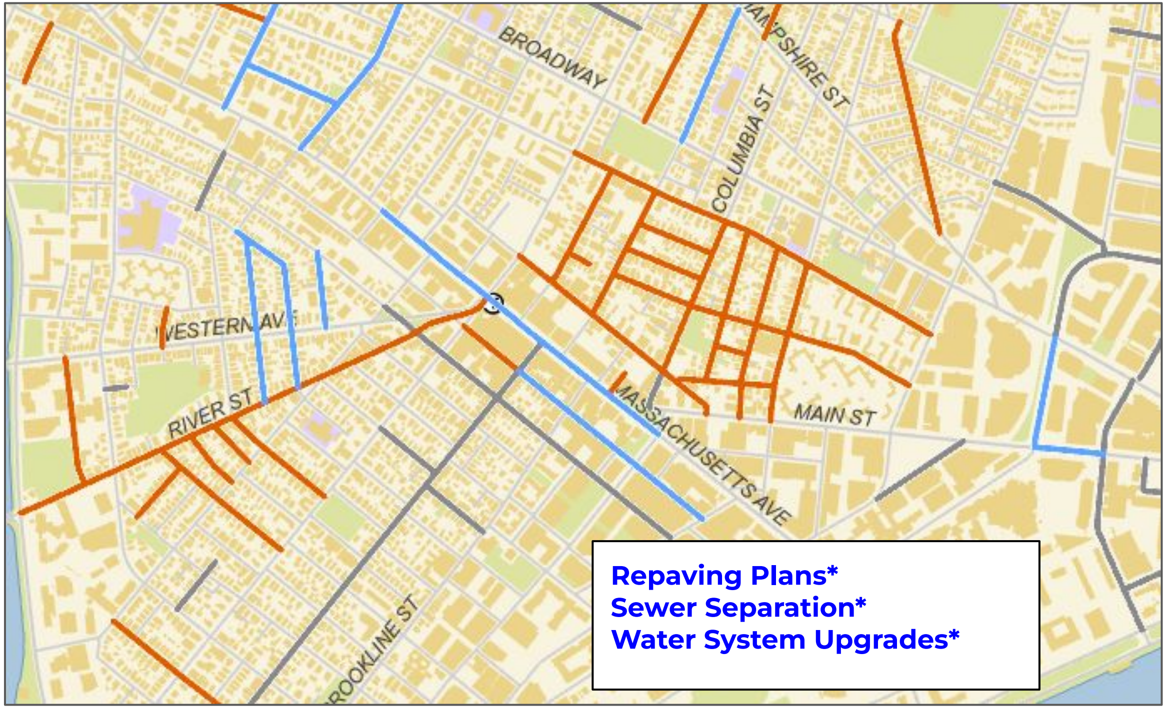


heet

Use Networked Geothermal When Possible

- To minimize unnecessary costs (avoided costs pay for customer retrofits?)
- For speed of transition

Synergize Infrastructure Work for Savings, When Possible



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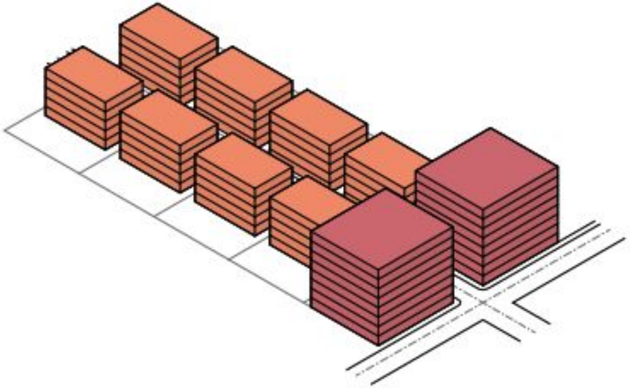
First Install

- 300 tons or more - i.e. the equivalent energy use of > 100 homes



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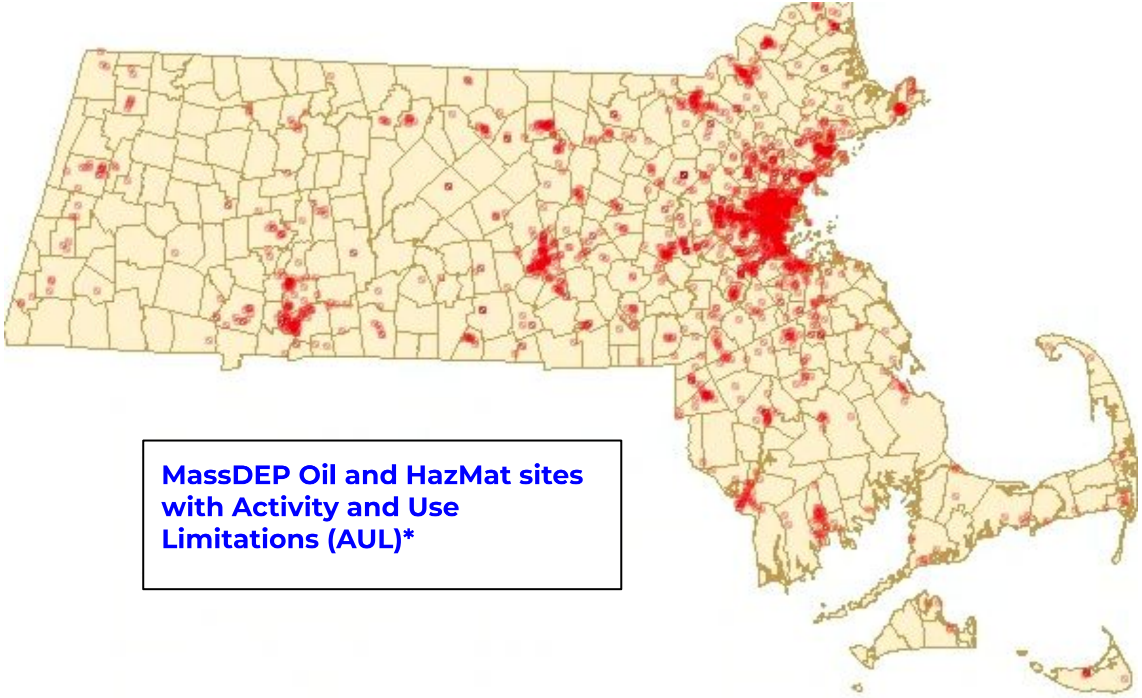
First Install

- 300 tons or more
- Avoid HazMat sites - for these sites, use air source heat pumps

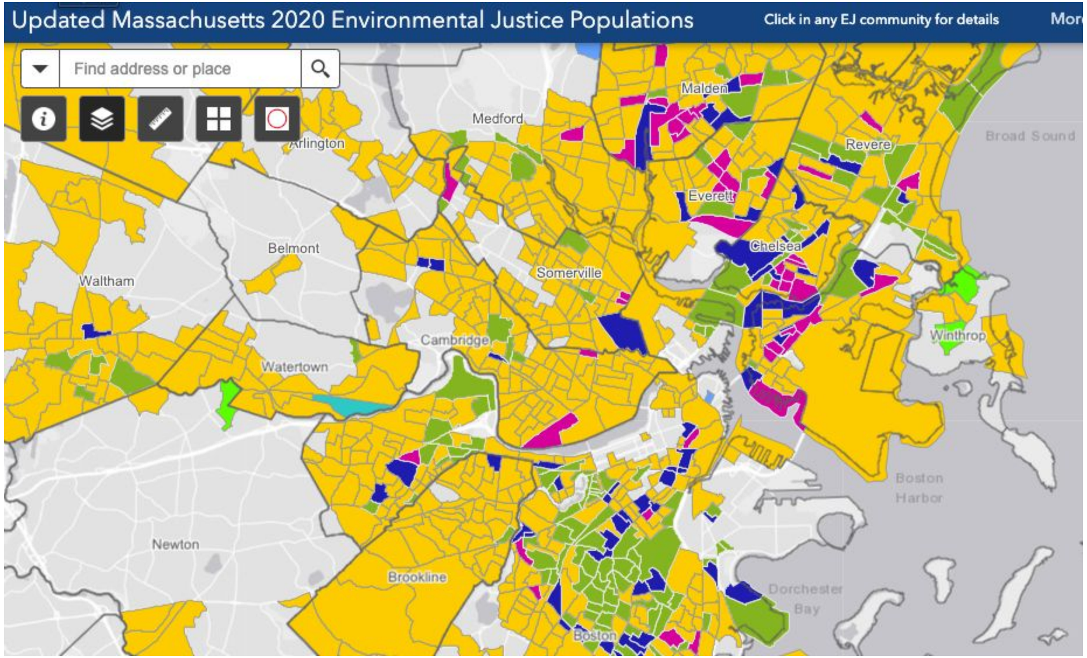


MassDEP Oil and HazMat sites with Activity and Use Limitations (AUL)*

heet

First Install

- 300 tons or more
- Avoid HazMat sites
- Prioritize **environmental justice***



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First Install

- 300 tons or more
- Avoid HazMat sites
- Prioritize environmental justice
- Balanced **street-segment heating & cooling loads***

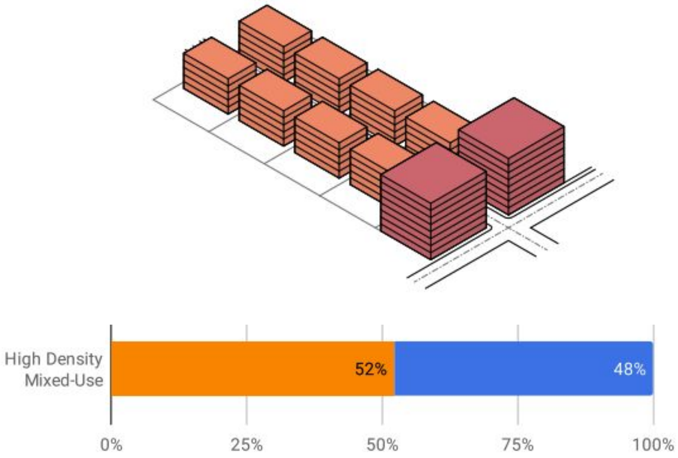

Figure III-5: Comparison of residential and commercial peak heating demand patterns

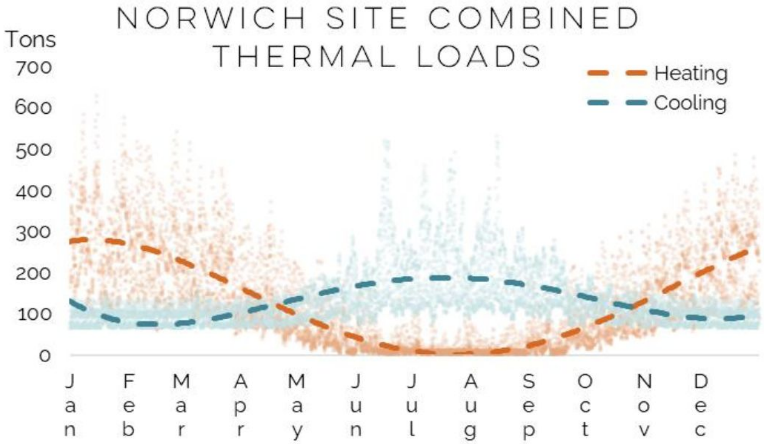

Figure 25: Thermal Load Profile for Norwich Site

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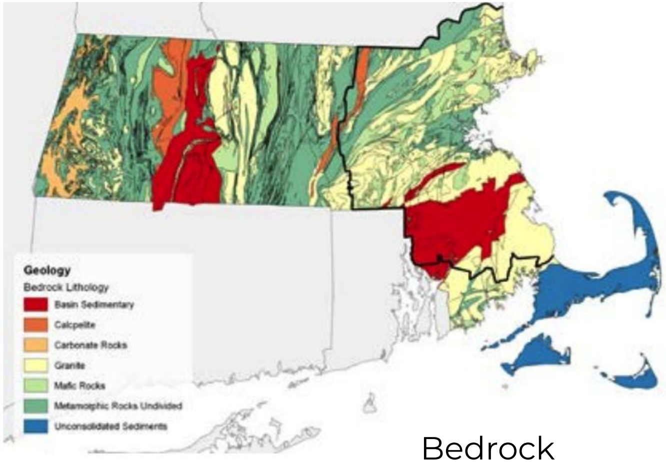
First Install

- 300 tons or more
- Avoid HazMat sites
- Prioritize environmental justice
- Balanced street-segment heating & cooling loads
- Incorporate **local thermal reservoirs***

Sewer infrastructure



Bedrock

Figure II-4: Bedrock lithology in Massachusetts (source: MassGIS)

Large bodies of water

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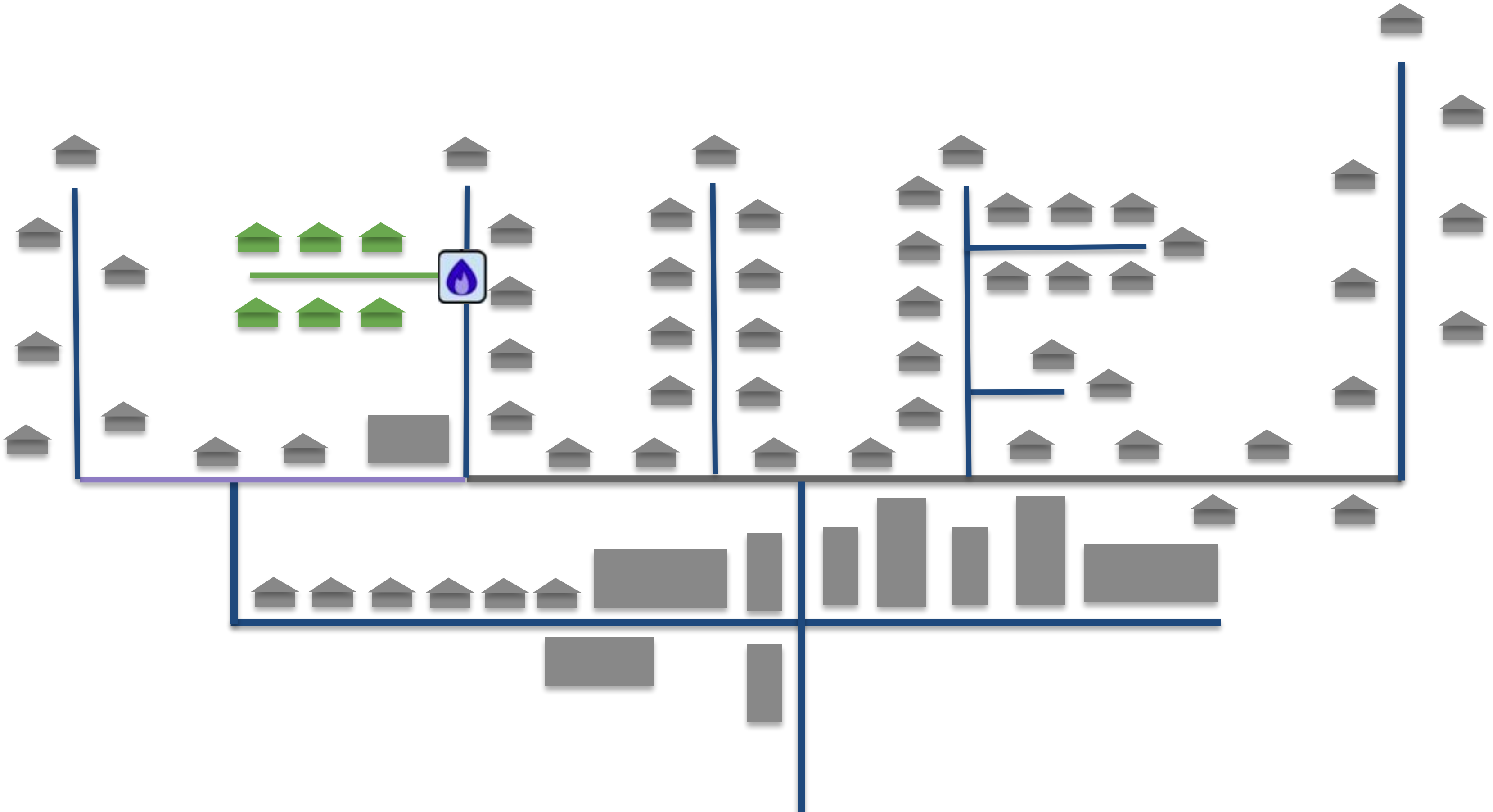
Include Backup Supplemental Heater & Chiller (not glycol)



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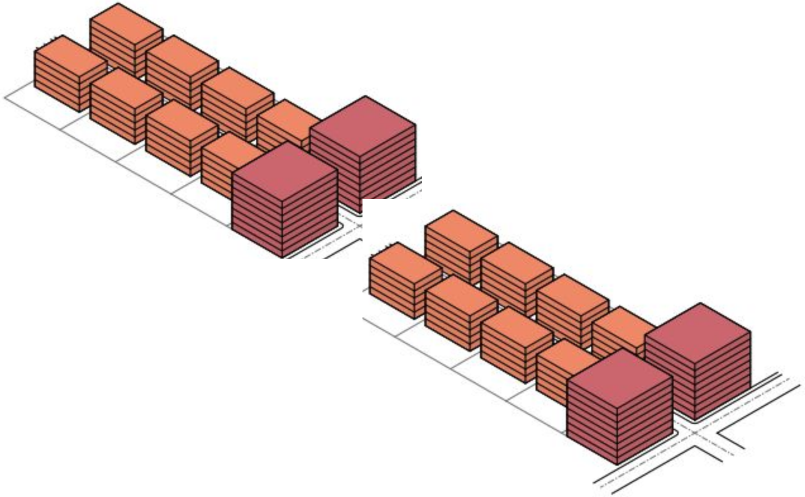
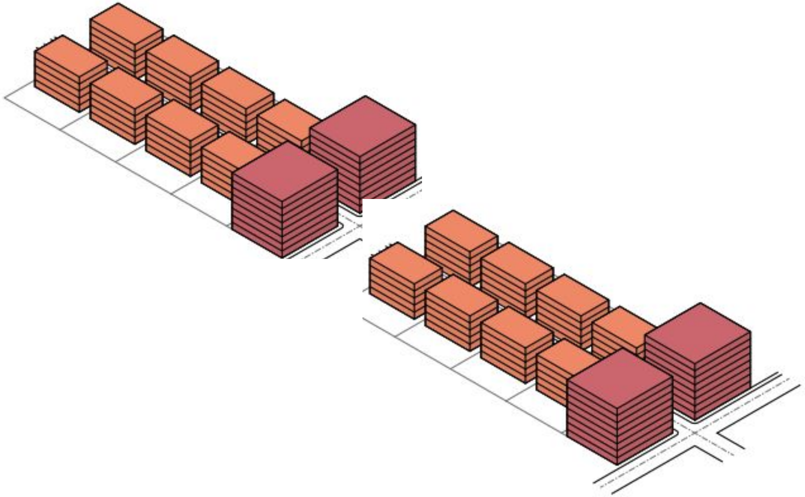
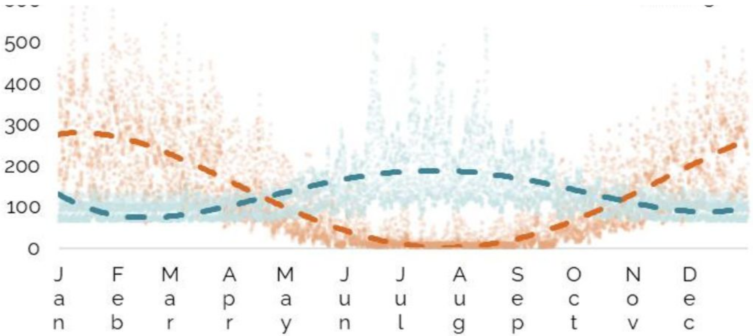
Interconnect to Grow the System



Interconnect to Grow the System

- Calculate interconnected load





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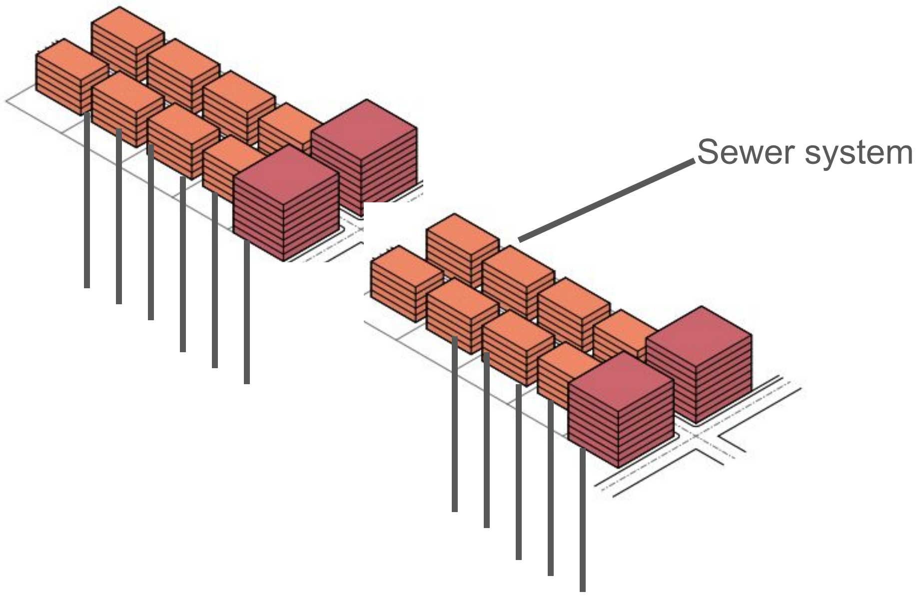
Interconnect to Grow the System

- Calculate interconnected load
- Add in distributed local reservoirs - so no “end of the line” issues



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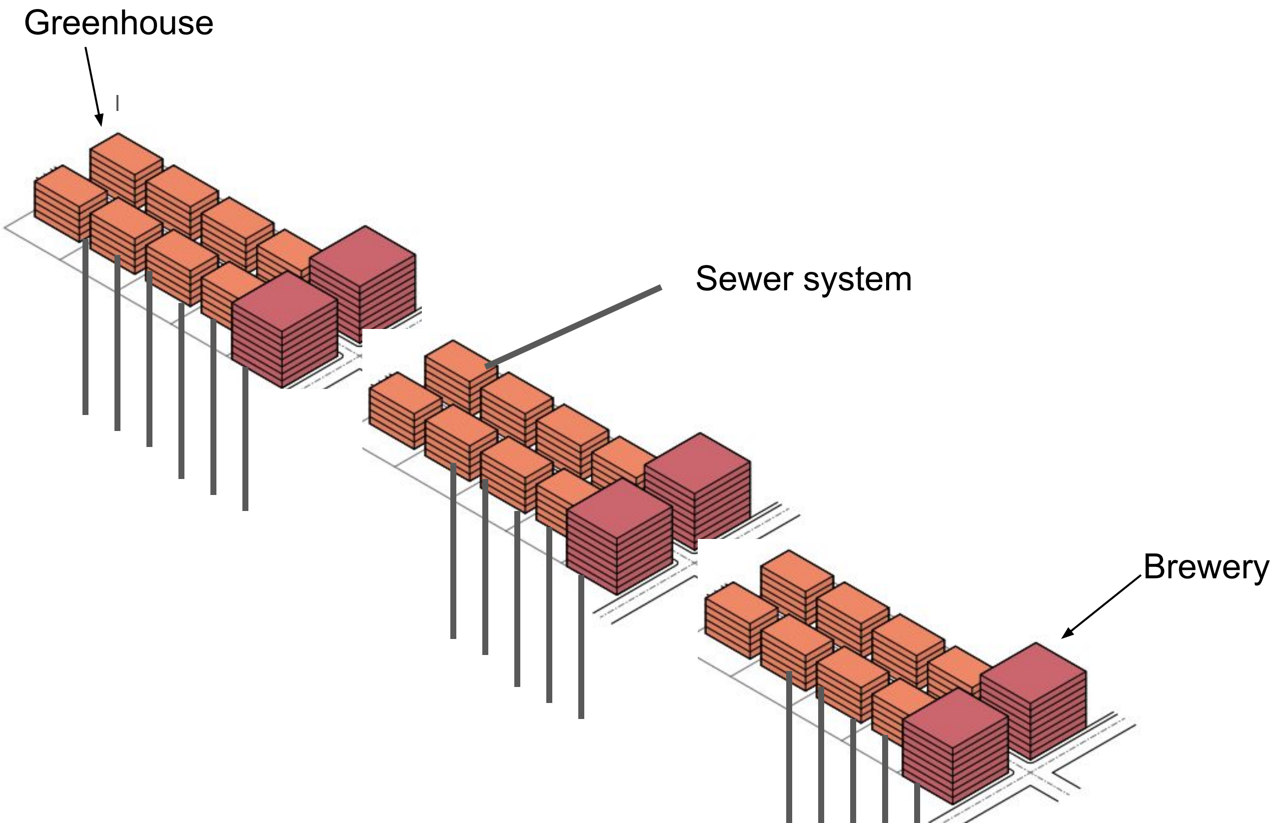
Repeat



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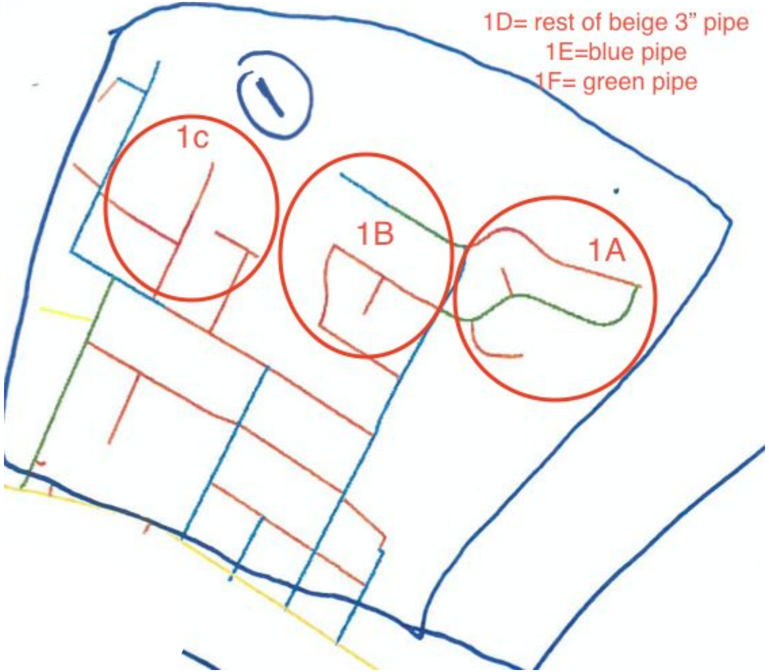
Plan a Phased Transition (neighborhood)

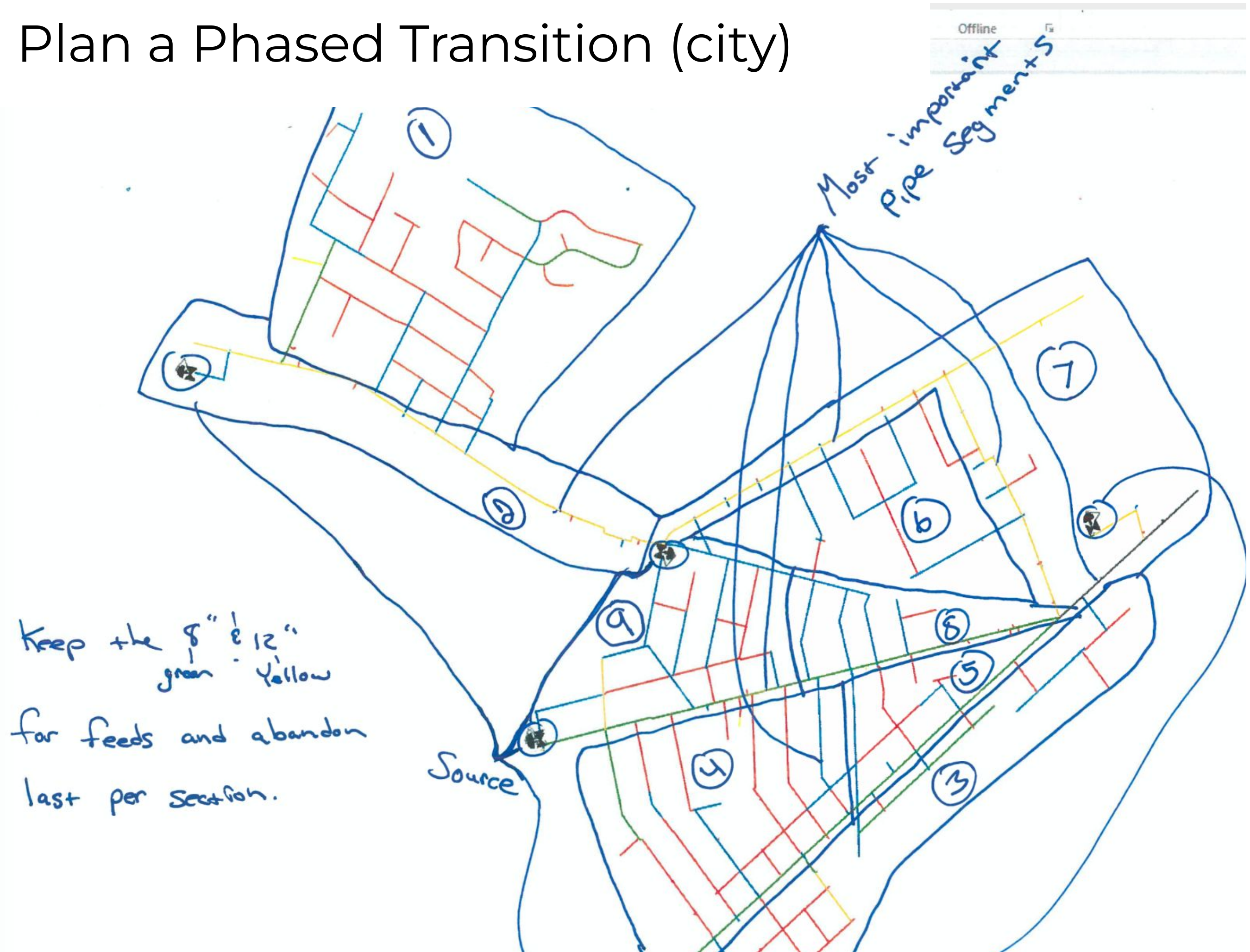
- Start at the ends of the gas system
- Transition the same size pipes, starting with the smallest
- Keep 2 of the largest pipes (feeders) for as long as possible



Pipe Size

—	3	3"
—	4	4"
—	6	6"
—	8	8"
—	10	10"
—	12	12"

Plan a Phased Transition (city)



Pipe Size

—	3	3"
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—	8	8"
—	10	10"
—	12	12"

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