HEET's Summary Comments

January 16, 2023

The Department has recently issued its order on the Future of Gas (DPU 20-80). The summary of this document was titled "Beyond Gas." With this order, the decision has been made. The state will move beyond gas. The question now is not *if*, but *how*.

Luckily the gas utilities are accustomed to changes, having moved from "manufactured" gas to "natural" gas and then to "produced" gas[1]. With each of these transitions, major changes in infrastructure and/or appliances were required. Each time the gas utilities and workers have risen to the challenge, always moving toward a product that is safer, more affordable and lower emitting.[2]

Following the Department's order, it is time to transition again. How we do so will impact the costs, speed, equity, safety and ease of this transition.

Enacted well, this transition can be a model for other states as they also move beyond gas to a safer, more affordable, non-combusting, renewable thermal system that works for all.

The Current Dilemma

As part of the Gas System Enhancement Plan (GSEP), Massachusetts gas utilities are spending over a total of $800 million per year installing new gas mains to replace old gas mains. These pipes have a lifespan of well over 50 years and are paid back over that time period by customers.

Dorie Seavey's presentation to the GSEP Working Group demonstrated that from now until the end of the GSEP program (currently projected to be 2039), an additional $34 billion[3] worth of new gas infrastructure will be installed. If paid for by customers in the normal way, these pipes would not be fully paid for until 2097.

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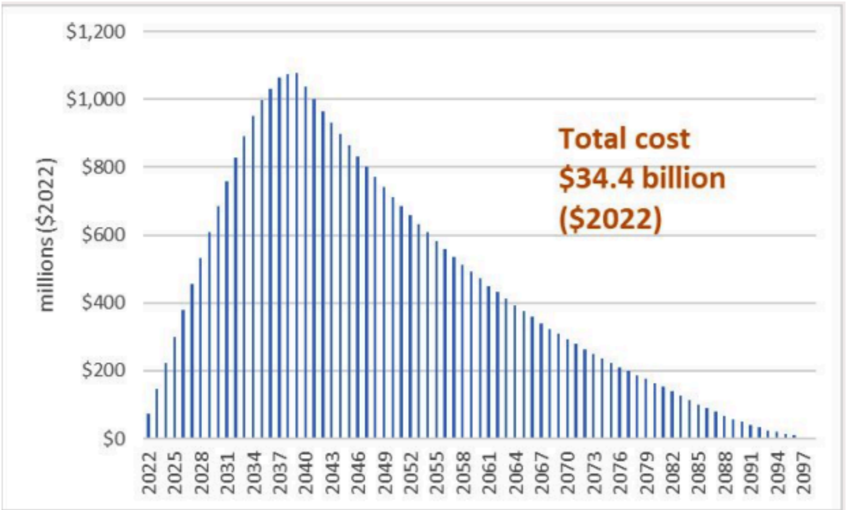
[1] Manufactured or "town" gas was made from gasification of coal, followed by natural gas, then fracked or produced gas.

[2] Please see the 1952 *New York Times* article at the end of this letter about the transition from manufactured to natural gas.

[3] Including return on equity and operations and maintenance.



GSEP's cumulative costs as derived from the "Future of Gas" Independent Consultant Reports, Dorie Seavey, PhD, 20 October 2023, GSEP Working Group.

Rising Energy Burden

Compounding the difficulty of the need for investment is that heat pumps are now outselling gas furnaces across the country, partly because they deliver cooling as well as heating.[4] In Massachusetts, heat pumps are also highly incentivized, since the state's Clean Energy Climate Plan has a goal of transitioning 1 million homes to them by 2030. It is thus not surprising that heat pump sales have tripled in Massachusetts each year for the last few years.[5]

As this trend continues of customers retrofitting their buildings to move from gas to heat pumps, fewer and fewer customers will remain on the gas system. However, that gas system will still have the same number of miles of pipe, with the same fixed maintenance costs. These maintenance costs will be shouldered by fewer and fewer gas customers, making the customers overall gas bills increase.

The higher gas bills will inspire more customers to move to heat pumps, creating a feedback loop. In the end, the only ones left on the gas system are likely to be those who cannot buy a new heating system: low-income residents and renters. This is not the sort of just transition we want for the Commonwealth.

Additionally, with a smaller and lower income customer base, the gas utilities will cut back where they can, potentially keeping fewer workers on staff—this could mean that the safety of the system will suffer.

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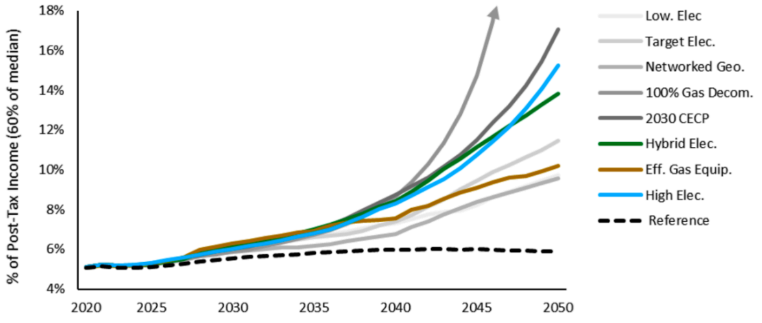
[4] Heat pump sales in US surged past gas furnaces in 2022, Canary Media, 2022.

[5] https://www.mass.gov/info-details/massachusetts-climate-report-card-buildings-decarbonization

Figure 38. Non-migrating customer energy burden for low-income customers (% of annual income spent on gas and electricity). A low-income customer is defined as a customer with a household income that does not exceed 60% of the state median income level.



The Role of Gas Distribution Companies in Achieving the Commonwealth's Climate Goals, Independent Consultant Report, 2022.

Stranded Assets

Since the Commonwealth has a net zero emissions mandate beginning in 2050 and gas is a fossil fuel, these new gas pipes being installed today are thus unlikely to be "used and useful" through their lifespan, but instead are likely to become stranded assets that will have to be paid for by the Commonwealth and its taxpayers.[6] We must end this installation of future stranded assets as quickly as possible.

Safety

The question is what to do about safety. Safety is the reason that GSEP was started. The most dangerous type of leak-prone pipes are small-diameter cast iron mains. This type of pipe is brittle enough to crack "catastrophically" during a frost heave, allowing the gas to then migrate underground into nearby buildings. Small-diameter cast iron pipe has thus wisely been prioritized to be replaced as part of GSEP. Since the program started, over 40% of all small-diameter cast iron mains in Massachusetts have been replaced.[7] Thus our gas system is now much safer than before the program.

However, unfortunately, that increased safety has not been demonstrated yet in the data. According to the Pipeline Hazardous Materials Safety Administration's (PHMSA) database, in the 11 years before GSEP started, there were 3 deaths and 24 injuries caused by hazardous events with gas. In the 8 years of PHMSA data since, there have been 2 deaths and 27 injuries.[8] The majority of those injuries, as well as one of the deaths, happened during the Merrimack Valley gas disaster.

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[6] Who Will Pay for Legacy Utility Costs? Lucas W. Davis and Catherine Hausman.

[7] Pipeline Hazardous Materials Safety Administration database shows the mileage of small diameter cast iron mains in MA have decreased from over 3,800 in 2010 to less than 2,250 in 2022.

[8] Pipeline Hazardous Materials Safety Administration database

This disaster was caused by a mistake made during a GSEP gas pipe replacement. The incident underlines the fact that, although the gas utilities and workers perform an exemplary job of keeping the gas system and customers safe, gas is explosive and inherently dangerous.

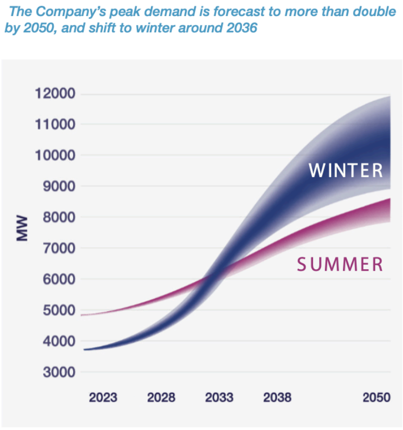
All of us, and especially gas workers, will be safer the faster we transition our gas system to a non-explosive method of piping heat to residents.

Electric Grid Impacts

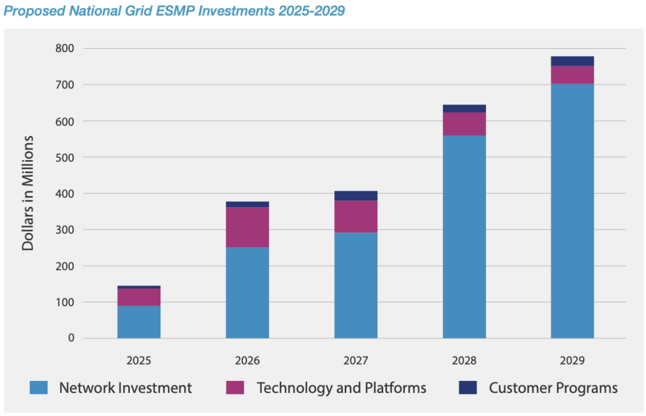
The best strategy to reduce our emissions is to move all of our energy needs to electricity and then create that electricity with renewables. To provide all that energy (as well as the energy for transportation), the electric grid will have to be upgraded. Since the gas system at peak can contain four times the energy of the electric grid, the electric grid's upgrades will need to be extensive.

As already stated, air source heat pumps are currently the most popular way to retrofit a building's heating system from gas to electric. These systems are reliable and very efficient, but on very cold days their efficiency decreases as they need to work harder to pull heat from cold air. On a cold February morning, having a majority of our buildings on air source heat pumps would create a very high electric grid peak.

Currently our electric use peaks in the summer, on hot days when customers turn on their air conditioning. However, by 2036, as more buildings move to electric heat, the assumption is that the electric peak load will move to the winter and, in the end, will dwarf the current summer electric peak use.


The Company's peak demand is forecast to more than double by 2050, and shift to winter around 2036

National Grid Future Grid Plan, Sept. 2023.


Proposed National Grid ESMP Investments 2025-2029

National Grid Future Grid Plan, Sept. 2023.

Electric Grid Upgrade Costs

The higher these potential electric peaks, the more the grid will need to be upgraded, as well as the more renewable energy and storage will be needed to meet that need. The Electric Sector Modernization Plans (ESMP) are currently in progress. National Grid's ESMP report predicts needing to increase its investments in its electric grid seven-fold within the next five years. If we assume that National Grid's prediction is conservative, and that the actual need is only half of the prediction, the needed upgrade would still require a considerable investment.

Peak electricity is the most expensive electricity we use—costing on average ten times or more that of an off-peak kilowatt hour. Additionally, the higher our future electric peaks are, the longer it will take and the more expensive it will be to:

- Upgrade the system to meet that peak
- Source all the renewables needed to produce clean electricity
- Source all the battery storage to supply that load in a non-intermittent way (when the sun is not shining and the wind is not blowing)

No one currently knows the total cost of this electric grid modernization work, or the total cost of the peak electricity during these future winter peaks. We do know, of course, that all of this will be paid for in the end by customers. If we aren't smart about how we transition and electric bills increase significantly, that would have a negative effect on customers' desire and ability to transition.

Workforce

If the gas system is not transitioned but instead stranded, the gas workforce will be left without jobs, even while we search for the trained workforce to upgrade the electric grid and to perform all the building retrofits.

Summary

Today we have a clear goal. We know we are about to transition from one system to another. However, we are not yet acting or investing as if we know our direction.

Instead we are investing significantly and actively in the gas *and* electric system at the same time, without thinking through how to synergize the work to reduce the cost and increase the speed. It is as though we are taking out a mortgage to replace the foundation on our horse's stable, even after we've ordered an electric car.

Suggested Solutions

Ramping Down GSEP

As part of the GSEP Working Group, the Attorney General's Office (AGO) suggests ramping down the accelerated cost recovery funds allocated to GSEP over time and stopping the program entirely by 2030. This suggestion would help maintain the affordability of gas customer bills (since the customers would not be paying for as many gas pipe replacements) and would commensurately reduce the investment in new assets that are likely to be stranded.

Year	Percent of the gas company's most recent calendar year total firm revenues
October 1, 2024	2.8%
October 1, 2025	2.5%
October 1, 2026	2.0%
October 1, 2027	1.5%
October 1, 2028	1.0%
October 1, 2029	0.5%
October 1, 2030	0.0%

The AGO's suggested ramping down of accelerated cost recovery for GSEP

However, there are problems with this proposed solution.

By 2030:

- The utilities will have installed, at current cost per mile, ~900 more miles of new gas pipe and spent approximately $5 billion more in capital expenditures (~$10 billion total, if return on equity, as well as operations and maintenance are factored in).
- The electric utilities will have assumed that the gas system is entirely going away and will be seven years into the needed electric grid upgrades, raising electric bills commensurately for customers. Higher electric bills will make electrification less attractive.

Additionally, after 2030, with GSEP over, there will still be at least 1,100 miles of the dangerous small-diameter cast iron pipe remaining in the state. These pipes will need to be addressed in one way or another.

Right-sizing

HEET supports the AGO's desire to quickly stop the investment in new gas mains but suggests that we go further in revamping GSEP.

Stopping investing in new gas pipes is only part of the answer. As the gas customer base continues to decrease, the gas system needs to be "right-sized" to maintain a reasonable ratio of customers to infrastructure. Right-sizing this ratio will help keep energy bills affordable and stop the downward spiral toward stranded assets.

This right-sizing can be performed through a combination of the following three **non-gas pipe alternatives (NGPAs):**

- **Advanced leak repair** where appropriate,[9] to reduce or eliminate emissions for a decade or more until a pipe can be retired or transitioned.
- **Retiring gas pipes** where appropriate, while moving the connected customers to electric appliances such as air source heat pumps.
- **Transitioning street-segments to water-based thermal systems**.

Both retirement and/or transition of a gas system can be performed (while maintaining safety and reliability) by starting at the distal ends of the gas system in each neighborhood and maintaining two gas feeder pipes into the area until all other gas pipes are removed.

Keep the 8" & 12" green - Yellow for feeds and abandon last per section.

Symbol	Value	Label
🟨	0.5	1/2"
🟨	0.625	5/8"
🟨	0.75	3/4"
🟨	1	1"
🟨	1.25	1 1/4"
🟨	1.5	1 1/2"
🟨	2	2"
🟥	3	3"
🟥	4	4"
🟦	6	6"
🟩	8	8"
🟩	10	10"
🟨	12	12"
⬛	14	14"
⬛	16	16"
⬛	18	18"
⬛	20	20"
⬛	24	24"

This sketch was created for HEET by a gas municipality expert to explain the steps by which a low-pressure cast-iron system could be transitioned or retired without affecting safety or reliability.

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[9] Advanced leak repair is already allowed as part of the GSEP statute. It is a set of techniques that is less expensive than replacement. These techniques include "sleeving" or "pigging" large diameter pipes to significantly reduce or stop gas leaks for a decade or longer. These larger diameter pipes are not prone to "catastrophic" breaks during frost heaves.

If the gas utilities are allowed to install utility-scale non-combusting renewable infrastructure, then every mile of such infrastructure installed will mean:

- One less mile of new gas pipes installed, one less mile of unsafe pipes remaining in the ground, and fewer future stranded assets.
- One more mile of customers transitioned permanently off of combustion to a highly efficient method of clean electric heating and cooling, a method that reduces the needed local electric grid upgrades and that lowers the overall peak electric load, thus helping to reduce future electric bills.

Transitioning to Non-combusting Thermal Infrastructure

One method of non-combusting thermal infrastructure is a water-based thermal system, such as networked geothermal. Because the water in the pipes can be heated or cooled days *before* the extreme temperature arrives, it can act as a thermal battery, shaving electric peaks. Networked geothermal can also store temperature in the bedrock for weeks or months.[10]

Water-based thermal systems can deliver heating, or heating and cooling. These systems can be:

A. District energy systems,[11] which use a central plant to deliver heated or chilled water through pipes across a district. The temperature of the water can be provided through clean electricity. The technology is well proven and financially viable. District energy systems exist primarily in urban areas such as college and hospital campuses, military bases, and business districts, providing heating (and/or cooling) to hundreds of buildings. In Boston and Cambridge, there is, for instance, a district steam system[12] run by Vicinity that is currently being transitioned to a six-stage air source heat pump and wind energy. The system heats over 65 million square feet.

B. Thermal energy networks,[13] which contain water at an ambient temperature (generally between 40 and 90 degrees Fahrenheit). Heat pumps in each building take the heating and cooling needed from the water. **Thermal energy networks (which include networked geothermal) are the most efficient thermal systems known**[14] and do not require central plants; instead they maintain the temperature in the system through local heat sources and sinks, such as office buildings, ice rinks, greenhouses, boreholes and bodies of water. Thermal systems can significantly lower the electric peaks through their efficiency.[15] Since they don't need a central plant but instead have distributed resources, they can:
    - Grow organically, interconnecting additional street segments and distributed sources and sinks as needed.

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[10] Design Considerations for Borehole Thermal Energy Storage (BTES): A Review with Emphasis on Convective Heat Transfer, H. Skarphagen, Volume 2019 | Article ID 4961781 |

[11] https://www.energy.gov/eere/amo/articles/combined-heat-and-power-technology-fact-sheet-series-district-energy

[12] It is important to note that a steam district system is significantly less efficient than lower temperature systems.

[13] Underground thermal energy networks are becoming crucial to the US's Energy Future, MIT Technology Review, 2023.

[14] See attached Xcel Energy Colorado Mesa University case study.

[15] Inefficient Building Electrification Will Require Massive Buildout of Renewable Energy and Seasonal Energy Storage, Sci Rep 12, 11931 (2022), J. Buonocore et al.

  - It is not necessary to know the maximum size of the district before it is built.

This technology is also well proven and can function in urban *and* suburban areas since the ambient temperature of the water in the pipes is close to the temperature of the ground and thus does not lose much temperature if it is piped further. Again, this is a proven, financially viable technology and is used by many large college campuses (for instance, currently UMass Amherst,[16] Smith College,[17] Brown[18] and Oberlin[19] are in the midst of installations).

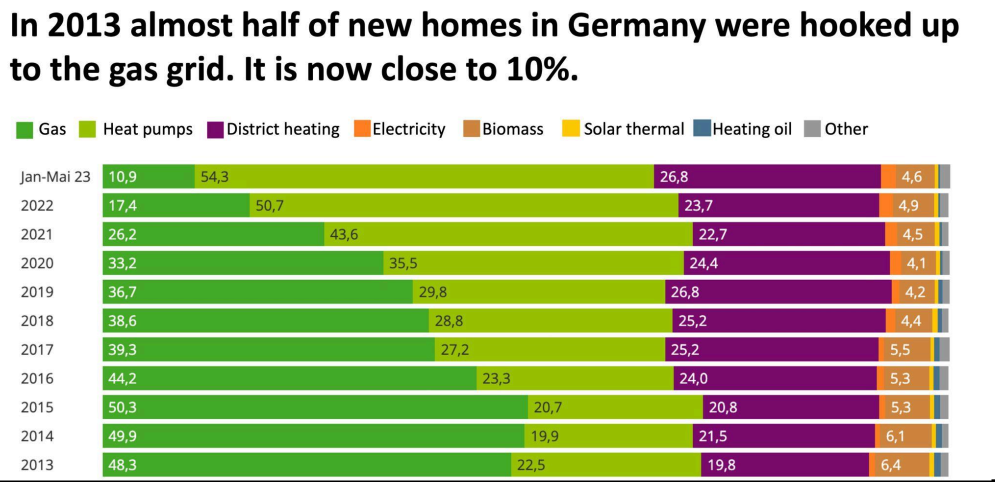
In both cases, the "gas" utility's role would be similar to what it is now: to install, own and operate the system, in the right of way in the street, using their current financing methods, with their current customers, to deliver the needed temperature through pipes to all customers on the system.

Gas/Thermal Merged Ratepayer Base

So long as the gas and thermal customers are in a single merged ratepayer base, and unneeded gas pipes are retired, the ratio of infrastructure to customers can be maintained, avoiding a rising energy burden and slow slide into stranded assets.

Can Thermal Systems Be Scaled Up?

New York and Colorado have both already passed legislation mandating that their gas utilities install systems like this. New York is currently figuring out how to regulate these systems. Meanwhile, Germany is far ahead of the US, having moved almost 40% of its new customers off of gas in just 10 years.


In 2013 almost half of new homes in Germany were hooked up to the gas grid. It is now close to 10%.

[Development of the heating structure in new buildings - building permits,](#) BDEW.

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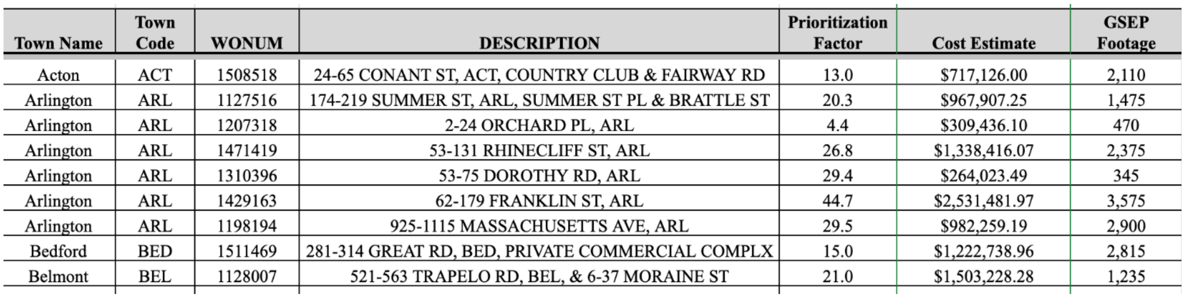
[16] https://www.umass.edu/news/article/umass-amhersts-carbon-zero-project-ramps-geothermal-test-well-drilling-two-locations
[17] https://smithgeoenergy.info/
[18] https://www.brown.edu/news/2023-11-02/geothermal
[19] https://www.oberlin.edu/news/ambitious-geothermal-project-make-oberlin-national-leader-clean-energy

Integrated, Street-segment-based, Phased Plan

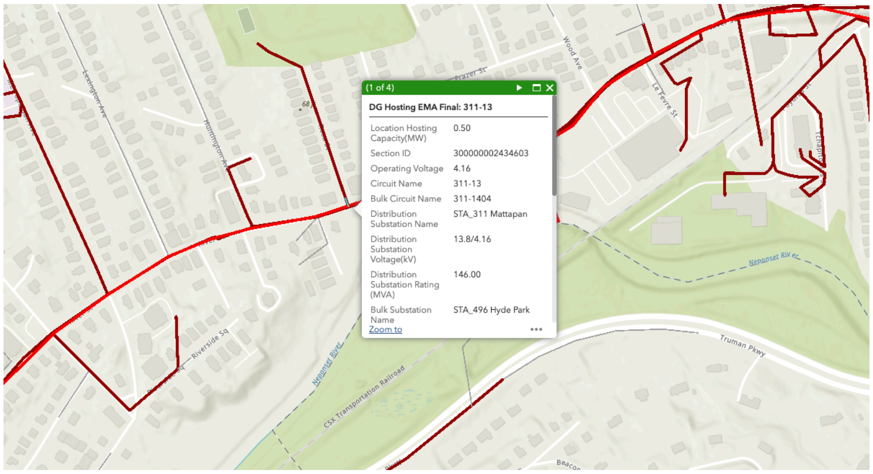
If you were about to do a major renovation on your home, the first thing you'd want is a blueprint of the building, including information on where the electrical wiring and pipes are. With that blueprint, you could create a specific and phased plan to help ensure that the work happened as smoothly as possible and for the least cost. Moving more than 1.6 million gas customers in the Commonwealth off of gas is a much larger and more complex project than any home.

In order to figure out which solution to use where, we need a plan. In order to create that plan, gas and electric utilities need to share their blueprints with each other to create a unified map of the state's gas and electric system capacities and constraints down to the street-segment level. To this map, can be added the local energy needs, building stock and geology. With this information, it will be possible to apply an algorithm that creates an integrated, street-segment-based, phased plan to transition the system with the greatest speed and equity and for the lowest cost.



Town Name	Town Code	WONUM	DESCRIPTION	Prioritization Factor	Cost Estimate	GSEP Footage
Acton	ACT	1508518	24-65 CONANT ST, ACT, COUNTRY CLUB & FAIRWAY RD	13.0	$717,126.00	2,110
Arlington	ARL	1127516	174-219 SUMMER ST, ARL, SUMMER ST PL & BRATTLE ST	20.3	$967,907.25	1,475
Arlington	ARL	1207318	2-24 ORCHARD PL, ARL	4.4	$309,436.10	470
Arlington	ARL	1471419	53-131 RHINECLIFF ST, ARL	26.8	$1,338,416.07	2,375
Arlington	ARL	1310396	53-75 DOROTHY RD, ARL	29.4	$264,023.49	345
Arlington	ARL	1429163	62-179 FRANKLIN ST, ARL	44.7	$2,531,481.97	3,575
Arlington	ARL	1198194	925-1115 MASSACHUSETTS AVE, ARL	29.5	$982,259.19	2,900
Bedford	BED	1511469	281-314 GREAT RD, BED, PRIVATE COMMERCIAL COMPLX	15.0	$1,222,738.96	2,815
Belmont	BEL	1128007	521-563 TRAPELO RD, BEL, & 6-37 MORAINE ST	21.0	$1,503,228.28	1,235

GSEP street-segment information showing the work and costs that will be performed the following year.
[23-GSEP-03 Exhibit NG-GPP-4]



DG Hosting EMA Final: 311-13

Location Hosting Capacity(MW): 0.50
Section ID: 300000002434603
Operating Voltage: 4.16
Circuit Name: 311-13
Bulk Circuit Name: 311-1404
Distribution Substation Name: STA_311 Mattapan
Distribution Substation Voltage(kV): 13.8/4.16
Distribution Substation Rating (MVA): 146.00
Bulk Substation Name: STA_496 Hyde Park

[DG Hosting Capacity - External Map Viewer]
EMA showing electric grid capacity.

Overlaying this map of street-segment capacity constraint information with *all* leakprone gas infrastructure in the state by street-segment (as shown above in the GSEP reports) would help identify how to transition for the least cost.

Suggested Actions

Legislating in a Time of Uncertainty

The time for action is now. Every year that goes by means around 270 more miles of new gas pipes are installed at roughly the cost of a billion dollars. Meanwhile, the electric grid upgrades planning is starting now and the physical work will begin by 2025. Every year, more money will be sunk into two sets of systems without a plan.

Unfortunately, although we know air source heat pumps, district energy systems and thermal energy networks work effectively and are financially viable, we don't know what system works best where. Nor do we have the local expertise and equipment to scale at the speed needed. We need time to plan and iterate on different models to begin to reach scale.

Although this lack of knowledge creates uncertainty, there are ways to move forward now so as to learn as quickly as possible, while minimizing the waste of time and money, and while maintaining affordability for all.

- **Stop the installation of and investment in new gas pipes as quickly as possible.** Enact the AGO's suggestion of a ramp-down of the funds spent on new gas infrastructure.
- **Mandate non-gas pipe alternatives (NGPA) wherever financially and technically viable**. NGPAs, in terms of GSEP, should include the options of advanced leak repair, water-based thermal systems, or retiring gas pipe (while moving customers to air source heat pumps).
- **Create a merged gas/thermal ratepayer base to maintain the ratio of customers to infrastructure** in order to avoid rising energy burden and the slide into stranded assets. Of course as part of this gas utilities should be able to sell and install thermal infrastructure and to meet their obligation to serve through whichever system (gas or thermal) is closer.
- **Slow down and lengthen GSEP to allow for learning.** The overall annual mileage of GSEP infrastructure installed each year can be decreased, while the program is lengthened. This will allow the truly unsafe small-diameter cast iron pipes to continue to be replaced, while giving enough time for trials with NGPAs. With an integrated energy plan, the Department would have the information needed to determine the future duration and speed of GSEP.
- **Create an integrated, street-segment-based, phased plan.** Gas and electric utilities need to share their system capacities and constraints to begin to create an integrated, street-segment-based, phased plan to transition the system with the greatest speed and equity and for the lowest cost.

- **Iterate on the phased plan through regular reassessments with the greatest possible transparency of information**. As it becomes more clear which non-gas pipe alternatives work best while maintaining affordability, the allowable or preferred NGPAs can be readjusted. Since regulation is a faster method to do this than legislation, the Department should be directed to perform this iteration and reassessment. Transparency of information will increase the trust of all stakeholders, while allowing more people to help provide potential answers.
- **Require a greater percentage of NGPAs annually to reach 100% of GSEP.** The least expensive way to affect a market is to give it certainty. Clarifying to the gas utilities that NGPAs is the way forward through a gradual required ramp-up in NGPAs will allow them to figure out how to get the work done, sourcing the expertise, materials and equipment. This required ramp-up will help maintain the workforce we need to accomplish the mammoth job in front of us.
- **Motivate action through a combination of accelerated cost recovery, pre-approval of funds, and/or incentives.** Most people and companies will not perform work without some money up front and without a guarantee of getting paid the rest of the funds. Asking the utilities to perform a year's worth of expensive work without any of the funds up front, and to perform that work without a pre-approval of getting paid back, is an effective way to stop that work. Thus HEET *strongly* encourages a mixture of accelerated cost recovery, pre-approval of expenditures, and/or performance-based ratemaking to help increase the speed of the gas utilities' transition.

As at other points in the history of our infrastructure transitions, there are many unknowns in front of us. The one thing we know for sure is that we are wasting money and time now by installing long-lived combustion infrastructure, while knowing that combustion is going away.

Let's multi-solve the problems in front of us. It's time to create a plan to right-size the gas system by transitioning it to a safer, more affordable water-based system, decommissioning pipes where necessary. With data transparency, a merged gas/thermal ratepayer base and the right incentives, we can iterate forward to meet the Commonwealth's net zero emissions mandate for the least cost and at the greatest speed.

This is a time to build the future and the legacy we want.

Respectfully,

Audrey Schulman
Co-founder and Co-executive Director, HEET

Note: Some of the comments from NEGWA/USW seem to suggest a misunderstanding about the scope of the GSEP Working Group. The group was not tasked with performing studies. Instead, each member was selected for their expertise in various fields. The idea was that by working together, these experts will be able to make recommendations that will help align the GSEP statute with the Commonwealth's net zero emission mandates. The legislature and Department could then choose which of the working group's recommendations to enact, and how to do so in conjunction with state and federal law.

Xcel Energy Report on Colorado Mesa University Geothermal Network System

Xcel Energy evaluated the efficiency of Colorado Mesa University's 15-year-old networked geothermal system. They calculated the average annual system efficiency (please see Table 1, comparing the Coefficient of Performance). The demonstrated efficiency is almost six times more than that of a gas boiler and approximately twice that of an air source system. During the winter, the season efficiency is even higher, demonstrating partly the thermal storage in the system's water and in the nearby bedrock of the boreholes. The report follows.

GAS MAN COMETH, AND SO EARLY TOO

At 7 A. M. He Starts Changing Brooklyn Appliances for Natural Type of Fuel

Since March 6 the breakfast routines of thousands of Brooklyn families have been interrupted by the early visits of traveling journeymen new to the local scene. They are among the 3,000 mechanics converting nearly 1,000,000 appliances of Brooklyn Union Gas Company customers from manufactured to natural gas.

The conversion men, each of whom specializes in one type of appliance, make their first calls between 7 and 9 A. M. The basic adjustment they make on each appliance is to drill the burner holes to three times their present size so that the slower-burning natural gas can provide the same amount of heat and the same height of flame as does the manufactured type.

Although the dismantling and reassembling of their ranges, refrigerators and heaters is a singular experience, most Brooklynites are accepting it with city dwellers' usual calm. One of the veteran conversion men on the job, Al Robbins of Fort Worth, Tex., recalled with a laugh the days when casual acceptance was not the normal attitude.

A Trick of the Trade

In nearly thirty years of following the extension of natural gas lines over the country, Mr. Robbins often met the housewife who didn't like the performance of the fuel after the conversion was completed. The workman's standard procedure in such a case was to return to the cellar, spend ten minutes harmlessly banging on pipes, and then report that manufactured gas was flowing again. The customer, he reported, was always satisfied.

The conversion of the Brooklyn-Queens area services is being done by Conversions and Surveys, Inc. More than one third of the men employed on the project, which is to be completed on Sept. 4, are permanent members of the company's staff who travel where the pipelines take them. The remainder were hired and trained here.

The trade has changed considerably since 1927 when Mr. Robbins was one of 120 men—each carrying $5 worth of tools—who converted the gas appliances of the whole of Los Angeles. The men who are calling on the 925,000 customers of Brooklyn Union take with them equipment valued at $80. Every two or three days the crew completes the conversion of one of the fifty-eight districts into which the territory has been divided. Traveling with them are four mobile machine shops equipped to handle any problem that might otherwise delay the conversion.

One Hazard of the Job

A job that entails spending most of one's time in other persons' homes is not without hazards, as Jack Smith of Washington, who has worked in thirteen states since joining the conversion company in 1946, learned one night in Augusta, Ga.

Mr. Smith and his crew were working late in a house that had been closed up for some time. A rookie policeman spotted the lights inside the usually darkened building, assumed burglars were within, and entered with pistol in hand. The conversion men spent a nervous twenty minutes with their hands on their heads until reinforcements arrived and assured the suspicious patrolman their presence was legitimate.

Typical of the many young men who have joined the work during the post-war boom of the natural gas industry is Frank Hart, of Oslo, Minn. Attracted by the high wages and opportunity for travel, Mr. Hart joined Conversions and Surveys in 1947 in Waukegan, Ill. He acquired a wife the same week he took the job, but solved his problem by investing in a trailer. He is now one of eighty employes of the company who have put their homes on wheels to follow their trade.

GAS MAN COMETH, AND SO EARLY TOO. The New York Times (1952).

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EVALUATING A COMMUNITY GROUND SOURCE HEAT PUMP SYSTEM AT COLORADO MESA UNIVERSITY

SUMMARY

Colorado Mesa University (CMU) is in Grand Junction, Colorado, serves approximately 11,000 students, and spans 141 acres. This campus consists of 37 buildings including admissions, dormitories, athletics, academics, and student centers.

Beginning in 2008, CMU began deploying a geothermal loop system to reduce the need for conventional cooling and natural gas heating and reduce overall campus water use. The system was designed to utilize water-source heat pumps to serve interior spaces with a closed geothermal loop that utilizes the thermal stability of the ground as a heat sink. The networked loop consists of five loop fields with 471 bore holes drilled to depths ranging from 375 to 600 feet. These loop fields can be utilized as a thermal energy source to mitigate on-peak demand by filling the bore holes with loop water during off-peak periods and discharging the bore holes during on-peak periods. In 2023 Xcel Energy commissioned Michael's Energy to analyze the performance of CMU's geothermal system.

Today, this system serves 1.2 million sq. ft. of building area across 16 facilities with a diversity of cooling and heating needs. The system is comprised of (7) 50-HP central loop pumps, 91 individual building pumps, 5 conventional cooling towers, 2 hydronic boilers, 21 water-to-water heat pumps, 962 water-to-air heat pumps, and a

sophisticated control system. This equipment is sized to meet a design cooling load of 3,113 tons and a design heating load of 2,728 tons.

It is important to note that the geothermal system wasn't designed to meet 100% of the load, 100% of the time. CMU strategically interconnected conventional assets that already existed as buildings were added to the network. These assets are intended to increase overall system efficiency. These sources include water-to-water heat pumps for domestic hot water needs and pool preheating, a heat exchanger that enables the facilities team to reject heat via irrigation water, and five conventional cooling towers to reduce loop temperatures. In the winter months when loop temperatures decline to less than 57°F, the hydronic boilers inject heat into the loop. There were no instances of boiler operation throughout the 2022/2023 heating season. Additional gas usage can be attributed to dormitory domestic hot water (DHW) heating because the water-to-water heat pumps aren't able to raise the temperature of the water high enough to meet designed supply temperatures (140 F). However, newer heat pump technology can potentially solve this problem.

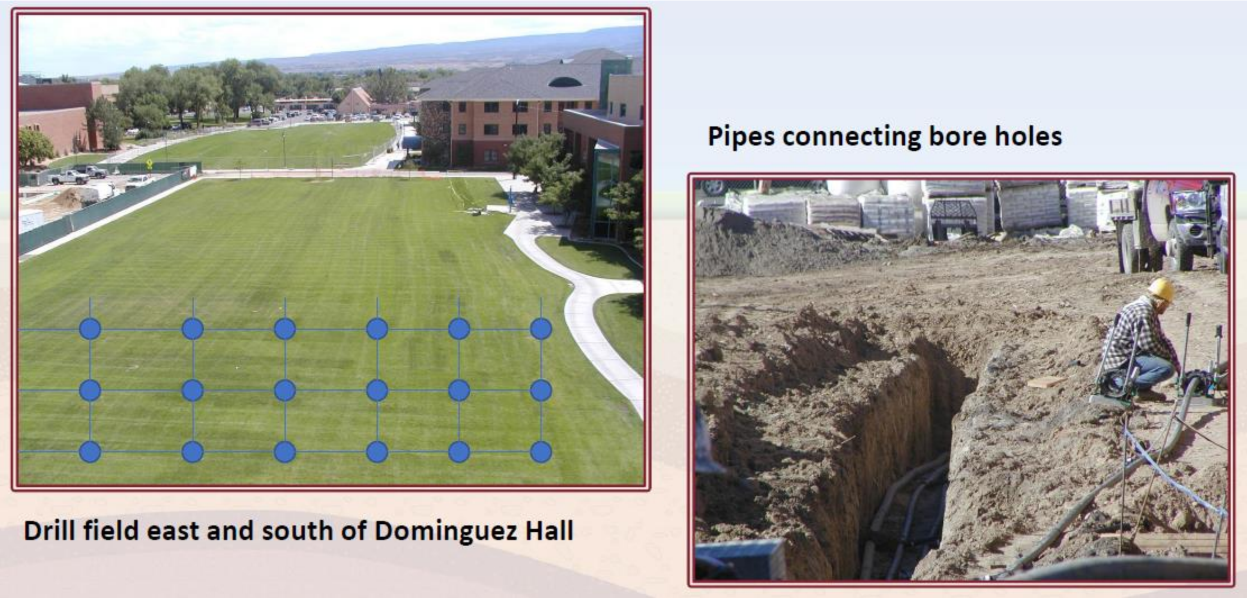
A key advantage of a network geothermal system is the system's ability to share heating and cooling loads. This load sharing can happen from room to room, floor to floor, and building to building. A water-to-air heat pump in heating mode removes heat from the building loop, cooling down the loop water. Another heat pump on the same loop in cooling mode expends less energy supplying space cooling than it would have otherwise. The same is true in reverse, where heat pumps in cooling mode reject excess heat into the building loop to be consumed by heat pumps in heating mode.

When comparing historical central campus loop temperatures versus outside air temperatures, it is apparent that this load sharing occurs when outdoor air temperatures are between 25°F and 55°F. This wide load-sharing operating band greatly increases the overall efficiency of the system as the need for heat pump compressor operation is greatly reduced.

When compared to a conventional cooling and heating system consisting of water-cooled chillers and natural gas hot water boilers, this system has a demand reduction of ~650 kW (13%), an energy savings of ~1.3 GWh (10%), a natural gas savings of ~58,000 Dth (55%), and a water savings of ~10 million gallons, annually. Water savings were provided by the Grey Edge Group and were not part of this analysis. Seasonal coefficient of performance (COP) values are displayed in Table 1, below. Note that a typical boiler operates with a COP of 0.8, a typical chilled water system at 3.4, and electric resistance heating at 1.0. A larger number indicates increased system efficiency and lower energy consumption per unit heating or cooling.

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
Overall	**5.7**	**1.9**



Pipes connecting bore holes

Drill field east and south of Dominguez Hall

8" dia. Pipes between Central Loop And H.H

Top: The drill field in front of Grand Mesa Hall

Right: A drill rig

18” diameter HDPE Central Loop

METHODOLOGY

Due to the large number of input assets that make up the Colorado Mesa University (CMU) Geothermal network, monitoring the system in empirical fashion would have proven cost and time prohibitive. Statistical regression analysis was used to discern power requirements and equipment performance in lieu of establishing automation system trend logs or taking onsite power measurements. The results are not an investment-grade analysis but provide a realistic understanding of overall and seasonal system performance, when compared to conventional cooling and heating equipment.

DEFINITIONS

HX	Heat exchanger	WSHP	Water source heat pump
AHU	Air handling unit	kW	Kilowatt
CFM	Cubic feet per minute	GPM	Gallons per minute
HP	Horsepower	COP	Coefficient of Performance
EER	Energy Efficiency Ratio		

DATA GATHERING

- Historical hourly data from April 2022 to April 2023 was collected for weather, central loop temperature, and available loop assets.
- Loop assets include central loop water pumps, building pumps, bore field pumps, cooling towers, cooling tower pumps, irrigation heat exchanger (HX) pumps, water-to-water heat pumps, and water-to-air heat pumps.

- Additional data was collected on known asset values and building settings, such as heating capacity, cooling capacity, heating design temperature, and cooling design temperature.

ASSUMPTIONS

- Conventional cooling and heating equipment power and efficiencies were estimated based on ASHRAE 90.1 documentation.
- Assumptions include chillers (0.61 kW/ton), primary pumps (0.018 kW/ton), secondary pumps (0.026 kW/ton), cooling towers (0.059 kW/ton), condenser pumps (0.057 kW/ton), and AHU fan kW (812 kW).
- AHU fan kW was derived using the following methodology and conversion factors: 400 CFM/ton, 0.75 HP/1000 CFM, Supply Fan HP (0.3*Max loop load), Return Fan HP (0.12*Max Loop Load).
- The water source heat pump (WSHP) efficiency disaggregation was built based on conversations with campus staff and is as follows: 60% - 13 Energy Efficiency Ratio (EER), 10% - 13.5 EER, 10% - 15 EER, 10% - 16 EER, 10% - 18 EER.

EMPIRICAL DATA

- Empirical data, consisting of average loop temperature and outside air temperature, was utilized to determine the load sharing temperature range. This is the temperate range where different buildings connected to the central loop are sharing energy between themselves, and little additional source and sink energy is required from the bore fields or conventional equipment.
- Data revealed a load sharing range when outside air temperatures are between 25°F and 55°F.

CALCULATION METHODOLOGY

- Loop cooling loads were derived from the relationship between outside air temperature, system balance point, and the design cooling temperature.
- Loop heating loads were derived from the relationship between outside air temperature, system balance point, and the design heating temperature.

- Input asset power (kW) was calculated using regression analysis for the equipment that didn’t have historical trend data configured. These assets are outlined below.
    - Heat pump cooling kW was calculated through regression analysis. This regression was built based on a load curve from a WSHP.
    - Heat pump heating coefficient of performance (COP) was calculated through regression analysis. This regression was built based on a load curve from a WSHP.
    - Cooling tower kW was determined through use of a second order polynomial regression, to model fan power between 85°F and the cooling design temperature.
    - Loop and building pump kW were determined through use of a third order polynomial regression, to model pump power based on a dual temperature loop load profile, assumed flowrate (GPM), assumed pump head, and pump horsepower.
- COP was calculated as a function of total loop load and input power.
- Total input power was determined by summing all input assets.
- Seasonal and overall system COP was evaluated for the geothermal system compared to a conventional water-cooled chiller system.