Public Facilities Committee Report

City of Newton
In City Council

Wednesday, May 13, 2020

Present: Councilors Leary (Chair), Kelley, Crossley, Norton, Laredo, Danberg, Kalis and Gentile

Also Present: Councilors Downs and Malakie

City Staff Present: Bill Ferguson and Ann Berwick Codirectors of Sustainability

#61-20 **Discussion to limit or prohibit the installation of fossil fuel infrastructure**
COUNCILORS CROSSLEY, KELLEY, LEARY, NORTON, ALBRIGHT, GREENBERG, AUCHINCLOSS, MARKIEWICZ, NOEL, DANBERG, KALIS, DOWNS & HUMPHREY requesting a discussion with the Sustainability Team to create an ordinance to limit or prohibit the installation of fossil fuel infrastructure in new construction and substantially renovated buildings, as well as to clarify the Council's authority to prohibit the extension of gas.
Public Facilities Held 8-0 on 04/22/2020

Action: **Public Facilities Held 8-0**

Note:

Cadmus's Presentation:

Jeremy Koo, a representative from Cadmus, gave the attached presentation on heat pump technology. Mr. Koo explained that the presentation is just to provide information to the City and Cadmus is not choosing a side on what is being considered. Additionally, Mr. Koo explained that a heat pump is like an air conditioner that runs in reverse. At a residential scale heat pumps are either air source, ground source and water heater heat pumps. The air source heat pump has become increasingly more common and is available in both ducted and ductless systems. Ground Source heat pumps are often referred to as geothermal heat pumps, which transfers heat from the ground. This provides a more stable source of heat throughout the course of the year. The heat pump water heater operates in one direction by extracting heat from the surrounding air and moving it into a hot water storage tank. Heat pumps are much more efficient than electric baseboard heating. Mr. Koo explained that heat pumps have become more common as the heating source for new construction in Massachusetts. Attached is a graph of the growth of the Mass CEC Heat Pump program and the growth of other programs within the Northeast. Mr. Koo explained that the cost of installing all electric HVAC using heat pumps in new construction versus retrofitting the same equipment in existing buildings, would be different depending on the

existing systems. Mr. Koo explained the cost comparison of installing heat pumps versus traditional fossil fuel sourced systems in his attached presentation.

The Committee asked the following questions regarding Mr. Koo's presentation:

Q: Why would someone who is building a new all electric home not use a ductless system? Ducts are both expensive and take up a lot of space, the ductless system is easier.

A: Mr. Koo explained that he agrees that in a new home a ductless system is easier to install. Additionally, Mr. Koo explained that in the comparison he gave with a mini ducted system, the cost of the duct work could be smaller because there wouldn't be a need for central duct work running from the basement all the way through the house. A ductless system is the most common type of installation, but the comparison was given assuming a similar distribution system to show what happens when someone goes from gas to electric equipment only.

Q: Was there a comparison done between oil and all electric?

A: Mr. Koo explained that this comparison was not done because when looking at new construction in Newton the assumption would be that a new home would have a gas connection. Additionally, Mr. Koo explained that he may be giving future presentations on discussing the cost comparison when replacing oil-fired equipment with all electric when dealing with retrofits.

Q: What equipment would cost more when building an electric home, compared to other equipment that could be used?

A: Mr. Koo explained that with new construction an architect can design a home in a way that would make a ductless system possible, which is normally less expensive than ducted systems. Overall, the aesthetic preference and the configuration of the home can add to the cost of the project. A more complicated configuration of the house may require more units to properly balance the conditioned air but having more HVAC units may not meet with the owner's aesthetic preferences. In the retrofit market changing the distribution system or simply adding cooling units, adds cost.

Q: Is this technology moving forward in a way, where the landlords of rental properties would be incentivized to move to all electric?

A: Mr. Koo explained that there are challenges with incentivizing landlords to make these modifications to their properties and that there is not an easy answer to this question. The next presenter, Beverley Craig, will be focused on the impact to new construction of low income and multi-family housing.

Q: Why did the (cost comparison) analysis not include incentives for solar?

A: Mr. Koo explained that he did not include the incentives of using solar to show that the cost of a heat pump system without adding incentives into the equation is still positive. There is also no certainty that the incentives will stay where they currently are.

The Committee made the following comments regarding Mr. Koo's presentation:

This docket item is dealing with new construction and complete gut renovation. The City does not have the authority to make residents retro fit their homes, this would have to be an incentive based program.

Jonathan Kantar, a representative from Green Newton, explained that he agrees with the previous comment and added that if the Committee is only discussing new construction and complete gut renovation then the cost comparison of any system that requires duct work will be much more expensive a ductless heat pump system.

MassCEC Presentation:

Robert Fitzpatrick and Beverly Craig, representatives from the Massachusetts Clean Energy Center (MassCEC), presented the attached PowerPoint. Mr. Fitzpatrick explained that the MassCEC is a quasi-state agency who work underneath the Executive Office of Energy and Environmental Affairs. Additionally, Mr. Fitzpatrick explained that through their program they advocate for the electrification of buildings but are at this meeting just to provide information to the Committee.

Ms. Craig explained that MassCEC have been working with heat pumps for a while and that in the past several years there has been a dramatic increase of the amount of heat pumps that are being used in multi-family buildings. Part of this is because a developer is going to look at different options for heating and cooling and at first glance the cost of the heat pump can be less expensive because there is not a need for two parallel systems for heating and cooling. In terms of operating cost, a single home is going to pay a premium even with new construction because of the difference between gas and electric prices. Ms. Craig explained that if the building envelope were better insulated, then the premium would decrease. Additionally, Ms. Craig explained that 7 of 8 multi-family new construction affordable projects under the Passive House Design Challenge are using all heat pumps for heating and cooling.

Ms. Craig explained that there are some constraints with using heat pumps in multi-family buildings. With larger multi-family buildings there would need to be multiple domestic hot water units located in the basement of the property, which would cause that basement to be extremely cold. An owner of a multifamily building would want to go with a central domestic hot water system. Ms. Craig explained that a centralized heat pump hot water system is not commercially available in the United States. The Brookline bylaw allows gas-fired DHW in multifamily.

Additionally, Ms. Craig explained that Brookline's proposed bylaw makes an exception for back-up generators. Battery storage technology is improving, but not readily available as of now.

Additionally, Ms. Craig explained that an energy premium can be a burden on low-income households. Energy burden is a concept based on the cost of energy compared to the household income. Ms. Craig outlined this burden on higher, median, and low income households in her attached presentation.

The Committee asked the following questions regarding the MassCEC's presentation:

Q: Statewide, how is electricity getting greener?

A: Ms. Craig explained the percentage of the electricity coming from renewable resources is legislated to go up 2% each year. The Governor wants to be at 100% by 2050. In Newton, due to the Newton Power Choice program residents are at 62% renewable energy unless they have opted out. The cost to the resident has only increased slightly during the summer as compared to Eversource Basic Service. (Because large multifamily properties are not on basic service, they may not participate in Newton Power Choice). Ms. Craig explained that multi-family owners have the option to buy third-party energy that is at 16% renewable energy.

Q: For older buildings, are there steps people can take to make their homes more energy efficient?

A: Ms. Craig explained that improving the building envelope performance is most important. The next step would be looking at heat pumps, but a retrofit is more complicated than new construction.

Q: What are the incentives?

A: Ms. Craig explained that currently there are generous incentives for multifamily buildings of 5 units and above. Additionally, Ms. Craig explained that there are Alternative Energy Credits for producing thermal renewable energy.

Q: Within the City how will residents learn about how to make these changes?

A: Bill Ferguson, Co-director of Sustainability, explained that this will be the main job of the Energy Coach. A job description has been approved for the Energy Coach and the Mayor has the job in her budget starting January 2021. Ann Berwick, Co-director of Sustainability, explained that there is a robust process going on with both volunteers and City Staff to make sure that the Climate Action Plan actually gets communicated to the public and to find ways for the Climate Action Plan to be implemented.

The Committee made the following comments regarding the MassCEC's presentation:

The proposal the Committee is discussing is limited to new construction and gut rehabs. As the Committee moves forward that is something to think about and the costs need to be considered.

As the committee moves forward, there should be a way to summarize the different topics, including the cost. The sustainability director has indicated her intention to draft a summary of cost implications under different scenarios from today's presentation.

Mr. Kantar explained that the cost of a mini-split heat pump system or even a ducted mini-split heat pump system will be much cheaper than any gas ducted system in new construction.

Inspectional Services or other City Staff need to be able to educate developers on what the City is trying to do. The Energy Coach will also be critical in this process and in the process of communicating to residents.

Ms. Craig added that one thing that was not clear in the discussion of the technologies is that much of the discussion has been around heating. But new construction, single family and multi-family homes also need cooling. Often adding heat pumps to do both and are lower cost upfront than two separate systems, and heat pumps normally lead to lower cooling costs than a traditional air conditioner. This will become even more important as climate warms and cooling becomes a bigger cost than heating. By 2030 resiliency plans anticipate the number of days over 90 will triple.

Jesse Gray's Presentation

Jesse Gray, a Town Meeting Member in Brookline, presented the attached presentation on Brookline's prohibition on new fossil fuel infrastructure in new construction and substantial or 'gut' rehabilitation. Mr. Gray explained an overview of Brookline's bylaw, including the exceptions that Brookline would make under this bylaw. Additionally, Mr. Gray explained that their Bylaw is currently being reviewed by Massachusetts's Attorney General's Office. Since Brookline is a town all their bylaws need to be reviewed by the Attorney General's Office; the requirements are not the same for a city. Mr. Gray also explained the practical and consensus-building exemptions in his attached presentation. Not all the consensus-building exemptions would be necessary for every municipality. Additionally, Mr. Gray explained that there is a waiver process that will be reviewed by a new Sustainability Review Board on a case by case basis. Other communities use their Zoning Board of Appeals to serve this function. The rationale behind this bylaw is outlined in the attached presentation. Mr. Gray explained that there is much more work to be done to combat climate change and that this bylaw is just step in the process. Additionally, Mr. Gray explained that electric is a good source for cooking and hot water (using heat pumps) and that, eventually, with all-electric homes, emissions will decrease over-time. Mr. Gray then went through the projected impact that their bylaw will have in Brookline. This bylaw will result

in 15% of buildings in Brookline being fossil fuel-free by 2050 and will result in a reduction in the towns overall emissions.

Additionally, Mr. Gray explained the legal authority of their bylaw and explained that cities and towns can adopt local ordinances or bylaws in response to climate change if these actions are not inconsistent with existing state or federal laws. Mr. Gray also explained that the State has asked for a partnership with municipalities in the form of the Green Communities Act. To avoid conflicting with existing laws and regulations the Brookline bylaw does not regulate materials or methods, so as not to compete with the MA Building Code or Fuel Gas Code, does not create any new standards for gas or oil infrastructure or conflict with state policy on protecting access to utilities. Mr. Gray explained what else the Brookline bylaw does not regulate in his attached presentation. Additionally, Mr. Gray explained that the Attorney General's Office will rule on the legality of their bylaw.

Mr. Gray also gave an example of the construction and operating cost of a new 2,500 sq. ft. single-family home being built with all electric power. Using current pricing the annual operating costs would be $500 more with an all-electric HVAC but this premium could decrease with a tighter envelope. One reason it is cheaper to build electric homes is because of rebates that Mr. Gray outlines in his presentation.

Mr. Gray noted that outreach and consensus-building is critical during this process. Brookline has a team that includes architects, engineers, building contractors, HVAC contractors and installers, developers and lawyers. Additionally, Mr. Gray explained that they also received expert impartial advice from town legal staff and had a number of town meetings to collaborate with the public. Mr. Gray also explained that it is critical to be able to answer residents' questions or have an expert that can answer questions so that residents can fully understand what is being asked of them.

<u>The Committee asked the following questions regarding Jesse Gray's presentation:</u>

Q: How will heat pumps work if there is a power outage?

A: Mr. Grey explained that if there is a power outage now a boiler is not going to work because a typical boiler requires an electric ignition and does not have a back-up. This would be the same scenario for an all-electric system.

Q: Where did Brookline receive their legal advice; in particular the advice regarding Chapter 164?

A: Mr. Gray explained that the Town of Brookline's Law Department has recently weighed in on this matter in a brief to the AG's office. The Brookline Town Council has several pages of analysis on Chapter 164 regarding the legal validity of the bylaw. Additionally, Mr. Gray explained that

they consulted with outside lawyers and hired a lawyer to advise the Town on crafting the bylaw. Town staff was also consulted during this time. Mr. Gray also consulted with the counsel that Berkley, California used to craft their legislation. Mr. Gray offered to share all relevant legal briefs with the city.

The Chair noted that there will be future meetings on this topic.

Councilor Laredo motioned to hold item #61-20 which passed unanimously.

The Committee adjourned at 9:05 p.m.

Respectfully Submitted,

Alison M. Leary, Chair

ARTICLE 21

SELECT BOARD'S SUPPLEMENTAL RECOMMENDATION

Article 21 is a petitioned article asking the Town to create a new by-law that would prohibit the installation of fossil fuel infrastructure in new buildings and gut/significant rehabilitation projects in Brookline. For these types of construction projects, installing gas or oil piping would be prohibited. This will have the effect of preventing the installation of new major appliances (e.g., boilers, furnaces, clothes dryers) or other systems that require on-site combustion of fossil fuels (e.g., natural gas or oil) for these types of projects. Specific exemptions are outlined in the By-Law, and construction project can also seek a waiver from a to-be-created Sustainability Review Board.

Specific exemptions in the By-Law include exemptions for piping required to fuel backup electrical generators, cooking and related appliances, centralized hot water systems in buildings with floor areas of at least 10,000 square feet (provided that the Engineer of Record certifies that no commercially available electric hot water heater exists), any building being constructed subject to a Waldo-Durgin Overlay District Special Permit, research laboratories for scientific or medical research or to medical offices regulated by the Massachusetts Department of Public Health as a health care facility, among other exemptions.

The Sustainability Review Board will be a three or more member Town Board established and appointed by the Select Board with expertise in affordable housing; commercial development; high-performance sustainable design; architecture; mechanical, electrical, and plumbing engineering; or other technical areas as determined by the Select Board.

The effective date will be the later of (1) January 1, 2021, (2) 5 months after written approval is received from the Attorney General's Office, or (3) the date upon which the Sustainability Review Board and its procedures have been established.

Significant consensus has been built between various boards, committees, commissions, community stakeholders and co-petitioners during the vetting of this Article. The Board appreciates the efforts of the petitioners and the Advisory Committee to craft language that can be supported by a wide range of stakeholders.

The Select Board unanimously voted FAVORABLE ACTION on the motion offered by the Advisory Committee.

ADVISORY COMMITTEE'S SUPPLEMENTAL RECOMMENDATION

SUMMARY:
Article 21 is intended to be a major step towards achieving Brookline's goal of reducing its carbon emissions to zero by 2050. It would, with limited exemptions, prohibit the installation of new fossil fuel pipe infrastructure (natural gas, propane, fuel oil) in new construction and so called "Significant Rehabilitations".

The Advisory Committee recommends FAVORABLE ACTION on Article 21 in the form presented on November 5, 2019.

As of November 11, the petitioners were considering revisions to the article that have not been reviewed by the Advisory Committee. No recommendation should be inferred for any version submitted subsequent to the November 5, 2019 vote.

BACKGROUND:
Article 21 is sponsored by a team of petitioners which include architects, lawyers, members of various advocacy groups including Mothers Out Front and the Greenspace Alliance plus three members of the Select Board.

The proposal is intended to support the Brookline Climate Action Plan which states the Town's intention to reducing its greenhouse emissions to zero by 2050. One strategy is to begin requiring the complete electrification of new buildings and buildings undergoing significant renovations. While the short term greenhouse emissions effects of this strategy is dependent on the fuels used to generate electricity, it is Massachusetts state policy to increase the percentage of electricity generated from renewable sources over time. Additionally, Brookline sponsors a community aggregation program in which the default choice has a higher percentage of renewable sources than the Eversource default. Plus Town electric customers can opt up to the Brookline Green Option which has 100% renewable source. Lastly, individual electricity consumers can make additional renewable investments on their own using strategies such as installation of onsite solar panels or participation in community solar.

The bylaw would prohibit installation of new fossil fuel piping in new buildings and "significant rehabilitation" of existing buildings. The original proposal had limited exemptions for (1) portable appliances for outdoor cooking and heating (ie., propane barbeque grills), (2) backup electrical generators and (3) the Waldo Durgin project (since that was the subject of a separate negotiation with the Town.) The original proposed effective date was June 1, 2020, but that has been revised to the later of:

1. January 1, 2021
2. 5 months after the Attorney General approves the bylaw
3. The date upon which the SRB is appointed by the Select Board and after a public hearing publishes its procedures and decision criteria.

The proposal does not affect existing piping, boilers, stoves or water heaters. However, in a covered project, the bylaw as originally proposed would prohibit new piping to accommodate relocating any existing appliances. For example, in a covered "gut" renovation project (called a "Significant Rehabilitation" in the bylaw) that includes a kitchen renovation, the homeowner would not be able to install pipes to relocate a gas stove to the other side of the room or to even move it a few inches.

Under the version of Article 21 adopted by the Advisory Committee and accepted by the petitioners, proposal, residential cooking appliances such as ranges, ovens and stovetops would not be covered even in a "gut" renovation, thus allowing renovated kitchens to continue to have gas appliances, no matter where in the kitchen the homeowner wishes to place them.

The petitioners, the Planning and Community Development Department plus various Town Boards and commissions have sponsored or participated in a number of "community feedback" sessions in addition to the normal vetting hearings that take place for Town Meeting warrant articles. As a result of the feedback prior to the Planning and Regulation Subcommittee's public hearing, the petitioners added additional exemptions for (1) restaurant kitchens, (2) large central hot water systems (with an engineer's statement) and (3) added a waiver process where it would be otherwise impractical or financially infeasible to go with all electric systems.

Additionally, with input from the Building Commissioner, they have attempted to clarify the definition of significant rehabilitation to generally correspond to a "Level 3" renovation as defined in the Building Code for commercial buildings. Exemptions proposed by others which the petitioners did not accept were (1) an exemption for all cooking, (2) a broad exemption for commercial buildings; (3) including only single family homes, and (4) including only new construction.

DISCUSSION;

Electrification of our infrastructure is one strategy to reduce and eventually eliminate our reliance on fossil fuels. Currently, fossil fuels (mainly natural gas in New England) are used to generate a percentage of our electricity, which percentage will decrease over time as more renewable generating sources come on line. No one on the Advisory Committee took issue with the need to reduce our carbon emissions and the electrification strategy. This report will now focus on the details of the proposed bylaw and the practical aspects of the proposal.

When the bylaw was originally submitted, the petitioners listed two exclusions; outdoor cooking and heating appliances and the Waldo-Durgin project. Waldo-Durgin was excluded because it was the subject of a Memorandum of Understanding with the Town which specifically addressed how the approaches to energy efficiency are to be handled

including involving the Town's Sustainability Program Administrator during the design phase.

Note that the bylaw only applies to new construction and so called gut renovations. No one is required to replace any existing gas appliances. Even in a gut renovation, a gas appliance can be replaced; but no new piping can be installed unless there is an exemption. But, in order for this to work, we need to have a sense of reality as to what can be replaced by electric appliances.

Heating and Cooling

In New England, space heating consumes the most energy in buildings. In Brookline, the predominant fuel source is natural gas and fuel oil. Many factors contribute to the amount of energy consumed including the efficiency of the heating appliance (furnace, boiler, heat pump, etc.) and how well the building envelope is insulated and sealed. This bylaw only addresses the fuel source, which is only one piece of the equation.

Typically, we think of electric heat as utilizing baseboard resistance heaters, which are cheap to install but very expensive to operate. The preferred electric heat sources now are either ground source or air source heat pumps. Heat pumps can be used for both air conditioning in summer and heating in winter. In winter, the refrigerant absorbs heat from the air outside (or the ground) and uses it to warm the space. Ground source heat pumps use heat drawn from geothermal wells to facilitate heat transfer. Generally, heat pumps are extremely efficient to operate (however as the temperature drops, heat pumps become less efficient and there is a point where they stop working though with today's heat pump they will work to as low as -25F degrees. The Planning and Regulation Subcommittee heard testimony that the industry is moving towards heat pumps as the preferred space heating and cooling technology and it works well for most applications.

Given the variety of commercial building types and their uses, blanket claims of practicality and financial feasibility of the technology for all uses are difficult to substantiate. The Planning and Regulation Subcommittee heard testimony that at least laboratories and certain types of medical offices have higher air circulation and replacement requirements, which heat pumps may not always be able to handle. We also need to balance the Town's critical financial need to be competitive with other communities with respect to promoting development of buildings devoted to medicine and science with its overall goal of reducing greenhouse emissions. The Town is in a unique position to leverage its close proximity to one of the world's great medical/science complexes.

The Advisory Committee therefore proposed, and the petitioner accepted, an exemption for such uses given the difficulty of quantifying the requirements to a degree sufficient to write into a bylaw in the timeframe of this Town Meeting. The failure to have a lab/medical exemption could work to divert such development to other close-by communities.

Domestic Hot Water

For residential and smaller commercial uses, there are practical alternatives to a gas hot water heater. These include traditional resistance and the newer technology heat pump hot water heaters.

For large central hot water systems, there are currently no alternates to the traditional gas hot water heater. Many large buildings are moving away from central hot water to a distributed hot water system, (the water is heated just prior to the using fixture or for a floor or unit in a building.), For systems of this type, there are electric alternatives.

The proposed bylaw does not mandate moving away from a central hot water system, and it implicitly recognizes the lack of alternatives. However, if an alternative becomes available, there is an exemption in the proposal if the alternative is more than 150% of the capital or operating cost of a conventional gas water heater as certified by an engineer. While at first glance a 150% cost differential seems high, remember that the requirement is only in effect for new construction or a "significant rehabilitation," where hot water will be a very small fraction of the total project cost.

Cooking

Cooking is where residents have the most interaction with natural gas. The bylaw, as originally submitted would have prohibited new fossil fuel infrastructure for cooking appliances.

There are two electric alternatives to the traditional gas range and stove top; the standard resistance electric range and the induction electric stove top. While resistance stoves work, they deliver a different, less controllable cooking experience. Induction stoves deliver a controlled cooking experience similar to natural gas but require cookware to be made of a magnetic based material such as cast iron or magnetic stainless steel. Aluminum or copper cookware does not work.

The subcommittee received an email and heard testimony from Dr. Jeffrey Macklis, Professor of Stem Cell and Regenerative Biology, Harvard University, and Professor of Neurology [Neuroscience], Harvard Medical School. Dr. Macklis researched induction stoves when he was considering purchasing one.

> "In brief, I found that the EU regulations and analyses show that a single burner on is reasonably safe for an adult user if the pan is of "appropriate"-correct size (completely covering the burner) and is perfectly centered with precision, but that this safety disappears for a pregnant abdomen with fetal head (developing brain) closer than 1 foot away, or a small child whose head (developing brain) would get closer than 1 foot away from the front of a burner. The EU agencies all point out that pregnancy and small children position developing brains directly at the least safe position– adjacent to the cooktop and at its level. That is because the main risk is within a foot or so (30 cm) of a burner, and electromagnetic field strength from the induction cooktop is limited by EU/Swiss/now US recommendation to approximately 6 uT (microTesla). While essentially all modern residential cooktops meet this standard for a single burner on with an optimally sized pot/pan that is

> perfectly centered, they fail under "real world" scenarios. Unfortunately exposure with a differently sized pot/pan or one that is not optimally centered is often found to be ~5X higher (>30 uT!) than the regulatory agencies use as their acceptable limit! This even exceeds adult "occupational limits" set by the agencies. If more than one burner is on (e.g. for a normal meal or worst at a Thanksgiving dinner), the leakage around centered or uncentered pans is additive, though some will be further away than others."

Dr. Jesse Gray, disagreed with Dr. Macklis's assertions as follows:

> "The concern raised here is a hypothetical one, since induction cooktops have been in widespread global use for decades without any demonstrated adverse health effects. No health or consumer protection authorities have banned induction cooktops for health or any other reasons, and there isn't a single peer-reviewed epidemiological study implicating induction cooking in any negative health impact. The petitioners brought this proposed by-law forward for climate reasons, not health reasons. However, in considering health, the competing technologies must be weighed against each other, since all technology has risks, and people are going to cook with one technology or another. As it stands, there is more substantial evidence about the dangers of gas cooking than there is about induction cooking. Gas cooking kills about 8,000 people every year in the United States due to fire. There are also well-documented health impacts from combustion byproducts of gas cooking, including asthma, that should be weighed against any hypothetical health impacts of induction cooking. These impacts of gas cooking are supported by numerous peer-reviewed epidemiological studies, unlike the speculative induction concerns."

Given (1) the competing health arguments, (2) the strong feelings by some about gas as a cooking energy source and (3) the unintended effect of prohibiting even small relocations of gas appliances in some kitchen renovations, the Advisory Committee was not prepared to support a complete ban of gas cooking appliances in projects subject to the bylaw at this time, and the petitioner accepted a cooking appliance exemption that includes residential properties.

<u>Unsafe or Dangerous Condition Exemption</u>

As originally submitted, the bylaw would not have permitted the repair of unsafe or dangerous existing gas infrastructure. An exemption has been added and agreed to by the petitioners.

<u>Waivers and Appeals</u>

This is a new area with developing technology and an all-electric infrastructure may not be practical or financially feasible in all situations not explicitly exempted by the bylaw. The Advisory Committee proposal creates a waiver and appeal process for these situations.

The Planning and Regulation Subcommittee heard concerns from the Economic Development Advisory Board, with respect to commercial development, the Housing

Advisory Board with respect to affordable housing and the Brookline Housing Authority with respect to their properties. For affordable housing in particular, capital funds may be limited to make investing in systems with lower operating costs in the long run difficult.

For all these Boards, a robust and effective waiver and appeal process is an essential component in coming to support the bylaw. The proposal establishes a "Sustainability Review Board" (SRB) to hear and decide waivers and appeals. The bylaw specifies that members shall possess areas of expertise with regards to affordable housing, commercial development, high-performance sustainable design, architecture, and mechanical, electrical, and plumbing engineering plus other technical areas as determined by the Select Board. The bylaw sets a general standard of review but requires the SRB to adopt procedural requirements with regard to filing waivers and appeals and criteria to evaluate projects. And one of the prongs for the effective date of the bylaw is the establishment of SRB and adopting procedures and criteria of review.

Other Municipal Ordinances

The movement surrounding mandating fossil fuel free infrastructures by municipal ordinance is a new one with the first such ordinance being passed in Berkley, CA on July 16, 2019. To the best of our knowledge, in the United States, only three other municipalities, all located in California, have passed similar ordinances since then. Other municipalities are considering this kind of legislation. All enacted ordinances, to date, cover only new construction and have various exemptions. They are summarized in the chart below:

City	Ord. Name	Summary	Exemptions	Commercial Buildings?
Brookline, MA (Proposed)	Article 21	Bans new fossil fuel infrastructure in all new construction and "Significant Rehabilitation(s)."	1. All cooking appliances 2. Backup generators 3. Outdoor cooking and heating 4. Large central hot water heaters 5.Waldo Durgin 6. Labs and certain medical offices 7. Repair unsafe conditions 8. Waivers if "financially infeasible or impractical"	Yes
Berkley CA	Ordinance No. 7.672–N.S.	The Berkley ordinance prohibits natural gas in **new** buildings. The ordinance is being rolled out gradually as the California Energy Commission (CEC) models different types of all-electric buildings. Currently, the ordinance bans installation of natural gas lines in low-rise residential buildings. As the CEC completes its modeling, the ordinance will expand to include additional building types.	Exemptions possible when a developer can demonstrate that all-electric isn't "physically feasible". There is also a general "public interest exemption" for cases where gas might be in the public interest to install vs. electric.	Eventually

City	Ord. Name	Summary	Exemptions	Commercial Buildings?
San Luis Obispo, CA	Clean Energy Choice Program	The Clean Energy Choice Program "encourages" all-electric **new** buildings. "Unlike some cities that are banning natural gas entirely, the Clean Energy Choice Program will provide options to people who want to develop new buildings with natural gas. New projects wishing to use natural gas will be required to build more efficient and higher performing buildings and offset gas use by performing retrofits on existing buildings or by paying an in-lieu fee that will be used for the same purpose.	Commercial kitchens are exempt. Various exemptions for "public health and safety" (e.g. hospitals) and an exemption for manufacturing that requires gas (see page 39 of ordinance for full list). The Clean Energy Choice Program also includes a "Public Interest Exemption", which allows the permitting authority to exempt projects should unexpected or unintended effects of the program arise.	Yes
Windsor, CA	Ordinance Adopting All-Electric Reach Code	All-electric requirement for **new** single-family homes, detached accessory dwelling units, and multi-family buildings up to three stories (also referred to as “low-rise residential”)		No
San Jose. CA	Building Reach Code for New Construction	The passed ordinance will ban natural gas in the construction of **new** accessory dwelling units, new single family homes and new low rise and multifamily buildings.		Yes

City	Ord. Name	Summary	Exemptions	Commercial Buildings?
Menlo Park, CA	Ordinance No. 1057	Heating systems in all **new** homes and buildings in the city must run on electricity, and all new commercial, office and industrial buildings, as well as high-rise residences, must rely entirely on electricity. Although new one- and two-story homes will be allowed to have natural gas stoves, they must be built "electric ready" with the proper wiring to enable all-electric operation in the future.	Life sciences buildings and public emergency operations centers (e.g. fire stations) need to apply for an exemption, but are eligible. For single family and three stories or less multifamily: Natural gas can still be used for stoves, fireplaces or other appliances if desired (but prewiring for electric appliances is required where natural gas appliances are used.). Nonresidential kitchens, such as for-profit restaurants and cafeterias, may appeal under certain conditions to an appointed body designated by the City Council if they want to use natural gas stoves. The advisory body's decision can be appealed to City Council.	Yes

What renovations should be covered in addition to new construction?

Other than the Brookline bylaw, all of the bylaws referenced in the chart above cover only new construction. With new construction, the entire project can be planned and designed to maximize energy conservation and take into account the design requirements of all electric systems. Renovations present a set of complications since an all electric system will need to be retrofitted into an existing building envelope which was, in all likelihood, designed around a fossil fuel infrastructure. This only begins to make sense if all the walls are open which would be the case in a so called "gut" renovation. The Advisory Committee worked with the Building Commissioner and other staff in coming up with a legal definition that is understandable, relatively easy to enforce and, hopefully, minimizes the

unintended consequence of creating a trigger where walls are not open to the degree necessary to perform a deep energy efficiency retrofit.

For buildings subject to the commercial building code (residential buildings with 3 or more families plus commercial buildings), there is already a well-defined trigger called a Level 3 renovation when triggered, requires a high degree of code compliance. Building professionals plus the Town Building Department are familiar with this trigger and it is easily computed. For those properties, it makes sense to incorporate a Level 3 renovation into the definition of "Significant Rehabilitation."

In the residential building code, there is no parallel concept to a Level 3 commercial renovation. Our intent is to use the existing definition of Gross Floor Ratio in the zoning bylaw as the denominator to compute the percentage to define a "Significant Rehabilitation." Since we do not want to have an inadvertent trigger, we are opting to set the trigger percentage to a very high 75%. As we gain experience with the bylaw and gather data on how it is working, the percentage trigger can be adjusted at a future Town Meeting, if appropriate.

Legal issues

In Massachusetts, municipal ordinances cannot supersede the state building code which covers plumbing and other aspects of the building envelope and components. This proposed bylaw is constructed in way that attempts not to supersede the code but it is breaking new ground. As such, according to Associate Town Counsel Jonathan Simpson, there is no history or case law that directly speaks to the legal analysis of whether this bylaw is preempted. However, Mr. Simpson has cautioned that there could be several statutes that may preempt what this bylaw is attempting to do. The Office of the Attorney General (OAG), which reviews bylaws passed at Town Meeting, will not issue preliminary opinions, so the only way to know for sure whether OAG will approve a By-Law such as this, is to pass it at Town Meeting and submit it for OAG review. Even if we receive a rejection from the OAG, we will have gained some clarity as to how to approach this issue in the future. Note that even if the Attorney General approves the bylaw, it would still be subject to challenge by other parties.

Effective Date

As noted above, sufficient lead time for homeowners and developers has been provided to adjust their plans to comply with this bylaw.

RECOMMENDATION:

By a vote of 21-4 with four abstentions, the Advisory Committee recommends FAVORABLE ACTION on Article 21 as follows:

Voted: That the Town amend the General By-Laws by adopting a new article 8.39 entitled "Prohibition on New Fossil Fuel Infrastructure in Major Construction" as set forth below.

8.39.1 Purpose
This By-Law is adopted by the Town of Brookline, under its home rule powers and its police powers under Massachusetts General Laws, Chapter 40, Sections 21 (clauses 1, 18) and 21D, and Chapter 43B, Section 13, to protect the health and welfare of the inhabitants of the town from air pollution, including that which is causing climate change and thereby threatens the Town and its inhabitants.

8.39.2 Definitions
"New Building" is defined as a new building or new accessory building (a building devoted exclusively to a use accessory to the principal use of the lot) that is associated with a valid building permit application on or after the Effective Date.
"On-Site Fossil Fuel Infrastructure" is defined as fuel gas or fuel oil piping that is in a building, in connection with a building, or otherwise within the property lines of premises, extending from a supply tank or from the point of delivery behind a gas meter (customer-side of gas meter).
"Significant Rehabilitation" is defined as a renovation project associated with a valid building permit application on or after the Effective Date of this article that:

(1) For existing structures regulated by the current edition of the Massachusetts State Building Code 780 CMR 51.00, Massachusetts Residential Code, includes the reconfiguration of space and/or building systems, in which the Work Area, not including any added space, is more than 75% of the Gross Floor Area as defined in the Brookline Zoning By-Law;
(2) For existing structures regulated by the current edition of the Massachusetts State Building Code 780 CMR 34, the Massachusetts State Basic/Commercial Code, includes the reconfiguration of space and/or building systems, in which the Work Area, not including any added space, is more than 50% of the building floor area prior to the project, as defined by the Massachusetts Building Code.

"Sustainability Review Board" (SRB) is defined as a Town Board established and appointed by the Select Board whose members shall, to the extent possible, possess areas of expertise with regards to affordable housing, commercial development, high-performance sustainable design, architecture, and mechanical, electrical, and plumbing engineering and other technical areas as determined by the Select Board. The SRB shall have at least three members with three year staggered terms. The mission charge of the SRB shall be set by the Select Board. The mission charge shall be broad enough to perform the requirements of Sections 8.39.5 and 8.39.6.
"Work Area" is defined as the portions of a building affected by renovations for the reconfiguration of space and/or building systems, as indicated in the drawings associated with a building permit application. Areas consisting of only repairs, refinishing, and/or incidental work are excluded from the Work Area.

8.39.3 Applicability

The requirements of this article shall apply to all permit applications for New Buildings and Significant Rehabilitations proposed to be located in whole or in part within the Town as follows.

A. The requirements of this article shall not apply to utility service piping connecting the grid to a meter, or to a gas meter itself.
B. The requirements of this article shall not apply to piping required to fuel backup electrical generators.

C. The requirements of this article shall not apply to piping required for cooking appliances and related appliances.

D. The requirements of this article shall not apply to the use of portable propane appliances for outdoor cooking and heating.

E. The requirements of this article shall not apply to the piping required to produce potable or domestic hot water from centralized hot water systems in buildings with floor areas of at least 10,000 square feet, provided that the Engineer of Record certifies that no commercially available electric hot water heater exists that could meet the required hot water demand for less than 150% of installation or operational costs, compared to a conventional fossil-fuel hot water system.

F. So long as new fossil fuel piping is not installed, the requirements of this article shall not apply to the extension or modification of heating systems via HVAC system modification, or modification of radiator, steam, or hot water piping.

G. The requirements of this article shall not apply to any building being constructed subject to a Waldo-Durgin Overlay District Special Permit, as described in Section 5.06.4.k of the Zoning By-Law.

H. The requirements of this article shall not apply to research laboratories for scientific or medical research or to medical offices regulated by the Massachusetts Department of Public Health as a health care facility.

I. The requirements of this Article shall not apply to repairs of any existing portions of a fuel piping system deemed unsafe or dangerous by the Plumbing and Gas Fitting Inspector.

8.39.4 Effective Date and Enforcement

Upon the Effective Date, no permits shall be issued by the Town for the construction of New Buildings or Significant Rehabilitations that include the installation of new On-Site Fossil Fuel Infrastructure, except as otherwise provided in Sections 8.39.3, 8.39.5, and 8.39.6. As used herein, “Effective Date” shall be the later of (1) January 1, 2021, (2) 5 months after written approval of Article 8.39 is received from the Attorney General’s

Office, or (3) the date upon which the SRB has been appointed and, after a public hearing, has adopted procedural requirements with regard to filing waivers and appeals and criteria to evaluate projects under Sections 8.39.5 and 8.39.6.

8.39.5 Waivers
A waiver from Article 8.39 may be sought from the SRB on the grounds of financial infeasibility supported by a detailed cost comparison, inclusive of available rebates and credits, or impracticality of implementation. A waiver request may be made at any time and may be based upon submission of conceptual plans. The SRB shall apply its criteria to evaluate whether particular portions of a project are financially infeasible or impractical to implement under the requirements of Section 8.39 and shall issue waivers narrowly for those portions, where appropriate, rather than for an entire project. Particular consideration for waivers will be given to projects sponsored by the Brookline Housing Authority (BHA), given the BHA's limited sources of capital funds.

8.39.6 Appeals
An appeal may be sought from the SRB following a denial of a building permit on the grounds that Article 8.39 is not applicable to a project pursuant to Section 8.39.3. Any appeal shall be supported by detailed information documenting the basis of the appeal.

ARTICLE 21

PETITIONER'S SUPPLEMENTAL EXPLANATION

Summary

This by-law will prohibit installation of fossil fuel piping in new buildings and in major renovation of existing buildings. Consequently, this policy will require heat, hot water, and appliances that are installed during new construction and major renovations to be all-electric. This by-law is intended to facilitate a practical transition to fossil fuel free buildings, and it thus provides for some exemptions including for fuel piping for backup generators, for cooking, and for central domestic hot water systems in large buildings.

Rationale

We are facing a global climate crisis. This climate crisis directly affects Brookline residents and businesses. Massachusetts is one of the fastest-warming states in the country. We have seen a rapid increase in extreme heat events that threaten the health of our children, our seniors, and those who need to work outside, not to mention our fragile ecosystem's plants and wildlife. Rising seas and increased flooding threaten Boston and coastal communities. Public health risks include an increase in heat-related illnesses and deaths, as well as outbreaks of insect-borne and waterborne diseases. As natural ecosystems change or collapse, Massachusetts farmers, fishermen, and residents will suffer.

In its Climate Action Plan, and consistent with state direction in the Green Communities Act, Brookline has committed to reducing its carbon emissions to zero by 2050. More recently, the United Nations International Panel of Climate Change announced in 2018 that we must reduce our carbon emissions by 50% by the year 2030 in order to avoid the most catastrophic effects of climate change. Buildings account for 60-70% of Brookline's emissions. Every new building constructed with fossil fuel infrastructure makes our emissions goal harder to achieve by lighting a new fire that will burn, on and off, for thirty years or more. To meet our climate goal, each of these fires will need to be put out through the retrofitting of buildings. It is unfair to the next generation to continue to install infrastructure that we already know will need to be replaced in a very short time. This by-law is an essential step if we are to have any hope of reaching Brookline's climate goals of zero emissions by 2050.

Eliminating fossil fuel infrastructure during new construction or major renovations is by far the most cost-effective way to decarbonize. All-electric construction is practical and feasible now. Numerous all-electric buildings have been built recently in Massachusetts (see Appendix B), demonstrating the feasibility and practicality of all-electric construction. Assuming that 0.5% of the building stock in Brookline is rebuilt or significantly renovated per year, this by-law would decarbonize 15% of our buildings by 2050.

All-electric buildings can operate immediately with zero emissions by purchasing 100% renewable electricity via programs such as Brookline Green Electricity. Even electric buildings using the default New England electrical grid mix are greener now than gas buildings, and they become greener every year as the electrical grid incorporates more and more renewable electricity generation, with a state-mandated minimum of 60% renewable energy by 2050.

Figure 1: Comparing the Greenhouse Gas Emissions of an All-Electric House with Air Source Heat Pumps to a House with Natural Gas Heat and Hot Water

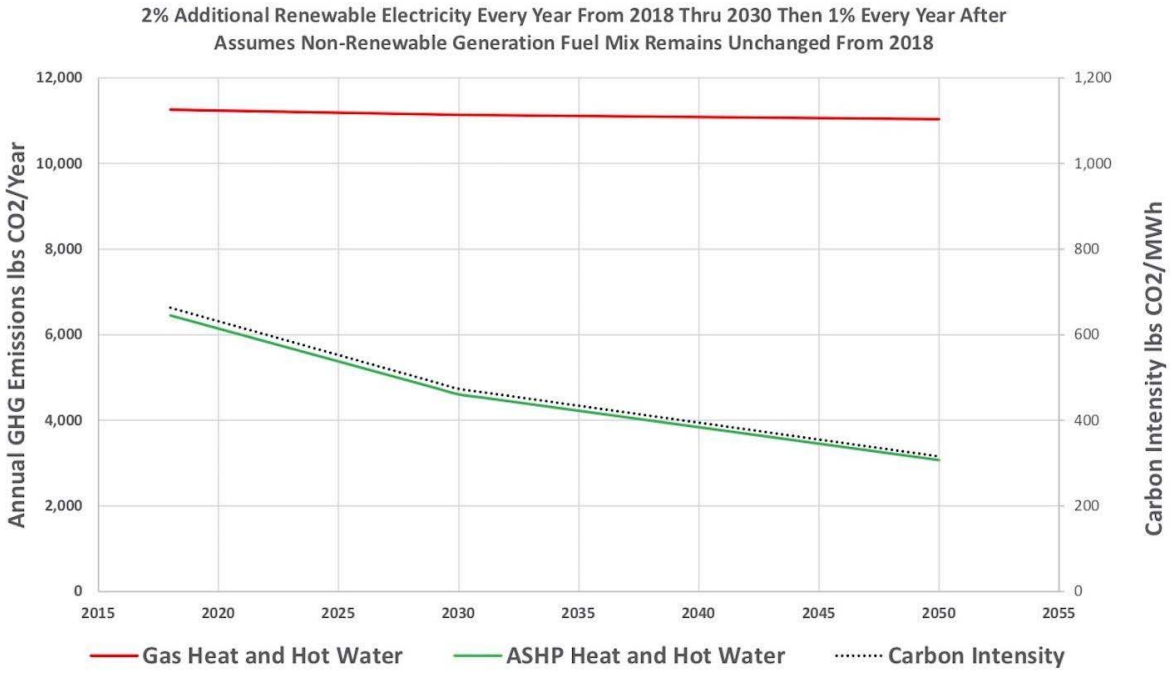


Figure 1 compares projected carbon emissions for a single-family home built in Massachusetts using air-source heat pumps to provide electric heat and hot water with a similar home that uses gas heat and gas hot water. This projection assumes the home uses the default electricity provider, which will include more renewable energy over time.

All-Electric Building Technology

Cost-effective and energy-efficient systems exist today for heating and cooling, domestic hot water, and other appliances for most buildings and applications.

Space heating and cooling. Heat pumps are air conditioners that can operate in reverse. Even in cold weather, they extract heat from outside air and move it into the building. Because heat pumps move heat rather than generating it, they are very efficient. Dramatic improvements in heat pump technology and building envelope technology now make it practical and cost-effective to heat new buildings with electricity in our climate.[1]

Most new Brookline buildings have air conditioning. In buildings with both heating and air-conditioning, heat pumps save money in two ways. First, only a single system needs to be purchased and installed (rather than separate air conditioning and heating systems). Second, heat pumps are more efficient than air conditioners and save on electricity costs.

Hot water heating. An electric heat pump hot water heater can be purchased from local home improvement stores and costs about the same to buy and operate as a gas-fired hot water heater. The costs of gas, electric resistance, and electric heat pump hot water heaters are described in Appendix A.

Other Appliances. Clothes dryers, ovens, and cooktops are also available in all-electric options. Many buildings already use electric resistance dryers. An alternative option, less expensive to operate, is the heat pump electric dryer. Compared to gas or most electric resistance dryers, heat pump dryers have the advantage of not requiring any outside venting. In the kitchen, electric or induction cooktops and electric ovens provide alternatives to gas.

All-Electric Building Costs

Construction Costs: All-electric construction is, in most cases, highly practical and essentially cost neutral. For example, one model commissioned for MassSave estimates a $754 construction cost premium for a 2,500 sq. ft. all-electric single-family home, compared to the same home fitted with the most efficient gas heat and hot water systems and electric central air conditioning. This premium is less than a 0.1% increase in cost for a similar new home in Brookline, and it does not include available incentives that result in a net savings on construction of the all-electric home.

Operating Costs: Building operation costs vary widely depending on building type, whether a building is new or retrofitted, whether a ground source or air source heat pump is used, whether solar is installed, the extent of air sealing and insulation, and other variables. To cite one example, buildings that are air-sealed and insulated to Passive House standards can use less than 10% of the energy of many existing buildings, a difference in cost that is far greater than the differential cost of fuels.

A relevant operating cost comparison comes from the same MassSave model cited above. Under this model, operation of a brand-new all-electric home in Massachusetts would be slightly more expensive than that of a brand-new gas home (by $41 per month). However, this $41 per month cost premium must be put into context. First, this cost increase is less than 1% of expected monthly costs on a newly built 2,500 sq. ft. Brookline home, including utilities, mortgage, and real estate tax payments. Second, when new all-electric buildings are compared with older existing buildings, in which most of us in Brookline live, the new all-electric buildings are significantly less expensive to operate than the existing gas buildings, due to the far better air sealing and insulation required in new buildings.

Appendix A -- Frequently Asked Questions

Q: Will this measure be effective (even if adopted beyond Brookline), or will the consequence simply be that more fossil fuels will be consumed in electricity generation?

If the occupant of a new all-electric building chooses to buy 100% renewable electricity, that all-electric building will operate with low-carbon energy from the moment it begins to operate, which is a dramatic reduction in emissions.

Assuming the occupant relies on the standard grid mix, a new all-electric building built today would have lower overall emissions than an otherwise identical building with gas heat and appliances in the first year of operation (see Figure 1 above). These emissions savings will increase each additional year, as the grid greens through an existing statewide legislative mandate that requires a minimum 60% carbon-free grid by 2050. This grid greening is likely to be accelerated further at the state level and through Brookline's Green Electricity program. Thus, the emissions savings are very large compared to a building that burned natural gas over the course of those 31 years.

Q: In light of the heat wave and the power outages in NYC, if we go all electric what happens to the chance of overloading of the grid? Will there be more power outages as a result?

Electrical demand is currently declining in New England due to solar panels on building roofs and gains in energy efficiency. There are declines in both annual and peak demand, and these declines are expected to continue. In addition, our electrical grid is currently adding significant renewable generation -- utility-scale wind and solar.

The proposed bylaw policy affects too few buildings too slowly to affect the electrical grid significantly. This new building policy will affect such a small fraction of buildings on the grid (~1% turnover in any one year, even if adopted across the entire New England grid territory), that it should not have an appreciable impact on the power grid, which already has year-on-year variation exceeding 1%.

Peak consumption is already a significant challenge to manage. But right now peak consumption is a summer problem, when AC kicks in on hot days. Because winter heating and summer AC are the biggest consumers of electricity in buildings, the proposed all-electric requirement would not have a large impact on summer peaks, as people already use electricity for air conditioning.

Q: What happens if the electricity goes out? Will we be able to have gas back-up generators? Do you have exemptions or waivers for certain facilities that would need back-up systems such as nursing homes or daycares?

This policy would not affect what happens when the power goes out, which is that most buildings would lose their heat. The reason is that today's boilers and furnaces typically require both the gas AND the electrical grid, because they have electronic ignition systems that lack battery backups. Therefore, most buildings in Brookline are already fully dependent on the electrical grid for their heat. For the few buildings, including schools and nursing homes, that need or want backup heating, the proposed policy includes an exemption for fuel pipes for backup generators.

Q: If this by-law is challenged in court, will it pass muster?

Like any ground-breaking law, this by-law may be challenged. But its rationale has been carefully thought through, and it is based on several months of legal research. We consulted with many lawyers. We cannot guarantee that this by-law will withstand legal challenge, but we have made it as legally defensible as possible. The only way to find out if it will pass legal muster is to pass it.

Q Will there be only a few contractors that can design build these systems? Will that drive costs up?

Many HVAC contractors have significant experience installing air source heat pumps. Ground source heat pump systems (sometimes referred to as "geothermal systems") have also been installed state- and nation-wide for several decades.

Q: What if this by-law triggered the need for a significant upgrade of the electrical service to an existing building? For example, a 50-unit building that has original wiring from the street to the building from the 1940's. What if the electrical upgrade costs $200,000?

Major renovations to multi-unit buildings cost millions to tens-of-millions of dollars. The $200,000 electrical upgrade cost must be considered in that context. This is precisely why the proposed by-law trigger is major rehabilitations and new construction.

Q: Does WA21 apply if I want to build an addition to my house?

As currently written, the work area *in the original space* would have to be over 50-75% of the original structure to trigger the by-law in the context of an addition. Just an addition alone without major rehabilitation in the existing portions of the building would not trigger this by-law. The vast majority of additions, such as adding a porch or remodeling a kitchen, do not meet this threshold. Even if the work area *in the original space* exceeded the 50-75% floor area threshold, it would still be permissible to keep an oil or gas boiler. In other words, ducts or water/steam pipes could be extended from the existing boiler or furnace into the addition. However, in this instance, fuel piping could not be installed into the new addition.

Appendix A -- Comparing Hot Water Heater Options

Manufacturer	Model	Type	Description	Price	Annual Energy Cost
A O Smith	ATI 240H 101	Tankless	Gas: Condensing	$912	$280
Rinnai	(RU1601) REU-N2530FF-US	Tankless	Gas: Condensing	$1,460	$280
Rinnai	(RUR1991) REU-NP3237FF-US	Tankless	Gas: Condensing	$2,014	$280
Rinnai	REU-VC2025FFU-US	Tankless	Gas: Condensing	$687	$282
Westinghouse	WGR050**076	Tank	Gas: Condensing	$1,951	$290
Rheem	XE80T10HD50U1	Tank	Electric: ASHP	$1,700	$306
A O Smith	HPTU-50N	Tank	Electric: ASHP	$1,380	$346
A O Smith	HPTU-66N 120	Tank	Electric: ASHP	$1,679	$356
Rheem	XG50T12HE40U0	Tank	Gas: Non-Condensing	$689	$407
Rheem	XE50M09EL55U1	Tank	Electric: Resistance	$524	$796

Comparing the Price and Operating Cost of a Variety of Hot Water Options

This table compares various types of hot water heaters based on data from the US Department of Energy. The prices are from Home Depot or similar outlets. The energy costs are based on what Brookline customers would be charged by Eversource and National Grid.

Appendix B - Sample Buildings in New England with Electric Systems

Residential (up to 3 family)

Building name	Heating and Cooling	Hot water	Location
All-electric house, rehabilitated in 2018 by Byggmeister	**ASHP**	**Electric**	**Fisher Hill, Brookline, MA**
Holland House, Passive, LEED Platinum, Hutker Architects	**ASHP**	**Electric**	**Vineyard Haven, MA**
Torcellini residence, Paul Torcellini	**ASHP, GSHP**	**Electric**	**Eastford, CT**
South End Row home by Zero Energy Design	**ASHP**	**Electric**	**Boston, MA**
Dartmouth Oceanfront House by Zero Energy Design	**ASHP**	**Electric**	**Dartmouth, MA**
Wellfleet modern house by Zero Energy Design	**ASHP**	**Electric**	**Wellfleet, MA**
Thoughtforms Net positive farmhouse by Zero Energy Design	**ASHP**	**Electric**	**Lincoln, MA**
Mediterranean style green home by Zero Energy Design	**ASHP**	**Electric**	**Newton, MA**
Marshview house by Zero Energy Design	**ASHP**	**Electric**	**Chatham, MA**

ASHP = Air Source Heat Pump, an all-electric technology for cooling and heating a building that is similar to an air conditioner but can also function in reverse to provide heat.
GSHP = ground source heat pump, similar to an ASHP but is more efficient due to its use of the ground, rather than the air, for heat transfer to and from the building.

Office buildings

Building name	Heating and Cooling	Hot Water	Location

Walden Pond Visitor Center, LEED, Passive, Maryann Thompson Architects	ASHP	Electric	Concord, MA
Bennington Superior Courthouse, Net Zero ready, Maclay Architects	GSHP		Bennington, VT
Massachusetts Fish & Wildlife Headquarters, Net Zero, Ellen Watts, Architerra	GSHP	Electric	Westborough, MA
The Studio for High-Performance Design and Construction, Passive, Studio HPDC	ASHP	Electric	Newton, MA
185 Dartmouth, Bargmann Hendrie + Archtype	Heat pumps		Boston, MA
Olympia Place, DiMella Shaffer and Holst Architecture	Heat pumps	Propane	Amherst MA

ASHP = Air Source Heat Pump, an all-electric technology for cooling and heating a building that is similar to an air conditioner but can also function in reverse to provide heat.
GSHP = ground source heat pump, similar to an ASHP but is more efficient due to its use of the ground, rather than the air, for heat transfer to and from the building.

Educational facilities (including universities and schools)

Building name	Heating and Cooling	Hot water	Location
King Open School (middle school, elementary school, administrative offices, public pool), William Rawn Associates, Architects	GSHP	Electric	Cambridge, MA
Lexington Children's Place, Net Zero, DiNisco Design, Inc.	Heat pumps	Electric	Lexington, MA
Hastings School, Net Zero, DiNisco Design, Inc.	GSHP	Electric	Lexington, MA
The Putney School Field House, New Zero, LEED Platinum, Maclay Architects	ASHP	Electric	Putney, VT
R.W. Kern Center, Hampshire College, Bruner/Cott Architects	ASHP	Electric	Amherst, MA

Smith College, Bechtel Environmental Classroom, Coldham and Hartman Architects	ASHP	Electric	Whately, MA
Trustees of Reservations, Powisset Net Positive Barn (demo kitchen with induction stoves, administrative offices, educational learning space, root cellar), Zero Energy Design	ASHP		Dover, MA

ASHP = Air Source Heat Pump, an all-electric technology for cooling and heating a building that is similar to an air conditioner but can also function in reverse to provide heat.
GSHP = ground source heat pump, similar to an ASHP but is more efficient due to its use of the ground, rather than the air, for heat transfer to and from the building.

Housing projects (large-scale)

Building name	Heating and Cooling	Hot water	Location
Auburn Court Lot C. 9, Goody Clancy Architects	Heat pumps		Cambridge, MA
Concord Highlands, ICON Architecture	VRF ASHP		Cambridge, MA
Bayside Anchor, Passive House, Kaplan Thompson Architects ⭑	Electric baseboard heating, electric ventilation		Portland, ME
Bristol Common, Lexington Gardens, The Architectural Team ⭑	ASHP		Taunton, MA
Highland Woods, Dietz and Company Architects	ASHP		Williamstown, MA
Parsons Village, Dietz and Company Architects	Heat pumps		Easthampton, MA
Millbrook Apartments, Bargmann Hendrie + Archetype Inc.	Heat pumps		Somerville, MA
Hyatt Centric Hotel, Arrowstreet	Heat pumps		Boston, MA
Distillery North, ICON Architecture	Heat pumps		Boston, MA

One East Pleasant, Holst and DiMella Shaffer	Heat pumps		Amherst, MA
Kendrick Place, Holst and DiMella Shaffer	Heat pumps		Amherst, MA
Whittier Street Apartments, The Architectural Team	Heat pumps		Boston, MA
Factory 63, Gerding Edlen	Heat pumps		Boston, MA

⭑ = Affordable housing

ASHP = Air Source Heat Pump, an all-electric technology for cooling and heating a building that is similar to an air conditioner but can also function in reverse to provide heat.

GSHP = ground source heat pump, similar to an ASHP but is more efficient due to its use of the ground, rather than the air, for heat transfer to and from the building.

CADMUS

BUILDING ELECTRIFICATION

Technologies and Costs in Residential New Construction

Newton Public Facilities Committee

May 13, 2020

What is a heat pump?

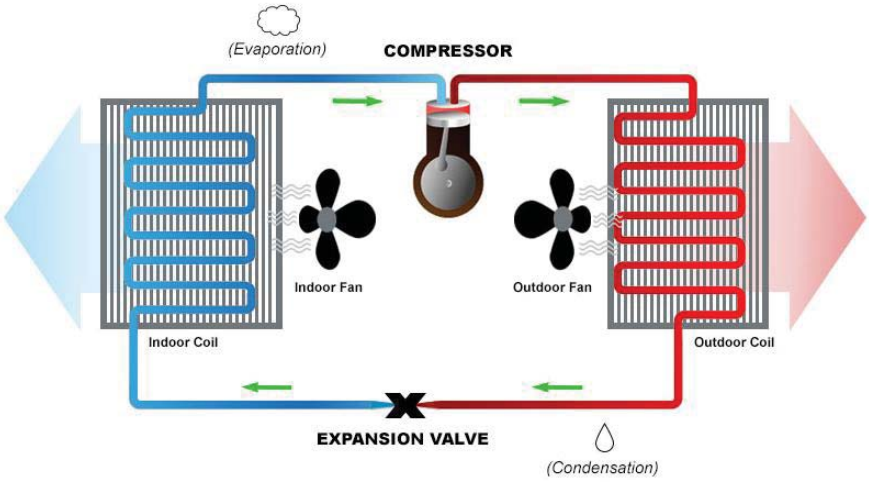
Heat pumps in the Northeast

Costs vs. gas in new construction

Disclaimer: *This presentation has been developed to provide best available information to the City of Newton and its relevant committees and is not intended for advocating for or against any ordinance under consideration. Cadmus does not take any position on the issue presently being considered by the City.*

What is a heat pump?

How an air conditioner works



Heat Pump: Run it in reverse!

Image Source: Carrier (https://www.carrier.com/residential/en/us/products/heat-pumps/how-does-a-heat-pump-work)

What is a heat pump?

Air Source

Ground Source (Geothermal)

Water Heater

Images courtesy of: Boucher Energy Systems, New England Ductless, EnergySmart Alternatives, and Hot Water Solutions Northwest

What is a heat pump?

Common misconceptions

- **Electric heat is inefficient**
- Heat pumps don't work in Massachusetts climate
- Heat pumps cannot serve as the only source of heat in a home

Air Source: 220-350+% efficient

Ground Source: 350-480+% efficient

What is a heat pump?

Common misconceptions

- Electric heat is inefficient
- **Heat pumps don't work in Massachusetts climate**
- Heat pumps cannot serve as the only source of heat in a home

Cold-Climate Air Source Heat Pump Specification requires high-efficiency at 5°F, many systems perform to -13 to -22°F

Ground source heat pumps unaffected by outdoor air temp

What is a heat pump?

Common misconceptions

- Electric heat is inefficient
- Heat pumps don't work in Massachusetts climate
- **Heat pumps cannot serve as the only source of heat in a home**

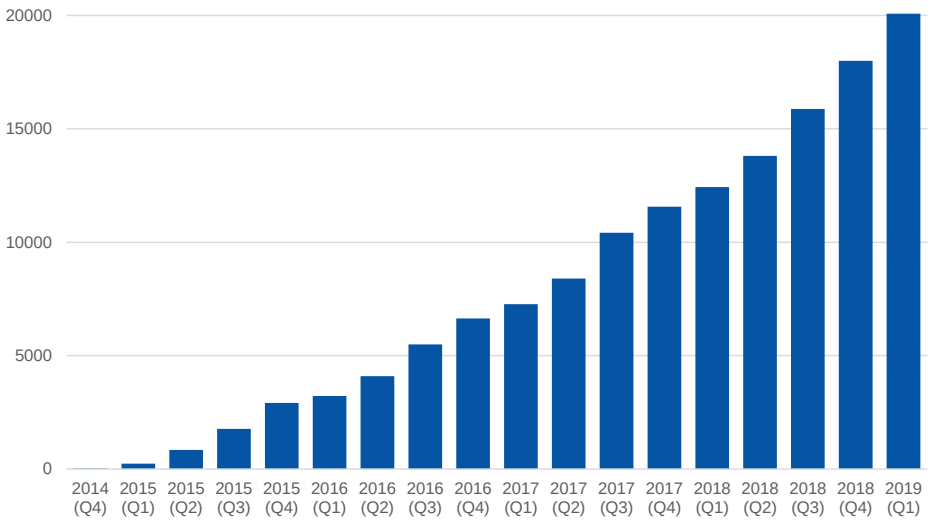
- In 2017, approx. **6%** of new homes in MA used a heat pump as the **primary or only source of heating/cooling**
- Ground source heat pumps **do not lose output and efficiency** significantly on the coldest days of the year
- Dozens of systems installed through MassCEC programs in retrofits had **no backup heat**

Sources: MA RLPNC 17-2: 2017 Massachusetts Single-Family New Construction Mini-Baseline/Compliance Study; 2019 HeatSmart Mass and Pilot program data; MassCEC Air Source Heat Pump Whole-Home Pilot Program data

Heat Pump Market in the Northeast

Massachusetts

Cumulative Cold Climate Air Source Heat Pump Rebates (MassCEC), 2014-2019



Rebate amounts were reduced twice during the life of the program!

MA utilities have committed to rebating over 62,000 ASHPs by 2021

Source: MassCEC

Heat Pump Market in the Northeast

The Rest of the Region

State	Program	# of Rebated Installations
	efficiency MAINE	**~30,000 systems** (2013-2018)
	Efficiency Vermont	**8,200+ systems** (Q1 2015-Q4 2017)
	NEW YORK STATE OF OPPORTUNITY. NYSERDA	**11,000+ sites** (9/2017-12/2019)

Heat Pump Cost Comparison

An example new single-family home scenario

- **One example scenario** sourced from study completed for Mass Save by NMR, modified to more closely reflect Newton costs
- **Every home is different.** Assumes ~2,500 sq ft of conditioned area (1,300 sq ft basement), modeled to meet MA Stretch Code requirements
- **Costs vary significantly** depending on the home (e.g. size, layout, building envelope, customer preference) and equipment selection
- **New construction differs significantly from retrofits** in costs and requirements
  - Installing all new ductwork greatly increases cost and can be highly variable
- This scenario aims for an apples-to-apples comparison (using the same ductwork/ventilation costs and only different equipment)

Heat Pump Cost Comparison

An example new single-family home scenario

Traditional
Gas Furnace
Central AC
Tankless Gas HW

All-Electric
Mini-split Air Source Heat Pump
*(installed in ducted capacity)***
Heat Pump Water Heater

***Ductless options may be more appropriate for and cheaper to install in some home configurations*

Heat Pump Cost Comparison

An example new single-family home

Space Heating/ Cooling Equipment	Installed Cost	Annual Operating Cost
Gas Furnace Central AC	$20,800	$1,384
Mini-split heat pump *(ducted indoor units)*	$23,300	$1,861 *($1,263 powered with solar)*

Water Heating	Installed Cost	Annual Operating Cost
Tankless Gas Water Heater	$2,900	$127
Heat Pump Water Heater	$1,800	$146 *($99 powered with solar)*

Source/Assumptions: Based on building and equipment assumptions from RLPNC 171-4: Mini-Split Heat Pump Incremental Cost Assessment with ductwork requirements and equipment/labor costs increased to reflect higher costs in Newton vs. model in Worcester; Estimate of Solar PPA/cost with financing price from Solarize MA Data

Heat Pump Cost Comparison

An example new single-family home

	Installed Cost	Annual Operating Cost
Gas Furnace Central AC Gas Tankless Water Heater	$23,700	$1,511
Mini-split heat pump *(ducted indoor units)* Heat Pump Water Heater	$25,100	$2,007 *($1,362 powered with solar)*

Reminder: Costs very significantly from project to project! In some projects, heat pumps could be cheaper (or significantly more expensive) to install.

Cost comparison **does not account for cost of eliminating gas service and piping** (could be $10,000+) or gas vs. non-gas appliances

Source/Assumptions: Based on building and equipment assumptions from RLPNC 171-4: Mini-Split Heat Pump Incremental Cost Assessment with ductwork requirements and equipment/labor costs increased to reflect higher costs in Newton vs. model in Worcester; Estimate of Solar PPA/cost with financing price from Solarize MA Data

Heat Pump Cost Comparison

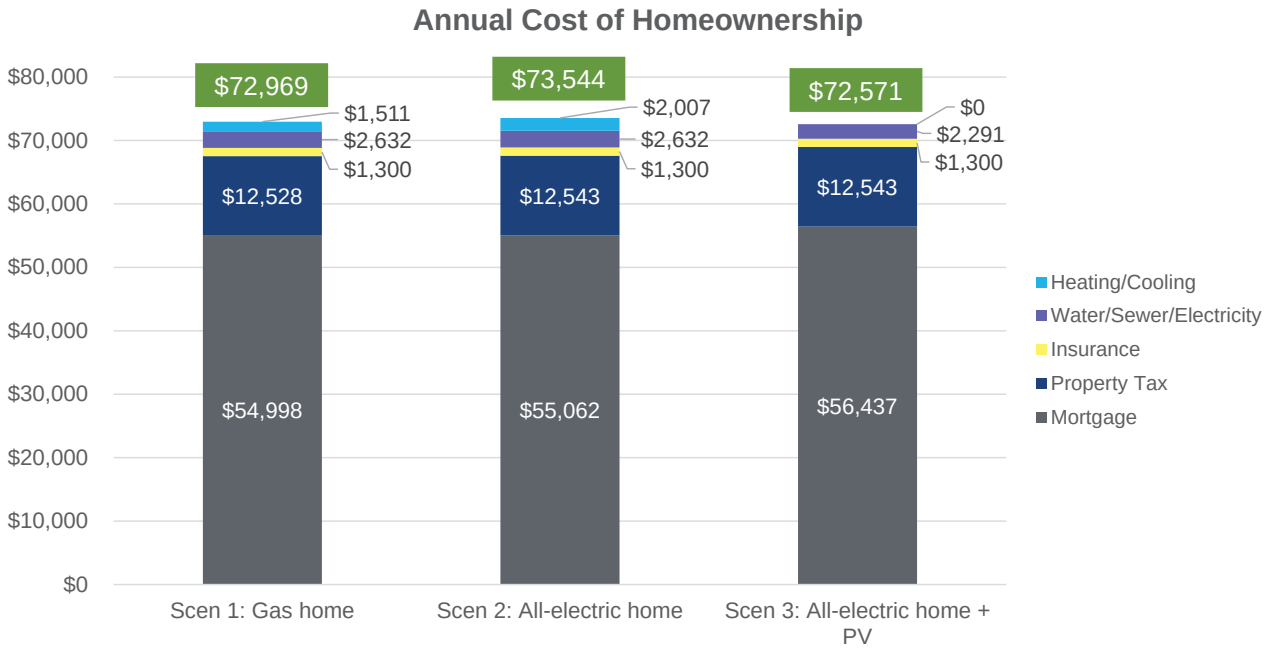
In context in Newton

Let's consider annual cost of homeownership:

- Median new home price: $1.2 million
- Compare three new home scenarios:
  1. Traditional Gas Home
  2. All-Electric Home
  3. All-Electric Home with Solar PV
- No incentives for solar, heat pumps, or high-efficiency appliances
- Incremental cost of heat pump/PV rolled into mortgage

Heat Pump Cost Comparison

In context in Newton



Assumptions and Sources: 30-yr fixed rate mortgage at 4%, 20% down; property tax rate of $10.44 per thousand (solar PV exempted); $1,300/yr insurance *(average from online estimates)*; $1,132 water/sewer bill *(MWRA 2018 Water and Sewer Retail Rate Survey)*; $1,500 other electricity bill *(EIA)*; heating/cooling costs from RLPNC 17-14 study model homes; installed cost of solar of $3.75/W *(MassCEC Middlesex County Average)* and 8 kW generating approx. 10,000 kWh/year *(modeled in PVWatts)*; no incentives included; impact of other non-gas appliances not included

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Thank You / Q&A

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MASSACHUSETTS CLEAN ENERGY CENTER®

ELECTRIFICATION IN MULTIFAMILY NEW CONSTRUCTION

Presented By

MassCEC

OUR MISSION

Grow the economy and help meet the state's ambitious clean energy and climate goals.

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MassCEC is providing information about the technical feasibility and constraints of using heat pumps in new construction of multi-family buildings but is not commenting on any policy proposals that might be proposed by Newton or other towns and cities.

MASSCEC HAS YEARS OF EXPERIENCE WITH HEAT PUMPS

2013: Ground Source heat pump pilot (w/DOER)

2015: MassCEC commits **$48M** for 5-year Clean Heating program

2017: HeatSmart launched

2019: Whole Home Heat Pump Pilot

2019: Mass Save mini-split incentives

MULTIFAMILY HEAT PUMP OPTIONS

Centralized Air Source Heat Pumps (Variable Refrigerant Flow)

- Can be installed as ducted or ductless systems
- Centralized outdoor compressors
- Takes less roof or balcony space
- Can pay premium to simultaneously heat and cool in different units

Individual Mini Split Heat Pumps

- Can be installed as ducted or ductless systems
- Less expensive
- Takes more roof or compressor space
- More "off the shelf" technology

Ground Source Heat Pumps

- Requires sufficient space to fit a drill rig truck on property and not too many underground impediments
- More expensive upfront
- More efficient

Photos courtesy of Green Energy Futures and Mark Johnson: flickr.com and commons.Wikimedia.com

HEAT PUMPS ARE BECOMING INDUSTRY STANDARD IN NEW CONSTRUCTION MULTIFAMILY

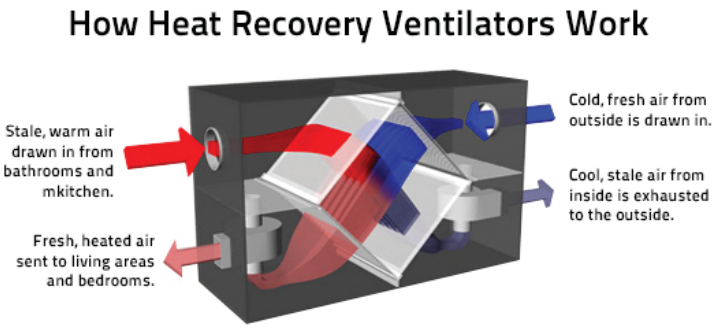
- Today's new multi-family buildings regularly use cold-climate air source heat pumps
- First costs often lower than separate heating and cooling systems in new construction
- Operating costs in new construction multi-family are comparable to gas heated with cooling
- 7 of 8 multi-family new construction affordable projects under Passive House Design Challenge are using all heat pumps for heating and cooling

CENTRAL HOT WATER HEAT PUMP TECHNOLOGY NOT COMMERCIALLY AVAILABLE IN US YET

- Individual heat pump water heaters very feasible for single family applications
- At 8+ units rental, developer will want to install central hot water system
- Not commercially available in US and operating costs will likely remain higher until the gap between gas and electricity prices narrows

HEAT RECOVERY VENTILATION WITH NO GAS CAN DRIVE OPERATIONAL COSTS HIGHER

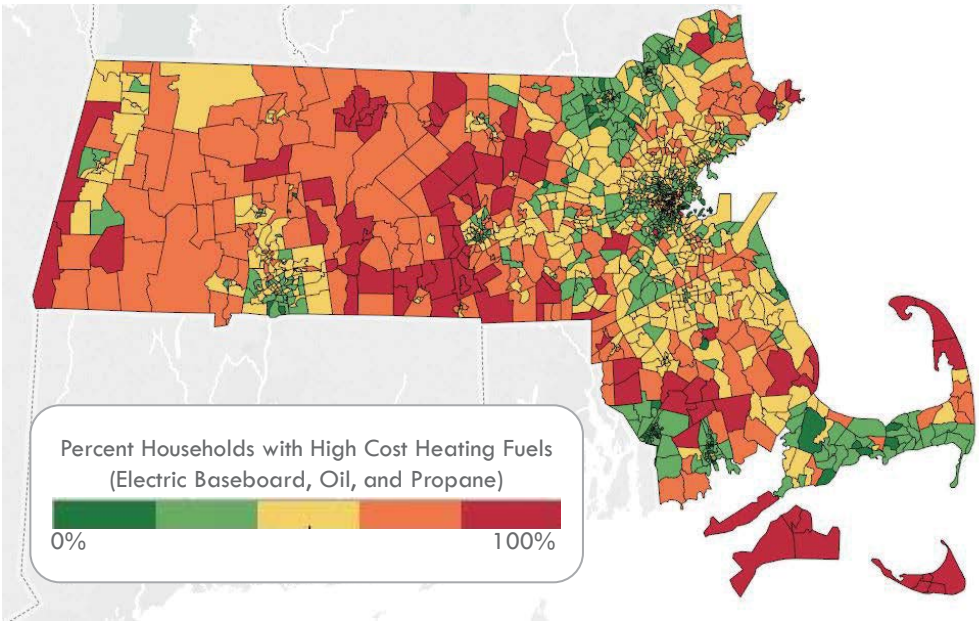
- Supplies unit with fresh air while also **recovering heat** (80+%) from exhausting stale air
- Creates **healthier** living environment by providing more fresh air
- **Lowers heating bills** by pre-heating fresh air with recovered heat
- Technology for all electric to avoid “drafts” from ventilation exists
- But all electric heat recovery ventilation may lead to higher operating costs than heat recovery with small gas pre-heat



BATTERY STORAGE FOR EMERGENCY OPERATIONS- FIRST COSTS REMAIN HIGH

- Multi-family buildings typically have a back-up gas or oil generator to run critical electrical loads
- First costs of battery storage have come done significantly but are still high relatively high compared to alternatives
- Some multi-family new construction might find battery storage attractive financially when paired with solar to shave peak electrical charges

ENERGY BURDEN IS IMPORTANT FACTOR FOR LOW INCOME HOUSEHOLDS



$$Energy\ Burden = \frac{Cost\ of\ Energy}{Household\ Income}$$

Income Demographic	Energy Burden (National)
Higher-income	2.3%
Median-income	3.5%
Low-income	7.2%

ACEEE Report: Lifting the High Energy Burden in America's Largest Cities

BUT NEW CONSTRUCTION ENERGY COSTS WITH HEAT PUMPS IS AFFORDABLE

- In new construction multi-family, there should not be an increase in net energy operating costs
- When include cooling, operating may be much lower in future years as climate warms
- However, if you retrofit an existing multi-family building with heat pumps and make no envelope improvements, there will likely will be higher energy operating costs
- Masonry/brick buildings will the most difficult to retrofit and not see increases in operating cost from gas

INCOME QUALIFICATION FOR FUEL ASSISTANCE

Number in Household	Annual Income
1	$35,510
2	$46,437
3	$57,363
4	$68,289
5	$79,215

Also Eligible for:

- Discount electric rate (29% off supply cost)
- Free Insulation
- Free Air Sealing
- Potential Appliance Replacement (refrigerator, dishwasher, washer, dryer)
- Potential Lighting Replacement

Fuel Assistance applications begin November 1, 2019. Call 617-796-1420 to schedule an appointment.

The Newton Health and Human Services Department is an intake site for the Fuel Assistance program

Brookline's Prohibition on New Fossil Fuel Infrastructure in Major Construction

Contents

Overview

- Brookline's bylaw prohibits the installation of *new* fossil fuel piping (gas or oil) in buildings. The bylaw applies to:
  - New construction
  - Significant rehabilitation ("gut rehab")
- The bylaw does not require the removal or replacement of any existing piping, equipment, or appliances.
- Brookline's bylaw is the first fossil fuel ban outside of California, the first in a climate with severe winters, and the first to include building renovations as well as new construction.
- The bylaw was overwhelmingly approved on November 19, 2019 at Brookline's Town Meeting. The vote was 211-3.
- The bylaw was designed *not* to conflict with zoning, regulatory code, or state law.
- The Massachusetts Attorney General's Office is currently reviewing the bylaw. If approved, it will go into effect on January 1, 2021.

Overview - Exemptions

Practical

All-electric technology is not yet fully feasible for:

- Emergency power. Backup batteries are not robust enough yet.
- Central domestic hot water systems in buildings over 10,000 square feet
- Commercial kitchens. Some specialized equipment is currently too costly to operate (pizza ovens, deep fryers, etc.).

Including these technical exemptions demonstrated that we "did our homework" and proposed informed and practical policy choices.

Consensus-Building Compromises

During the negotiation process, the following exemptions were made to increase support for the bylaw:

- Residential cooking
- Laboratories and medical facilities

These consensus-building exemptions may not be necessary for every municipality.

Overview - Waivers

- Waivers allowing fossil fuel infrastructure will be granted on a case-by-case basis to projects encountering prohibitive financial or practical issues.
- A new Sustainability Review Board appointed by the Brookline Select Board* will oversee the waiver process.

** The Brookline Select Board is an elected five-member board that adopts Town administrative policies and enforces town bylaws and regulations among other administrative duties.*

Image Credit: Hugh Dutton Associates

Rationale

- The catastrophic consequences of climate change are well-understood, as are the actions we must take to avoid worst-case scenarios. We know we must reduce our greenhouse gas emissions by 50% by 2030 and become “net-zero” by 2050.
- Existing Massachusetts legislation requires the state to reduce greenhouse gas emissions 80% by 2050. New proposed legislation will require the state to reduce emissions to net-zero by 2050.
- If the goal is net zero emissions by 2050, installing and paying for new fossil fuel infrastructure that will be in place for over 30 years doesn’t make sense.
- Zero carbon emissions can only be achieved by using renewable electricity. The Massachusetts electrical grid currently uses a mix of renewable and fossil fuels - and the grid is continuously greening by state mandate.
- *Every building built today with fossil fuel infrastructure defeats emissions goals and will require an expensive retrofit in the future.*

Source: United Nations Intergovernmental Panel on Climate Change Special Climate Report, 2018; Massachusetts Clean Energy and Climate Plan, 2020; Global Warming Solutions Act, 2008

Rationale – All-Electric Technology Exists Today

Heating and Cooling

- Recent and dramatic improvements in heat pump technology now make it practical and cost-effective to heat new buildings with electricity in cold climates.
- Air source and ground source heat pumps act as air conditioners on warm days and provide heating during cold days.
- Air source and ground source heat pumps are 3-4 times more efficient than the most efficient gas systems.
- In buildings with both heating and air-conditioning, it is simpler to install, operate, and maintain a single system. Heat pumps reduce greenhouse gas emissions immediately and over time as Massachusetts moves towards all-renewable energy sources.

Rationale – All-Electric Technology Exists Today

Cooking

- Induction stovetops, powered by electricity, offer a clean alternative to gas. Benefits include improved indoor air quality – no emissions from gas cooktops. Cooking with induction is also safer, more precise, and faster than cooking with gas.

Hot Water

- Electric heat pump hot water heaters are widely available and cost about the same to purchase, install, and operate as a gas-fired hot water heaters.

Image Credit: National Renewable Energy Lab

Impact - All-Electric Home Emissions Decrease Over Time

- *Current* Massachusetts electrical grid electricity sources provide any single-family home that converts from gas to electric heat and hot water an immediate 30% reduction in emissions.
- As electricity production migrates to renewable sources ("greening of the grid") this home gets cleaner.
- By 2050, using current grid mix projections, the house will have a 70% reduction in emissions.
- In Massachusetts, *any* home or building can purchase 100% renewable energy through direct purchase agreements with their local electric utility and achieve zero emissions immediately.

Projected Impact in Brookline

- Buildings are the source of two thirds of Brookline's emissions. Assuming 0.5% of buildings turn over (i.e. built new or "gut renovated") per year:
- 15% of buildings in Brookline will be fossil fuel-free by 2050.
- This bylaw alone will lead to a 10% reduction in overall Town emissions.

Image Credit: Michael Eickelmann

Legal Authority

- Cities and Towns can adopt local ordinances or bylaws in response to climate change as long as these actions are not inconsistent with existing state or federal laws.
- The *Green Communities Act* is a potential source of local power to regulate emissions. The Town of Brookline's Climate Action Plan has a goal of zero emissions by 2050. Compliance with Massachusetts State mandates will also not be met by installing new fossil fuel infrastructure.

Image Credit: Arnaud Regnier

Legal Authority

- **Important!** The bylaw is not preempted or in conflict with existing MA State laws or regulations. Existing state and federal laws take precedent over local laws.
- To avoid preempting or conflicting with existing laws and regulations, the Brookline bylaw does not:
  - Regulate materials or methods in Building Code or Fuel Gas Code
  - Create any new standards for gas or oil infrastructure
  - Conflict with state policy on access to utilities (Chapter 164)

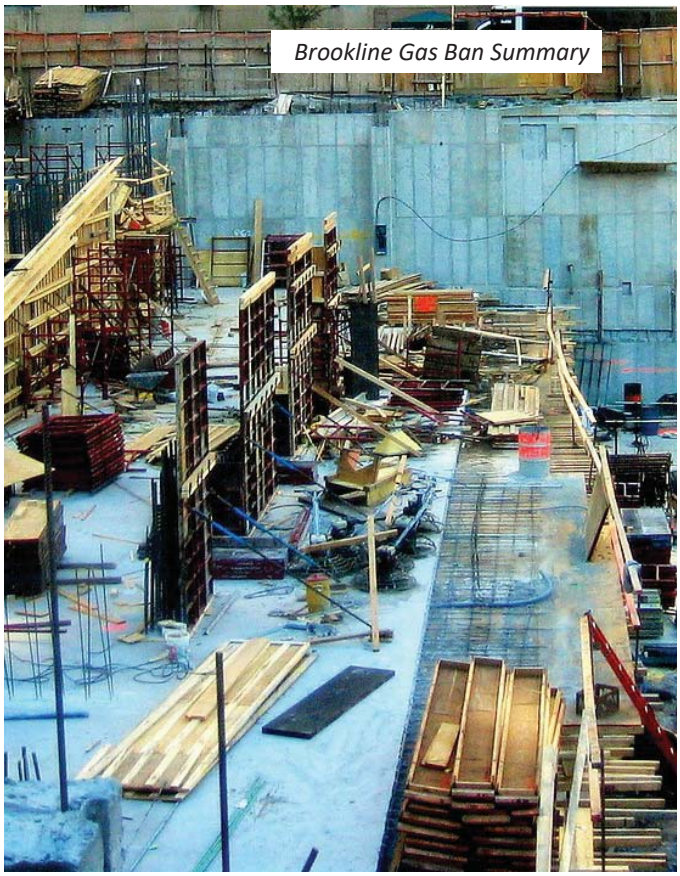


Image Credit: Susan Sermoneta

Legal Authority

*The Brookline bylaw does **NOT** regulate:*

- Gas pipelines in the street
- Gas meters and hookups (connections to the street)
- Removal of any existing infrastructure, piping, equipment or appliances
- Building insulation
- Energy efficiency of equipment
- Specific equipment or technologies to be installed

Regulating these areas would conflict with state building code or other state laws.

Current Status:

Bylaw review by Massachusetts Attorney General's Office expected to be complete by July, 2020.

Cost – Construction and Operating

- Construction and operating costs can vary by building type. The Brookline team focused on a case example of a new, 2,500 sf single-family home to illustrate costs.
- Total heating and cooling costs over a decade are approximately equal.

	Construction and Operating Costs		Total Costs	
	Construction	**Annual Operating**	**Five Year**	**Ten Year**
Gas Heat and Water, Central A/C	$11,700	$1,500	$19,300	$26,900
Air Source Heat Pumps*	$5,700	$2,000	$16,400	$27,100
Cost Difference	*$6,000*	*($500)*	*$2,900*	*($200)*

** After rebates and incentives*
Sources: Construction Costs – Brookline Developer,
Operating Costs – RLPNC 17-14: Mini-Split Heat Pump Incremental Cost Assessment

Cost – Incentives and Rebates

Massachusetts Clean Energy Center (Mass CEC)
Ground-Source Heat Pump Rebates
Whole-Home Pilot Program for Air-Source Heat Pumps
HeatSmart Massachusetts

Mass Save
Central Air Conditioning and Heat Pump Rebates
Mini-Split Heat Pump Rebates
Pay for Savings Incentives
HEAT Loan Program

State of Massachusetts
Massachusetts Alternative Energy Credits

MA Low-Income Energy Affordability Network (LEAN)

Rebate Case Example:
Air-Source Heat Pump Rebate for a New 2,500 SF Single Family Home

Gas Heat and DHW + Central A/C	
Equipment and Installation	$11,700
Mini Split Air Source Heat Pumps + ASHP DHW	
Equipment and Installation	$12,500
Alternative Energy Credit	*$2,600*
Mass CEC Rebate	*$2,500*
Mass Save Rebate	*$1,700*
Equipment and Installation, Net Cost	$5,700

Case Source: bylaw team research

Team

Outreach and consensus-building is critical!

The co-petitioner team spoke with, engaged, and was comprised of:

- Local experts for technical support including: architects, engineers, building contractors, HVAC contractors and installers, and developers, and lawyers;
- Leaders in other MA municipalities and in California for information and support;
- Nonprofits and state agencies for technical advice;
- Town representatives and elected officials.

This engagement and research allowed the team to:

- Understand technical and practical issues;
- Assess state-level and national all-electric feasibility studies and provide easily understood data and charts;
- Provide local examples of built projects;
- Share that the affordable housing sector is leading the way in installing electric systems which was an important goal of the team as well as key to widespread acceptance.

Collaboration

- Town staff members offered expert and impartial advice on policy development, *not* advocacy or opposition.
- The bylaw was not put forward by Town staff but required staff expertise to coordinate and execute.
- Approximately 50 public meetings were held for this bylaw – all requiring the co-petitioners' and Town staff time and expertise.

Image Credit: Christiane Wilke

Extensive Outreach and Engagement

Community Feedback

- Four public listening sessions (letters sent to anyone who had recently pulled a building permit). Listening sessions led by a Town staff member with professional mediation training.

Outreach Campaign to all 240 Town Meeting Members

- Extensive effort to whip the vote with team leaders in every precinct and a lead whip organizer
- One-on-one meetings
- Citizen advocate emails
- Follow-up emails by co-petitioners
- Information sheet w/FAQs
- Emphasis on feasibility: "this bylaw is practical, doable, and cost-effective"
- Involvement of high school students supporting bylaw with public demonstrations and speeches
- *Every Town Meeting Member was well informed before the vote*

Consensus-Building Results

- The bylaw team obtained the support of all relevant Town boards and commissions, as well as endorsements from various community groups.

- Obtaining support from these various parties often involved multiple meetings, extensive negotiations, and political compromises. The Warrant Article was modified as it was reviewed by various boards (e.g. creating the waiver process, exempting residential cooking). Including "substantial renovations" was of critical importance to the co-petitioners and remained in the final bylaw.

- The following groups and boards voted to support the bylaw:
  Brookline Select Board
  Advisory Committee and Planning and Regulations Subcommittee
  Economic Development Advisory Board
  Housing Advisory Board
  Preservation Commission
  Commission for Diversity, Inclusion & Community Relations
  Climate Action Brookline, Brookline Green Caucus, Brookline PAX, and Elders Climate Action

Addressing Feedback and Concerns

Be prepared to answer questions! (or have access to an expert who can.)

- **Technical questions**
  Will electric systems work in cold climates? Can the grid support HVAC electrification?

- **Practical questions**
  Are there contractors who can install? How will my heat work in a power failure?

- **Economic questions**
  How much extra will this cost to install? Isn't electric more expensive to operate?

- **Crystal ball questions**
  How will this impact future development? What about any unintended consequences?

- **Old habits die hard**
  But I like cooking with my gas stove!

“When you’re in a hole, the first thing is to stop digging… This bill simply takes away the shovel.”

- MA State Representative Tommy Vitolo

Image Credit: Adam Bindslev

The Brookline team is deeply thankful for the hundreds of individuals who questioned, researched, developed, and supported this bylaw:

Community volunteers and concerned citizens

Town of Brookline staff, Town Meeting Members, and other elected and appointed leaders

Sustainability and climate leaders

Officials and community advocates from other cities and towns

Design and construction professionals

Appendix

Definitions and Examples
Sources

Definitions and Examples

Renovations Critical to Meet Brookline's Climate Goals

Brookline's housing stock is old:

- Over 24,000 housing units (apartments, condos, houses)
- More than 50% of housing stock built before 1940
- Less than 13% of housing stock built after 1980
- *Less than 4% of housing units built after 2000*
- ***Critical need to upgrade older housing construction***

Source: U.S. Census Bureau, 2013 – 2017 American Community Survey (ACS), 5-year Estimate

Definitions and Examples

"Significant Rehab" = "Major Renovation" = "Gut Rehab"

- **Bylaw includes "gut rehab" projects**
  - Scope of work similar to new construction
  - Opportunity to upgrade envelope, HVAC
- **Defining "gut rehab":**
  - Ratio of renovation area to building total area
  - bylaw applies when ratio exceeds threshold
- **Two different thresholds**:
  - Projects with Residential Building Permits: *renovation work area exceeds 75% of floor area*
  - Projects with Commercial Building Permits: *renovation work area exceeds 50% of floor area*
  - *Important: renovation thresholds match existing statewide code*
- Easily calculated by a design professional
- Easily assessed by Building Department as part of permit review process

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Definitions and Examples

Typical Features of a Gut Rehab

- Not occupied during construction
- Removal of interior partitions and doors to reconfigure layout
- Removal of interior finishes
- Exterior wall framing exposed and easier to insulate, air-seal
- All new HVAC, electrical and plumbing systems and fixtures
- All new insulation, drywall, doors, flooring, cabinets, appliances
- ***Work area exceeds threshold - bylaw would apply***

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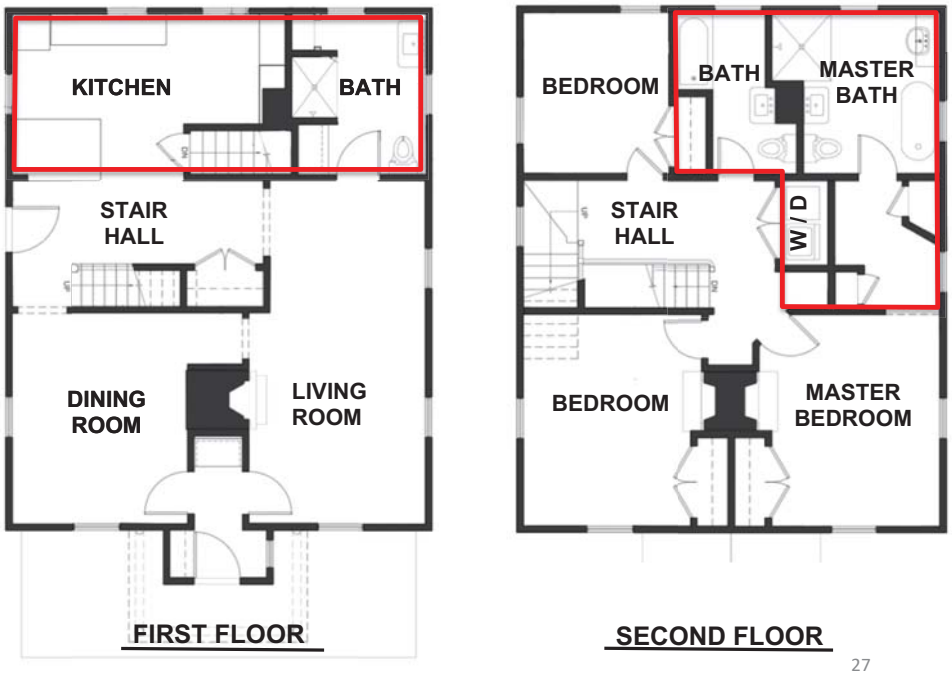
Single Family Home Example

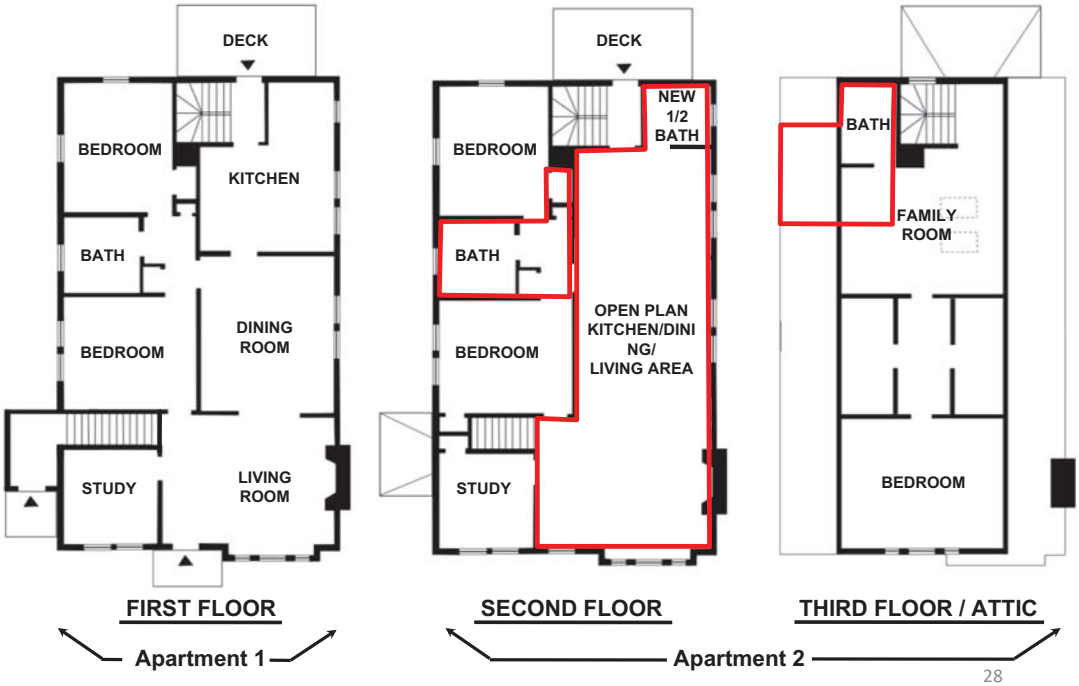
- Update, expand existing Kitchen and Bathrooms
- Add upstairs Laundry and Master BR Suite
- Extend existing HVAC, plumbing, electrical
- Refinish wood floors and paint throughout
- ***Bylaw would not apply - work area less than 75% residential threshold***



Two Family Home Example

Renovation Scenario 1

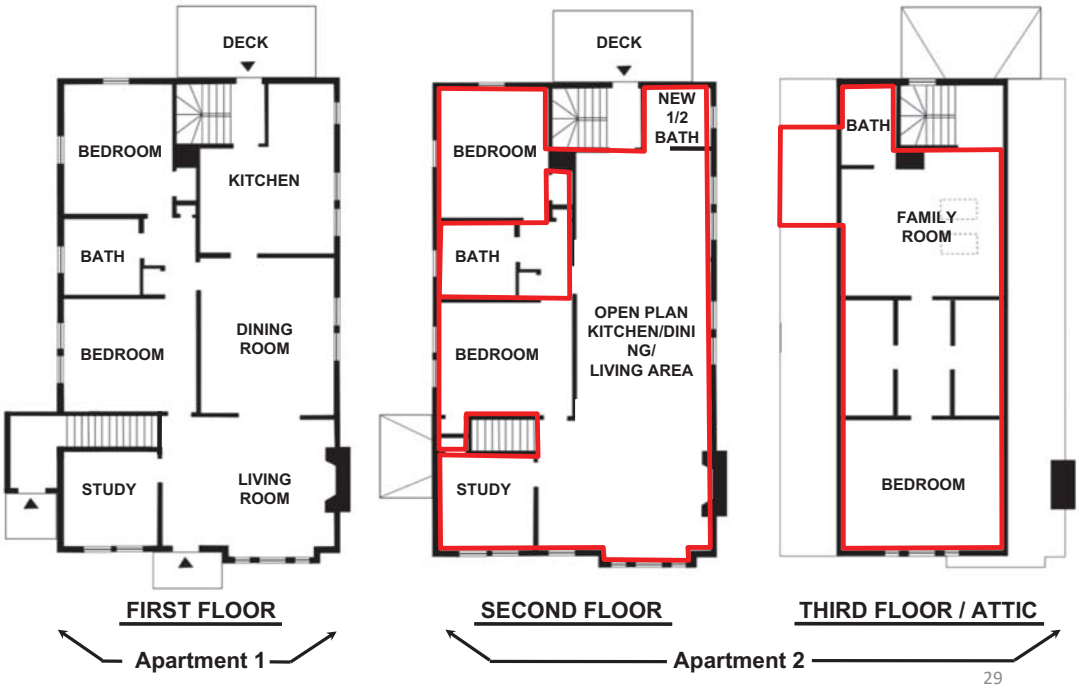
- Remove Fl 2 walls for open Living/Dining/Kitchen; add new half Bath
- Reconfigure Fl 2 Bath and Closets
- Add attic dormer and reconfigure Fl 3 Bath and Family Room
- Paint and refinish wood floors throughout
- ***Bylaw would not apply - - work area less than 75% residential threshold***



Two Family Home Example

Renovation Scenario 2

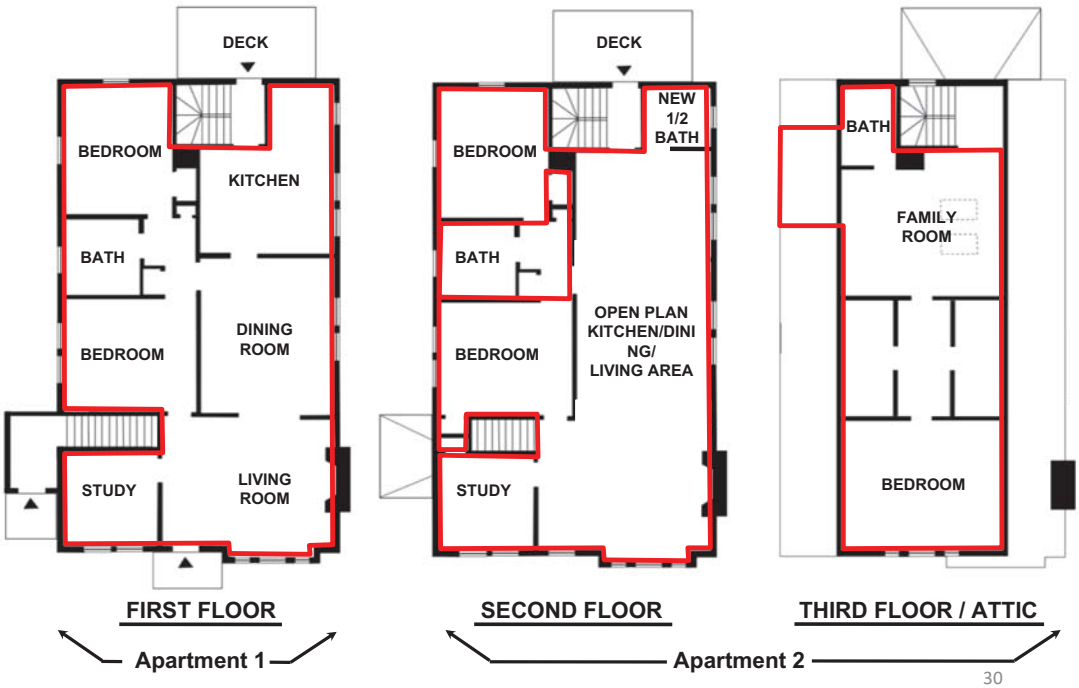
- Gut rehab entire Duplex Unit, both floor levels
- New insulation, drywall, partitions, doors, flooring, electrical, plumbing, throughout
- ***Bylaw would not apply -- work area less than 75% residential threshold (area of Duplex Unit is only 60% of total building)***



Two Family Home Example

Renovation Scenario 3

- Gut rehab entire building, both units, all floor levels
- New insulation, drywall, partitions, doors, flooring, electrical, plumbing, throughout
- ***Bylaw would apply -- work area more than 75% residential threshold***



Three Family Home Example

Renovation Scenario 1

- Renovate Kitchens & Baths, all three units
- Paint throughout
- Refinish wood floors throughout
- ***Bylaw would not apply -- work area less than 50% commercial threshold***

Three Family Home Example

Renovation Scenario 2

- Gut Rehab entire unit on one floor level
- New insulation, drywall, partitions, doors, flooring, electrical, plumbing, throughout
- ***Bylaw would not apply -- work area less than 50% commercial threshold***

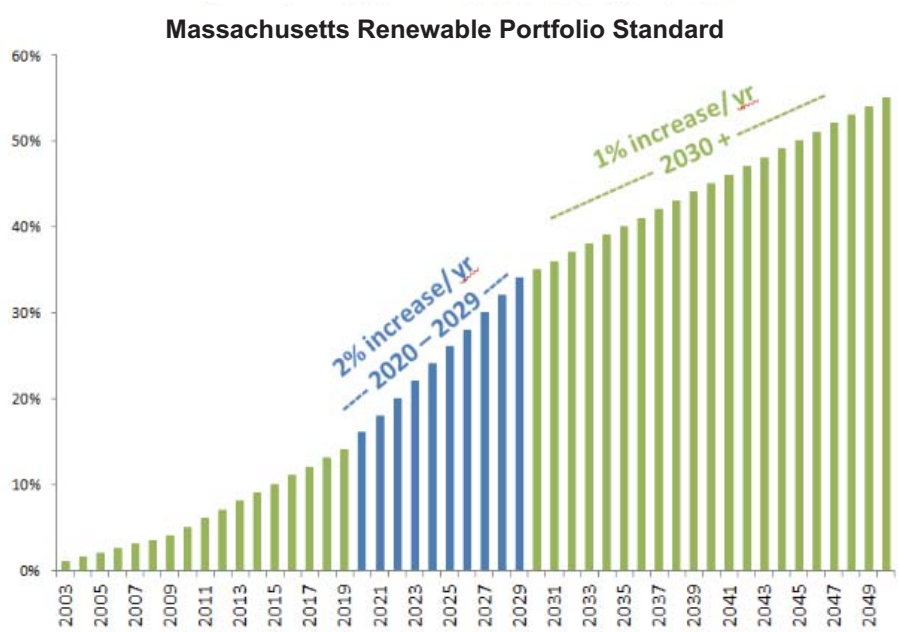
Three Family Home Example

Renovation Scenario 3

- Gut Rehab entire building, all three units
- New insulation, drywall, partitions, doors, flooring, electrical, plumbing, throughout
- ***Bylaw would apply -- work area more than 50% commercial threshold***

Greening the Electrical Grid is a State Policy Mandate

- Renewable energy is already expanding and required by Massachusetts law.
- The state-mandated percentage of renewable electricity generation is increasing yearly and reducing GHG emissions in electric utility supply.
- MA state legislature increased renewable percentage twice in 10 years.
- MA state legislature is considering a new bill to further accelerate this transition.

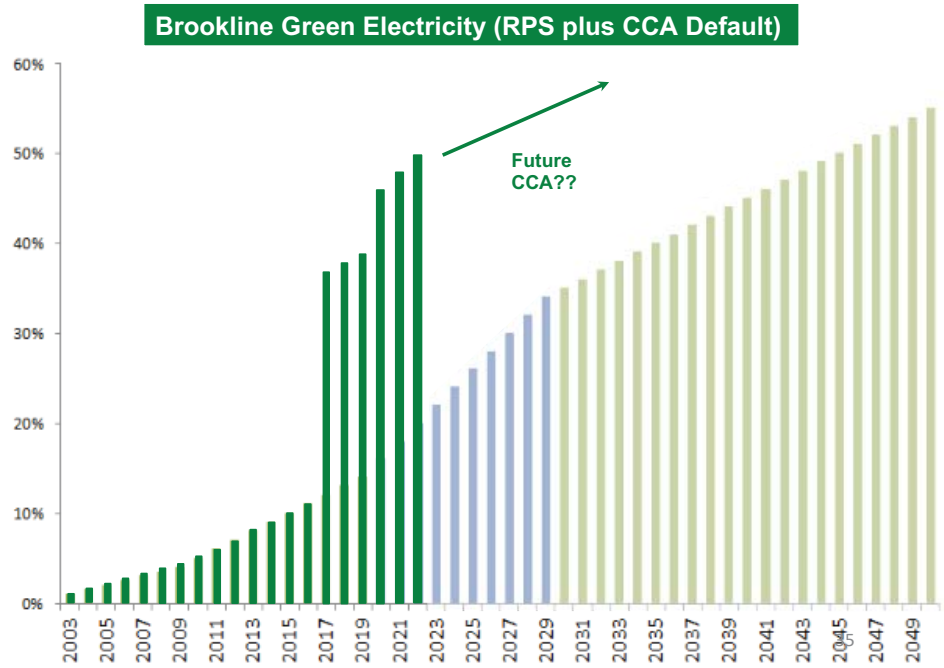


Source: Green Energy Consumers Alliance
https://blog.greenenergyconsumers.org/blog/rps-res-in-plain-english

Sources

Brookline's Electricity Exceeds State Renewable Standards

- Brookline has a community choice aggregation program that provides even more renewable energy than the statewide default levels.
- Brookline's default electricity plan contains 30% local, renewable energy.
- Approximately 90% of Brookline residents and businesses are currently at this default plan.

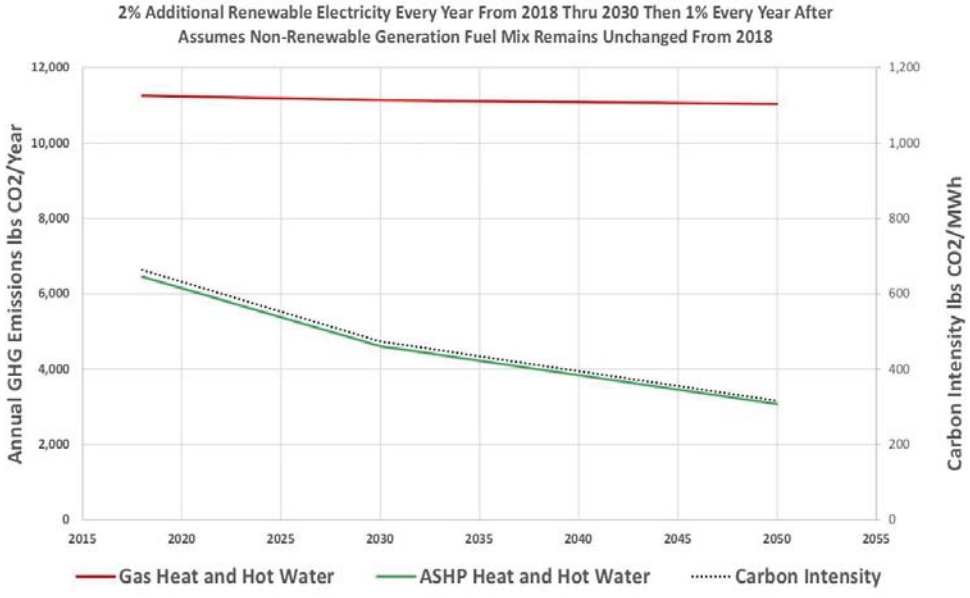


Data Source: bylaw team research

Sources

Emissions from All-Electric Homes Will Decrease Over Time

- A single-family home that converts from gas to electric heat and hot water has an immediate 30% reduction in carbon emissions.
- This home emits less carbon every year as the electric grid transitions to renewables.
- By 2050 this house will produce 70% less carbon emissions if relying on the conventional grid.
- Through Brookline's municipal energy aggregation program, any home or building can purchase 100% renewable energy immediately.



The chart uses a 2,500 sq. ft. single family house for calculations

Data Source: bylaw team research