LEXINGTON, MA

ENERGY INVENTORY

Prepared for

The Lexington Getting to Net Zero Task Force

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PEREGRINE
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Background and Population

- Lexington has a population of 33,394. The population grew 6.4% from 2010 to 2015.
- Median household income is $149,306, more than twice the state average.

Building inventory

Residential buildings:

- Three styles account for nearly half the square footage: colonials (19%), contemporary colonials (19%), and capes (11%).
- While historic homes and new properties are prominent, far more of the town's homes were built in the 1950s and 1960s than any other decades. Construction from that era is less energy efficient than modern construction.
- Since the 1970s, the average new home has been getting larger every decade. In fact, the average size of homes built in the 2010s is nearly twice the town average.
- New homes are being added, and existing homes replaced, at very low rates—in both cases well less than one percent per year.

Non-residential buildings:

- Non-residential square footage is dominated by three building types: office (32%), office/lab (27%), and school (16%).
- The average building size is 14,093 SqFt. However, the size of the individual buildings varies quite considerably, with 18 buildings over 100,000 SqFt and three buildings over 200,000 SqFt.
- The great majority of the buildings were constructed from the 1950s through the 1980s.
- The ownership of non-residential buildings is concentrated in 17 large property owners, which together own more than half of the non-residential square footage.

Energy consumption

Electricity

- Lexington used nearly 450 million kilowatt-hours of electricity in 2015.
- Non-residential electricity use dominated, accounting for 77% of the total with residential use accounting for only 23% of the total. This indicates that Lexington will have to address non-residential electricity uses in order to achieve its emission goals.
- The electricity use data provided by Eversource includes two very large users, Hanscom Air Force Base and MIT Lincoln Lab, that are not included in the Lexington assessor's database. The Town will need to decide whether this use should be included when calculating Lexington's emissions.

- Overall electricity use in Lexington has been fairly constant since 2009 at approximately 450 million kWh per year. This flat usage pattern is consistent with the experience of the state as a whole over the same time period.

Natural gas

- Lexington used 14.6 million therms of natural gas in 2015.
- Unlike the electricity use, natural gas use is evenly split between residential and non-residential buildings. In 2015, residential accounts were responsible for 48% of gas use, and non-residential accounts for 52%.
- Natural gas use has increased significantly since 2009 and has been quite variable from year to year. While some of the increase is explained by an increase in gas accounts and some of the variability explained by weather, statewide gas consumption has seen much less of an increase and less variability during the same period. This suggests that there may be some anomalies in the data reported for Lexington.

Heating oil

- Heating oil use is not reported, so we have had to estimate it. We've estimated use at just under 3.5 million gallons per year.
- Oil use has been dropping as homes have switched from oil to natural gas or electric heat pumps.

Greenhouse gas emissions

- Buildings in Lexington were responsible for nearly 265 thousand metric tonnes of CO2 in 2015.
- Electricity is responsible for the lion's share of Lexington's CO2 greenhouse gas (GHG) emissions, accounting for 57% of the total, followed by natural gas at 29% and oil at 13%.
- Non-residential buildings were responsible for 59% of the total. Looking by fuel as well as sector, non-residential electricity use was the single greatest contributor, at 44% of the total.
- The emission factor for electricity varies each year based on the mix of resources used to generate electricity. The region's factor dropped by 28% from 1999 to 2014 as the region replaced relatively dirty oil- and coal-fired generation with cleaner gas-fired generation. However, the factor is starting to increase again due to the closure of the region's nuclear power stations, which are a carbon-free source of electricity.

Greenhouse gas emissions by building type

- Homes account for slightly over 40% of emissions.
- While downtown shops are the face of Lexington business, the great bulk of non-residential emissions are related to the federal facilities, office buildings, and labs. That is where the Town will need to make progress if it wishes to reduce non-residential energy consumption and associated GHG emissions.
- As would be expected, the labs are very electricity-intensive. The electricity use per square foot of buildings that house both lab and office space is more than twice that of offices alone.

- Other high-electricity-intensity buildings include supermarkets and restaurants. However, those buildings account for only a small fraction of the total energy use because they represent only a small fraction of the square footage.

Recommendations

Data:

- Work with Eversource and National Grid to obtain a more reliable set of electricity and natural gas use data that provides accuracy about the past and can be updated consistently going forward.
- Determine if use from the Hanscom Air Force base and Lincoln Labs should be included in Lexington's use and modify the data accordingly.
- Given that reducing the use of oil will likely be a major source of GHG reductions, refine the methodology used for reporting heating oil use to improve the precision of future reporting.

Residential buildings:

- Target home heating. According to the Energy Information Administration, space heating accounts for 59% of household energy use.[1]
- Target the retrofit of existing homes rather than increasing the efficiency of new homes. Given the low rate of new construction, the vast majority of the homes using energy in Lexington today will be the homes using energy 10, 20, and 30 years from now.
- Among existing homes, target those built in the 1950s and 1960s. These homes account for the most square footage and the most energy use, and are likely to be less efficient than new homes.
- Promote switching from oil heat to electric heat pumps or natural gas. This will be among the most effective actions for reducing GHG from the residential sector.
- Help residents to secure a cleaner electricity supply through municipal aggregation.

Non-residential buildings:

- Target the office buildings and the office/lab combinations rather than the retail stores and restaurants. While the stores and restaurants may be more prominent, the office buildings and labs use vastly more energy.
- Potential targeting and engagement strategies include:
    - Target businesses that have been engaged in other town efforts
    - Reach out to businesses through employees that live in town, particularly businesses where senior executives are Lexington residents
    - Start with the largest property owners. Just seventeen entities own more than half the non-residential square footage in town.
    - Given that the town itself is the single largest property owner, make the town's treatment of its own buildings a model for other large property owners to follow.

Introduction

The Town of Lexington is exploring strategies to become a "net zero emissions" community. Achieving this goal will require reducing the energy use intensity of buildings and taking advantage of opportunities to harvest energy from renewable sources. This Energy Inventory is intended as a first step toward that goal, and it provides information about building energy use, emissions, and changes in the Town's building stock.

Lexington Background and Population

Settled in 1641, Lexington's presence looms large in the history of this country, yet it remains a relatively small community of 33,394 within 16.43 square miles. Population has been increasing in recent years. With estimated growth of 6.4% from 2010 – 2015, Lexington has grown faster the state as a whole (3.8%) for the same period and faster than 6 of the 8 communities on its border (Arlington at 4.6%, Burlington at 5.8%, Woburn at 3.7%, Belmont at 3.5%, Waltham at 4.5%, and Winchester at 4.9%.) The legacy of this growth is a population density that, at 1910 people per square mile, far exceeds the state average of 893 people per square mile.[2]

Lexington attracts and supports talented, financially successful people who move in and stay:

- Median household income is $149,306 compared with $67,846 for the state, and just 3.8% Lexington residents are below the poverty line, compared with an 11.5% poverty rate for the state.
- 77.5% hold a bachelor's degree or higher, compared with 40.5% for the state.
- Just about half of Lexington residents are of working age: 50.7% of residents are between the ages of 18 and 64, while 18.6% are aged 65 and older.
- 81.9% live in a house they own, and 91.5% lived in the same house one year ago.[3]

2012 data from the American Community Survey shows "professional, scientific, and technical services" companies dominate Lexington's commercial sector in number of businesses, though "wholesale trade" comes a close second in value of business done, in spite of having only 29 such businesses.[4]

Building Inventory

The Lexington Assessor's database confirms that Lexington is primarily a residential community, with residential buildings accounting for 95% of the buildings and 77% of the building square footage in town.[5]

Residential

Among residential buildings, three styles account for nearly half the square footage: colonials (19%), contemporary colonials (19%), and capes (11%). Twelve building types make up the other half of the square footage.

Two features of the building stock may be particularly significant for Lexington's efforts to reduce its greenhouse gas emissions:

- While historic homes and new properties are prominent, far more of the town's homes were built in the 1950s and 1960s than any other decades. Construction from that era is less energy efficient than modern construction.
- Since the 1970s, the average new home has been getting larger every decade. In fact, the average size of homes built in the 2010s is nearly twice the town average. Although more energy efficient than older homes, the size of these homes will cause them to use more energy, particularly for heating.

Figure 1 below illustrates construction over time and shows changes in both the number of buildings and the average size of those buildings. The blue bars show the number of homes built. The orange circles show the average size of those homes.

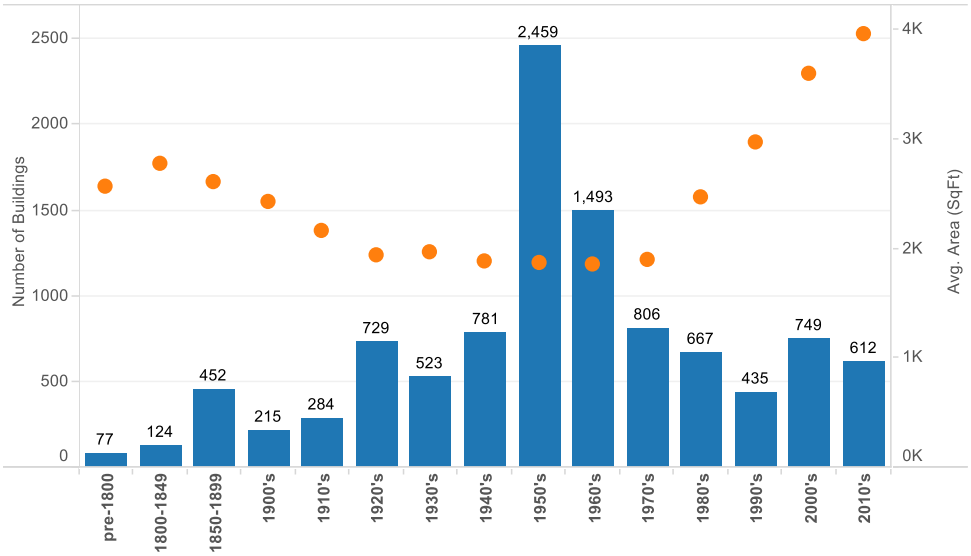

Figure 1. Residential construction by time period. Apartment buildings have been excluded from the table because their large size can distort the average square footage in the years they were built.

Figure 2 shows the percentage of square footage and the percentage of the number of properties by building style. It shows the predominance of colonials, contemporary colonials, and capes. Table 1 that follows provides more detail about construction by building type.

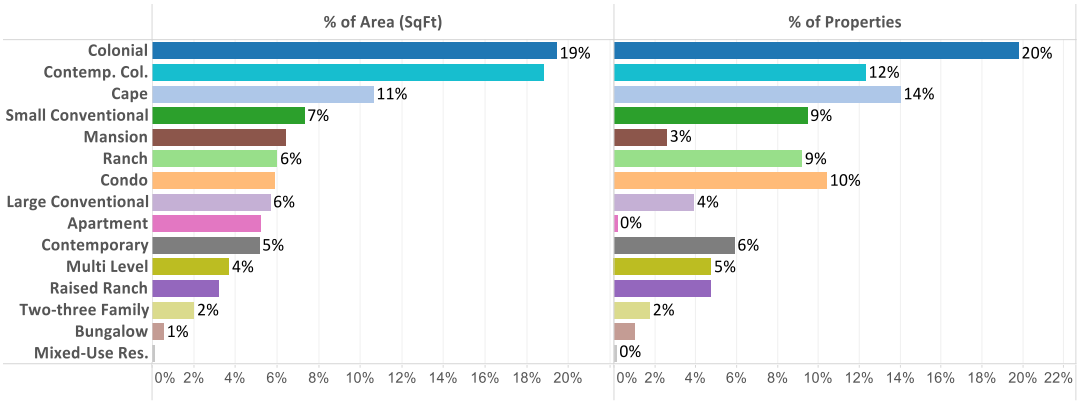

Figure 2. Residential properties by style

Table 1. Residential properties by style

Style	Properties	% of Properties	Area (SqFt)	% of Area (SqFt)	Avg. Area (SqFt)	Avg. Year Built
Apartment Building	15	0%	1,295,919	5%	86,395	1946
Bungalow	105	1%	138,923	1%	1,323	1925
Cape	1,461	14%	2,647,678	11%	1,812	1949
Colonial	2,062	20%	4,837,861	19%	2,346	1954
Condo	1,083	10%	1,463,895	6%	1,352	1971
Contemporary Colonial	1,284	12%	4,677,278	19%	3,643	1999
Contemporary	613	6%	1,283,049	5%	2,093	1963
Large Conventional	406	4%	1,407,987	6%	3,468	1893
Mansion	270	3%	1,594,884	6%	5,907	1989
Mixed-Use Residential	11	0%	27,348	0%	2,486	1909
Multi Level	493	5%	922,944	4%	1,872	1960
Raised Ranch	491	5%	794,036	3%	1,617	1967
Ranch	958	9%	1,491,859	6%	1,557	1955
Small Conventional	986	9%	1,822,921	7%	1,849	1914
Two-three Family	183	2%	499,055	2%	2,727	1895
Grand Total	**10,421**	**100%**	**24,905,637**	**100%**	**2,390**	**1956**

A review of residential building permits shows the rate of building construction and demolition in town. Over the last four years, the town has issued an annual average of approximately 75 new construction permits and 50 demolition permits. This shows that new homes are being added, and existing homes replaced, at very low rates—in both cases well less than one percent per year.

In one way, this low rate of new construction helps with the town's greenhouse gas (GHG) emissions reduction goals: the town does not have to address a rapidly increasing population of buildings. However, the low rate of new construction also emphasizes that Lexington will need to find a way to reduce emissions from its existing building stock, as it will not see gains from a large-scale replacement of old inefficient homes with new, highly efficient homes. Based on recent trends, the buildings using energy in Lexington today will be the same buildings using energy 10, 20, and even 30 years from now.

One factor contributing to the low rate of turnover in Lexington is the high percentage of protected homes. Nearly 2,000 buildings in town are either located in an historic district or protected under the town's Demolition Delay bylaw. That bylaw applies to buildings listed on the National Register of Historic Places, in the Town's Comprehensive Cultural Resources Survey, or otherwise determined by the Historic Commission to be significant. The bylaw requires a one-year delay before these homes can be demolished.[6]

Non-Residential

In the assessor database, the non-residential square footage is dominated by three building types: office (32%), office/lab (27%), and school (16%). The average building size is 14,093 SqFt. However, the size of the individual buildings varies quite considerably, with 18 buildings over 100,000 SqFt and three buildings over 200,000 SqFt.

Looking at non-residential buildings by year built shows that the great majority of the buildings were constructed from the 1950s through the 1980s. Also, the average size of buildings has increased over time.

Figure 3 below illustrates non-residential construction over time and shows changes in both the number of buildings and the average size of those buildings. The blue bars show the number of homes built. The orange circles show the average size of those homes. Figure 4 and Table 2 provide more detail about construction by building type.[7]

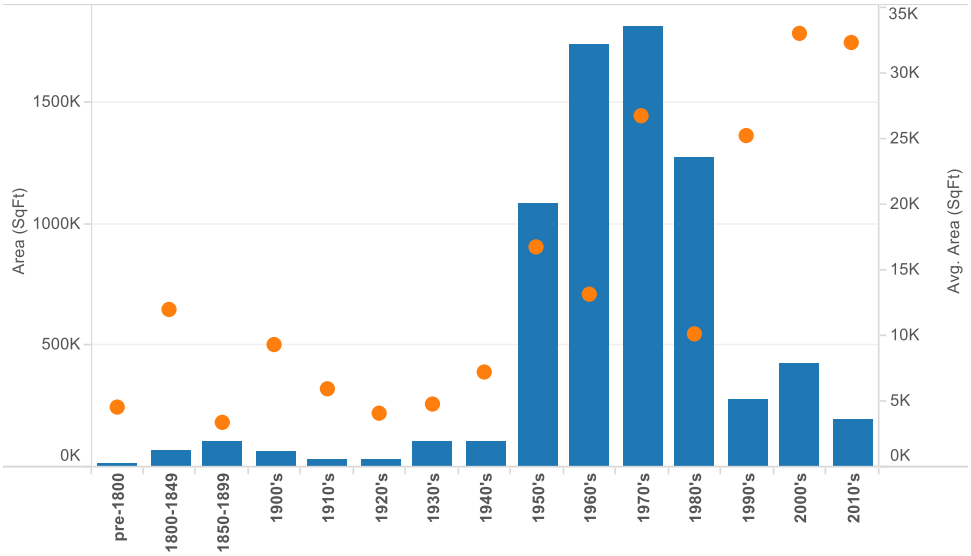

Figure 3. Non-residential construction by time period

Figure 4 shows the percentage of square footage and the percentage of the number of properties by building style. It shows the dominance of offices, office labs, and schools. It also shows that buildings in the office/lab category are much larger than average; those buildings make up only 5% of the number of buildings but 27% of the square footage. Table 2 that follows provides more detail about construction by building type.[8]

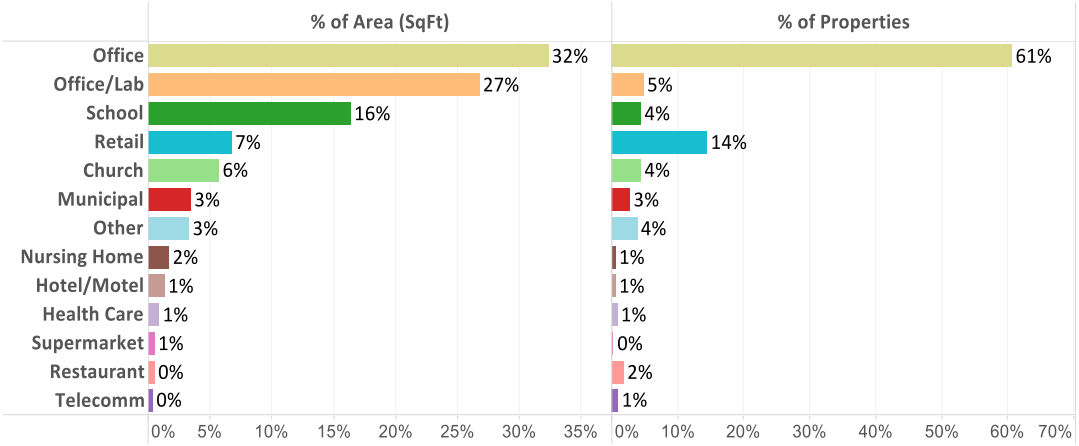

Figure 4. Non-residential properties by style

Table 2. Non-residential properties by style

Style	Properties	% of Properties	Area (SqFt)	Avg. Area (SqFt)	Avg. Year Built
Church	23	4%	418,353	18,189	1945
Health Care	4	1%	63,846	15,962	1945
Hotel/Motel	3	1%	97,269	32,423	1956
Municipal	14	3%	254,051	18,147	1954
Nursing Home	3	1%	126,203	42,068	1962
Office	316	61%	2,373,844	7,512	1962
Office/Lab	25	5%	1,965,602	78,624	1975
Other	20	4%	241,747	12,087	1968
Restaurant	9	2%	36,400	4,044	1956
Retail	75	14%	495,413	6,606	1951
School	23	4%	1,199,910	52,170	1945
Supermarket	1	0%	40,014	40,014	1965
Telecomm	5	1%	29,558	5,912	1952
Total	**521**	**100%**	**7,342,210**	**14,093**	**1959**

According to the assessor's database, the Town of Lexington is the single largest property owner in town, accounting for nearly 1 million square feet. Overall, ownership is concentrated in 17 large property owners, which together own more than half of the non-residential square footage. In many cases, those owners are not the businesses located in the properties, but a real estate firm or investment entity. The list of large owners is set out in Table 3 below.

Table 3. Largest non-residential property owners

Name	Area (SqFt)	Properties
Town of Lexington	978,739	22
Shire Human Genetic Therapies, Inc	596,113	5
Normandy Lexington Acquisition	296,028	1
95 Hayden LLC	229,982	1
Alexandria Real Estate Equities	171,459	4
191 Spring Street Trust	166,471	1
3 Forbes De LLC	161,202	1
128 Spring Street Lexington LLC	133,024	1
Colangelo Steven Trustee	128,672	1
85 Hartwell Avenue Trust	117,710	1
Grace Chapel Inc	113,791	3
Duffy Hartwell LLC	113,570	3
Wellford Corp C/O BAE Systems	102,879	1
Cranberry One LLC	102,572	1
King 113 Hartwell LLC	102,096	1
WLC Five VI LLC	101,690	1
Cong of Armenian Cath Strs	99,663	1
Total	**3,715,661**	**49**

However, as addressed in more detail in the discussion of energy use by property below, the assessor database does not include state or federal properties. The energy use data from Eversource includes large federal facilities that, if included in the property list, would likely put federal entities into the list of largest property owners.

Energy Consumption

Buildings in Lexington are fueled by three primary sources: electricity, natural gas, and heating oil.

Electricity

According to data provide by Eversource, Lexington used nearly 450 million kilowatt-hours of electricity in 2015. Non-residential electricity use dominated, accounting for 77% of the total with residential use accounting for only 23% of the total. This indicates that Lexington will have to address non-residential electricity uses in order to achieve its emission goals.

The Eversource data includes two very large users, Hanscom Air Force Base and MIT Lincoln Lab, that are not included in the Lexington assessor's database. The Air Force base is located only partially in Lexington. Eversource's inclusion of the property in Lexington is likely due to the location of the electric meter, rather than the location of the bulk of the energy use. The Town will need to decide whether this use should be included when calculating Lexington's emissions.

Looking across the years, it appears that overall electricity use in Lexington has been fairly constant since 2009 at approximately 450 million kWh per year.[9] This flat usage pattern is consistent with the experience of the state as a whole over the same time period. The annual electric usage for both Lexington and Massachusetts are presented in Figure 5.

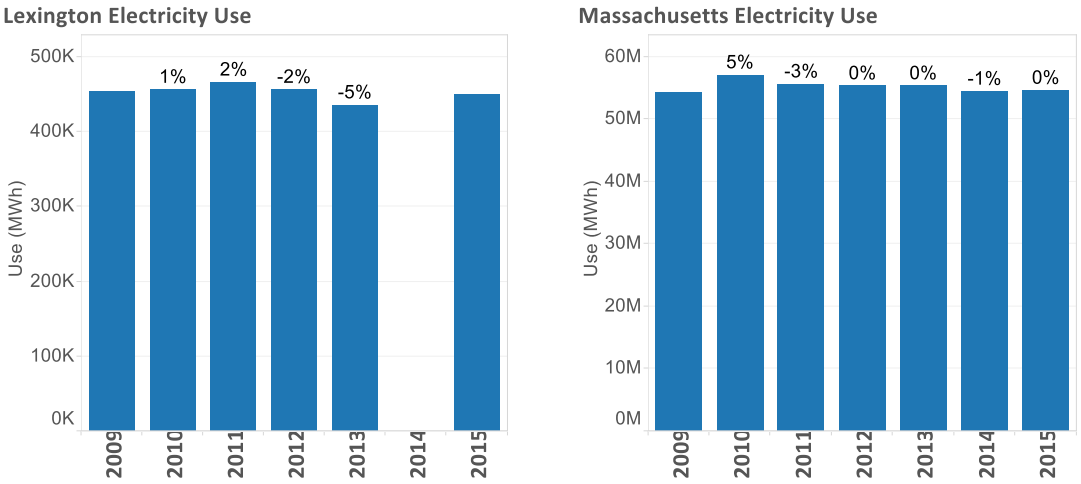

Figure 5. Lexington and Massachusetts electricity use. Lexington data was not available for 2014.

Keeping electricity usage flat is a significant accomplishment given an increasing population and an increasingly electrified society. While we do not have use data for Lexington prior to 2009, we know that for the state as a whole, electric use typically increased one to two percent per year up until 2007.

Solar Electricity

Lexington has added a significant amount of solar photovoltaic generation in town, on residences (2.2 MW), schools (1.1 MW), and at the landfill (2.2 MW). Altogether, those systems will generate over 7 million kWh per year.

The total production of the solar systems will equate to approximately 1.6% of Lexington's total electricity use. The actual reduction in Lexington's use of grid electricity will be smaller, however, and will depend on how the solar systems are connected. Some systems are set-up to provide electricity to the on-site customer. This is typical of solar systems on homes and true of some systems on commercial buildings and schools. Other systems, particularly those located where there is no significant customer on-site, are wired to send electricity directly to the grid. This is typical of systems on landfills. Systems connected in this way will not reduce Lexington's use of grid electricity, although they will contribute to the region's supply of clean electricity. Subtracting the solar electricity generated at the landfill, the remaining solar systems in Lexington will reduce the town's use of grid electricity by about 1%.

Natural Gas

According to National Grid, Lexington used 14.6 million therms of natural gas in 2015. Unlike the electricity use, natural gas use is evenly split between residential and non-residential buildings. In 2015, residential accounts were responsible for 48% of gas use and non-residential accounts for 52%. The gas data does not indicate whether it includes the large federal users that are included in the electricity data.

Lexington's natural gas use was 14.6 million therms in 2015 and has increased significantly since 2009. The reported natural gas use is also much more variable year to year than the electricity use. Specifically, gas use ranged from a low of 8,681,628 therms in 2010 to 15,155,071 therms in 2014.

Several factors help to explain this variability:

- Residential gas use is devoted primarily to heating. Gas use for heating varies with weather, and winter weather has been quite variable over the last few years.
- The number of gas accounts in Lexington has been increasing as customers have switched from oil to gas. This would lead to an increase in use even if the average use per account stayed the same.

Nonetheless, the level of variability in the Lexington data is higher than would be expected and higher than the variability of Massachusetts natural gas use as a whole. Figure 6 below presents gas use for Lexington and gas use for Massachusetts as a whole as reported by the Energy Information Administration. Orange bars show gas use. Green circles show heating degree days. The figure illustrates that statewide gas use is less variable and tracks degree days more closely than does the reported Lexington use. For example, the Lexington data shows use dropping by 16% in 2013, but heating degree days increased that year which should result in higher use, not lower. This suggests that some of the variation in the reported Lexington use may be due to anomalies in the data rather than actual variations in use.

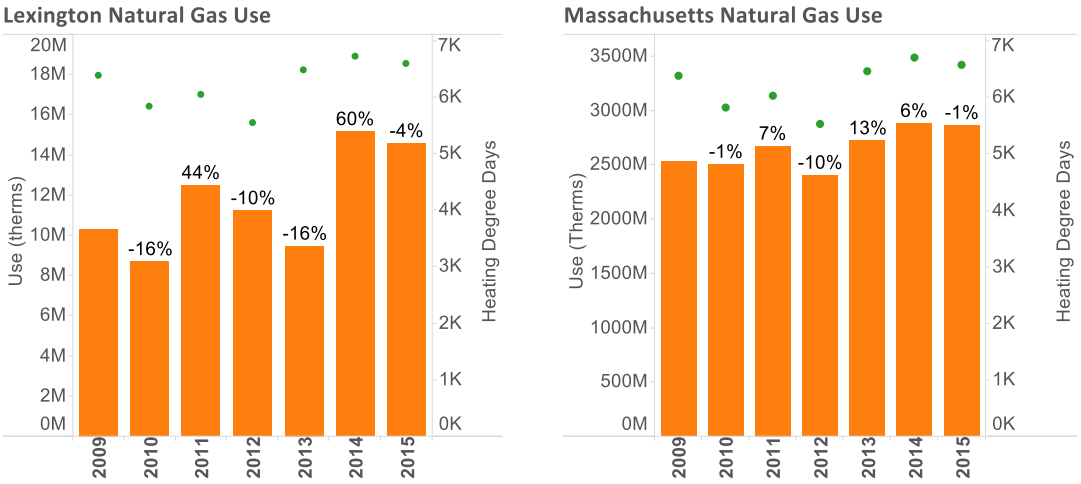

Figure 6. Lexington and Massachusetts natural gas use

Heating Oil

It is challenging to determine town-wide heating oil use. Unlike for electricity and natural gas, there is no regulated utility that serves all customers and is willing to provide aggregated use data. Instead, heating oil is provided by numerous private companies that do not report their customer use. As a result, heating oil use must be estimated.

We estimated the total annual heating oil use at just under 3.5 million gallons per year. The estimate is based on an estimate of the number of oil-heated homes in Lexington from the American Community Survey[10] and a calculation of average annual heating use from the Massachusetts Department of Energy Resources.[11] Our estimate reflects only residential heating oil use. We have no reliable way to estimate non-residential use. However, non-residential oil use is becoming increasingly uncommon. It is possible that there is none in Lexington.

Heating oil use has been dropping as homes have switched from oil to natural gas or, in some cases, electric heat pumps. Figure 7 below estimates oil use by year.

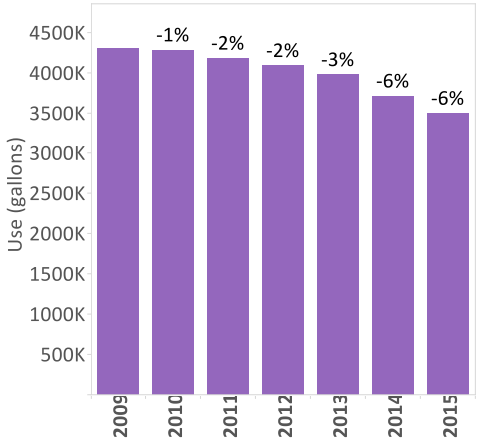

Figure 7. Estimated oil use by year. The estimate is calculated from an estimate of oil-heated homes from the American Community Survey and Massachusetts' average annual heating oil per home from the Massachusetts Department of Energy Resources. The oil use has not been adjusted for year-to-year variations in weather.

GHG emissions

GHG emissions by fuel and sector

We applied the energy use to GHG emission factors to calculate GHG emissions by fuel and sector. The emission factors are explained further in the next section.

As shown in Figures 8 and 9 below, electricity is responsible for the lion's share of Lexington's CO2 emissions, accounting for 57% of the total, followed by natural gas at 29% and oil at 13%. Looking by sector as well as fuel, non-residential electricity use is the greatest contributor at 44% the total.

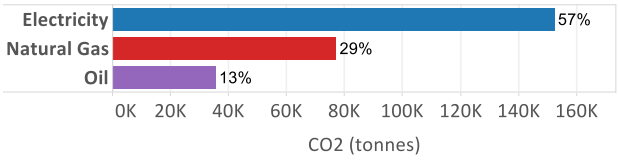

Figure 8. CO2 emissions by fuel

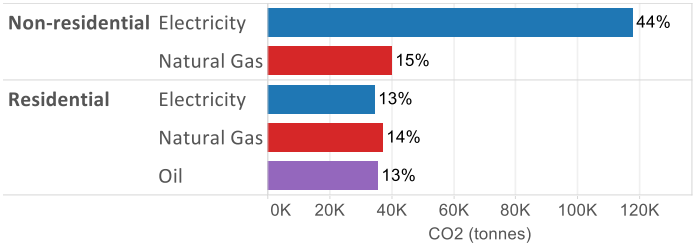

Figure 9. CO2 Emissions by sector and fuel

GHG emissions factors

Emission factors are used to determine the emissions associated with energy use.

For electricity, the GHG emissions factor is determined by the fuel sources used to generate the power. Power plants that burn coal or oil have higher factors (more CO2 per kWh generated), and plants that use cleaner fuels have lower factors. The electricity consumed in Lexington is generated by a mix of generating sources. Determining the overall factor requires determining the amount of electricity generated by each source and then applying the specific factor for that source to the amount of electricity generated. In determining an electricity emissions factor for Lexington, we used the emissions factor calculated by ISO New England for the regional electric grid as a whole.[12]

For natural gas and heating oil, we do not have the complexity of different generating sources and a mix of sources that varies by year. We have used the factors published by the Environmental Protection Agency for its Climate Leadership Program.[13]

However, the calculation of the greenhouse gas emissions associated with natural gas use can become more complicated given the existence of leaks in the gas distribution system. A recent analysis has estimated a 2.7% leakage rate in Metro Boston.[14] Given the higher GHG impact of gas leaked directly to the atmosphere rather than

burned when used, leaks significantly increase the GHG impact of natural gas. The effect of leaks has not generally been incorporated yet into GHG reporting, but this will be an issue to watch going forward.

Combining the annual energy use figures with emissions factors, it is possible to calculate Lexington's GHG emissions over time. Figure 10 below shows Lexington's emissions for 2012 – 2015, omitting 2014 as there is currently no electric data available for that year. As the figure shows, emissions from oil is dropping as the number of oil heated homes is declining. Emissions from electricity has increased. Electric use has remained relatively steady, but, as discussed below, the emissions factor for electricity has worsened. Emissions from gas jump around quite a lot. This is likely due to anomalies in the gas use data, as discussed in more detail in the usage section. Given the anomalies in the data, the figure is only illustrative, and will need to be refined when more reliable data is available.

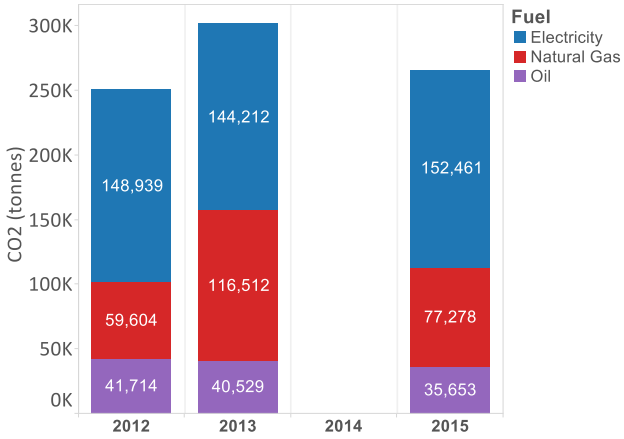

Figure 10. CO2 emissions by year

The electricity emission factor varies each year as the mix of generating resources varies. In recent years, New England's emission factor has declined considerably as our generating mix has gotten cleaner. Relatively dirty coal and oil-fired generation has been replaced by cleaner natural gas-fired generation, and the region has increased its use of renewable energy. As a result of these changes, the region's C02 emission factor declined by 28% from 1999 to 2014.[15]

Looking ahead, however, the picture is not as bright. The retirement of the region's nuclear generating fleet is removing a large, carbon-free generating resource from the mix. The Vermont Yankee plant closed in 2014, and the Pilgrim Nuclear Power Station is scheduled to close in 2019.[16] Also, the constraints in natural gas pipeline capacity coupled with low oil prices have produced a small increase in oil-fired generation. The region is planning to further increase its use of renewables which would reduce emissions, but that may not be enough to offset these other forces.

For Lexington, this trend increases the importance of making conscious decisions about the Town's power supply. The emissions reported above are based on the generation mix for the region as a whole. Lexington is pursuing municipal aggregation, which will enable it to choose a cleaner power supply for the community.

GHG emissions by building type

To assist Lexington in targeting its emission reduction efforts, we estimated the CO2 emissions by building type. Since we had access only to aggregate natural gas and oil use data, we could not calculate the actual emissions. Instead, we estimated emissions using several sources of information including the aggregate energy use, square footage from the assessor's database, energy use intensities (use per square foot) (EUIs) from the US Energy Information's Commercial Buildings Energy Consumption Survey (CBECs), and actual account-level electricity use information.

The resulting estimates are necessarily not precise, but should provide guidance as to where the sources of energy-related emissions are concentrated. Figure 11 below shows the percentage of emissions attributable to each of the major building types.[17] As the figure shows:

- Homes account for slightly over 40% of emissions.
- While downtown shops are the face of Lexington business, the great bulk of emissions are related to the federal facilities, office buildings, and labs. That is where the Town will need to make progress if it wishes to reduce non-residential energy consumption and associated GHG emissions.
- As would be expected, the labs are very electricity-intensive. The electricity use per square foot of buildings that house both lab and office space is more than twice that of offices alone.
- Other high-electricity-intensity buildings include supermarkets and restaurants. However, those buildings account for only a small fraction of the total energy use because they represent only a small fraction of the square footage.

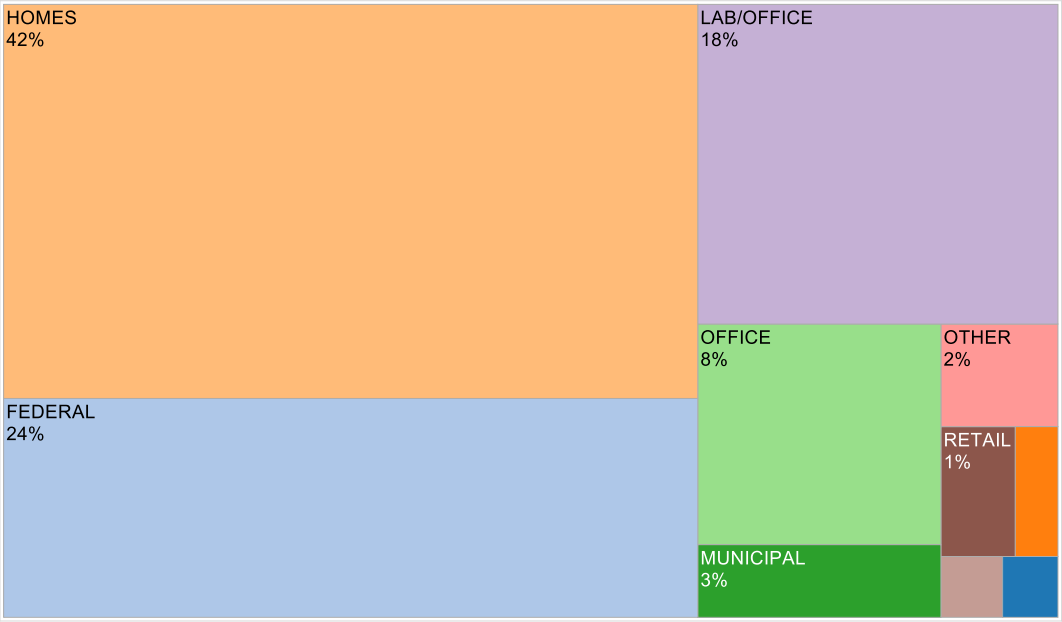

Figure 11. CO2 Emissions by building type

Because of questions about whether some of the federal facilities are appropriately included in Lexington's emissions total, we also calculated the emissions by type excluding the federal facilities. This is shown in Figure 12.

With the federal facilities excluded, of course, the percentage contributions of the other building types increases. The importance of the homes, labs, and office buildings is still apparent.

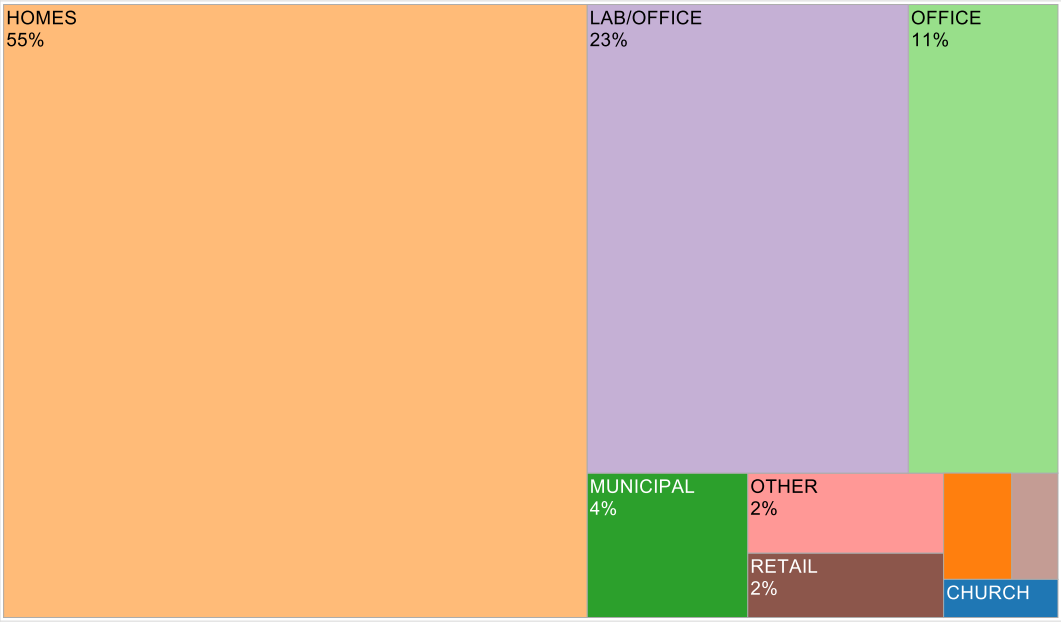

Figure 12. CO2 Emissions by building type – excluding federal facilities

To provide more detail on Lexington's non-residential buildings, we also calculated the percentage totals after excluding the residential buildings as well as the federal buildings. This is shown in Figure 13. This highlights the importance of the labs and office buildings, which account for 76% of the total emissions from the non-residential buildings.

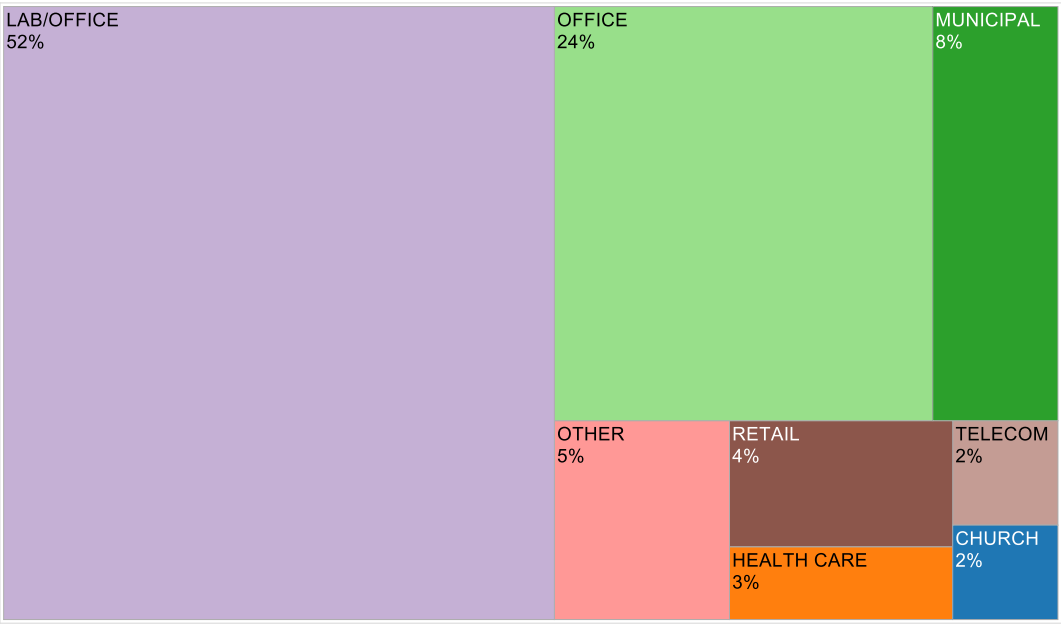

Figure 13. CO2 emissions by building type – excluding federal facilities and homes

Looking at energy use per square foot revealed one interesting fact about Lexington's non-residential buildings: the newer homes are using electricity much more efficiently. Figure 14 below shows how electricity use per square foot peaked from the 1950s through the 1970s (when most of Lexington's homes were built) and has been dropping since. The blue bars illustrate square footage, and the red circles illustrate average kWh per square foot.

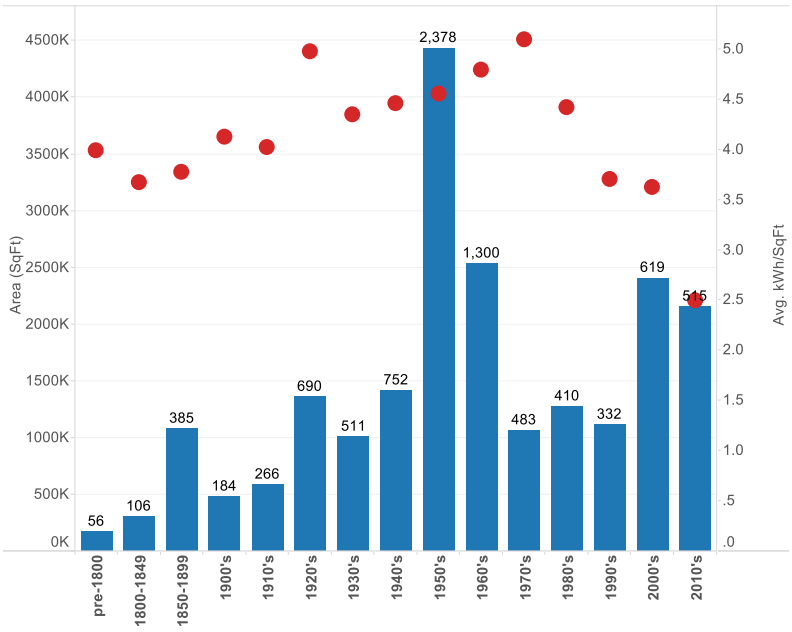

Figure 14. Residential building square footage and electricity use intensity by period built

Recommendations

The review of Lexington's building inventory and energy use suggests some promising next steps for Lexington's greenhouse gas reduction efforts.

Data

Both the electric and gas data sets used in generating this report were compiled from data requested at different times. As a result, the data (particularly the gas data) contains potential anomalies that may make it unreliable for showing historic trends. Lexington can work with Eversource and National Grid to obtain a reliable data set that provides accuracy about the past and can be updated consistently going forward.

The electricity data (and potentially the gas data) includes use from the Hanscom Air Force base and Lincoln Labs. Lexington should determine if this use should be included in the town's data, and ask the utilities to modify the data if needed.

The heating oil use reported in this report is a rough estimate. Given that reducing the use of oil will likely be a major source of GHG reductions, the town would benefit from refining this methodology to improve the precision of future reporting.

Residential energy use and emissions

The following specific recommendations can help Lexington to reduce residential energy use and emissions:

- Target home heating. According to the Energy Information Administration, space heating accounts for 59% of household energy use.[18]

- Target the retrofit of existing homes, rather than increasing the efficiency of new homes. Given the low rate of new construction, the vast majority of the homes using energy in Lexington today will be the homes using energy 10, 20, and 30 years from now.

- Among existing homes, target those built in the 1950s and 1960s. These homes account for the most square footage and the most energy use and are likely to be less efficient than new homes.

- Promote switching from oil heat to electric heat pumps or natural gas. This will be among the most effective actions for reducing GHG from the residential sector.

- Help residents to secure a cleaner electricity supply. Given the expected changes to the generation fleet, it is likely that the average region-wide supply will not get cleaner and may well get dirtier over the coming years. Lexington is already taking a powerful action to green residents' electricity supply through its municipal aggregation program.

Non-residential energy use and emissions

We recommend Lexington target the office buildings and the office/lab combinations rather than the retail stores and restaurants. While the stores and restaurants may be more prominent, the office buildings and labs use vastly more energy.

However, making progress with those large users will likely prove difficult. Other communities have found that many large businesses do not feel as strong a connection to the town as residents and retail merchants do, and so are more difficult to influence with town programs.

Potential targeting and engagement strategies include:

- Target businesses that have been engaged in other town efforts

- Reach out to businesses through employees that live in town, particularly businesses where senior executives are Lexington residents

- Start with the largest property owners. Just seventeen entities own more than half the non-residential square footage in town.

- Given that the town itself is the single largest property owner, make the town's treatment of its own buildings a model for other large property owners to follow. Document and publicize the town's energy efficiency efforts to date, and prioritize and publicize additional actions.

References

[1] US Energy Information Administration. (2009). *Household Energy Use in Massachusetts*. https://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ma.pdf

[2] United States Census Bureau. (2017). *Quick Facts: Lexington Town Massachusetts.* http://www.census.gov/quickfacts/table/PST045215/2501735215,25

[3] Ibid.

[4] United States Census Bureau. (2016) *American Fact Finder*. http://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012_US/00A1/E600000US2501735215

[5] Information about the building stock comes from the Lexington Assessor's database. That database reports "properties" which includes condominiums. In many cases, the condominiums represent a portion of a physical building, making the number properties reported higher than the number of buildings.

[6] Town of Lexington. *Demolition Delay*. http://www.lexingtonma.gov/demolition-delay

[7] Totals include condominiums, which in many cases represent a portion of a physical building.

[8] Ibid.

[9] The historic electricity use data was compiled from several different reports provided by Eversource. While the numbers look credible year-to-year, compiling different data sets does not always produce an accurate picture. Sometimes data sets requested at different times are generated in different ways, preventing apples-to-apples comparisons. To get a more reliable picture of use over time, it would be useful to ask Eversource to generate a single data set with all the needed years.

[10] United States Census Bureau. (2016) *American Fact Finder*. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF

[11] Massachusetts Executive Office of Energy and Environmental Affairs. (2016). *2016/2017 Projected Household Heating Costs*. http://www.mass.gov/eea/energy-utilities-clean-tech/misc/household-heating-costs.html

[12] ISO New England. (2017). *2015 ISO New England Electric Generator Air Emissions Report.* https://www.iso-ne.com/static-assets/documents/2017/01/2015_emissions_report.pdf

[13] EPA Center for Corporate Climate Leadership. (2015). *Emission Factors for Greenhouse Gas Inventories*. https://www.epa.gov/sites/production/files/2016-09/documents/emission-factors_nov_2015_v2.pdf. We converted the factors from kg per mmbtu to lbs per therm and gallon for use in the report.

[14] McKain, K. et al. *Methane emissions from natural gas infrastructure and use in the urban region of Boston, Massachusetts*. Proc. Natl. Acad. Sci. 112 (7), 1941e1946. http:// dx.doi.org/10.1073/pnas.1416261112.

[15] ISO New England, Air Emissions Report.

[16] US Energy Information Administration. (2017). *Massachusetts State Energy Profile*. http://www.eia.gov/state/print.cfm?sid=MA

[17] The total for municipal includes non-building related electricity uses such as streetlighting and water pumping.

[18] US Energy Information Administration, Household Energy Use in Massachusetts.