Community Decarbonization Documentation for The Town of Holliston

Town of Holliston
Community Decarbonization Documentation
June 30, 2023

Town of Holliston,

Thank you for the opportunity to help provide background information for Holliston's community decarbonization plan. With financial assistance from the MA Department of Energy Resources (MA DOER), the Metropolitan Area Planning Commission (MAPC) has prepared the following community decarbonization plan background information report for the Town of Holliston.

This report was developed by MAPC and its consultant John Snell LLC who are solely responsible for the accuracy of this report. We have worked closely with Matt Zettek, Holliston's Sustainability Coordinator to confirm the information in this report and to shape the timing and scale of potential activities designed to meet the state's 50% by 2030, 75% by 2040, and net zero (85%) by 2050 decarbonization goals.

The process that we followed to produce this report included:

1. Prepared a preliminary community-level greenhouse gas emission inventory
2. Estimated potential building, vehicle, and off-road equipment decarbonization investments
3. Reviewed draft reports with municipal staff
4. Prepared a final report and provided Holliston with the supporting analysis files for future reference

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Explanation of Terms and Acronyms

AMI –Advanced Metering Infrastructure. Also known as a smart meter

BEV – battery electric vehicles

Biodiesel - a renewable, biodegradable fuel manufactured domestically from vegetable oils, animal fats, or recycled restaurant grease.

Btu – British thermal unit. A unit of heat equivalent to

Carbon Sequestration - The removal and storage of carbon dioxide from the atmosphere, commonly by plants and soil.

CECP - Clean Energy and Climate Plan

CES - Clean Energy Standard

CO2 - Carbon Dioxide

CPACE – Commercial Property Assessed Clean Energy program

DCR - Massachusetts Department of Conservation and Recreation

DOE – US Department of Energy

DOER - Massachusetts Department of Energy Resources

DPU - Massachusetts Department of Public Utilities

DVMT – Average Vehicle Miles Travelled per Day

Ductless Minisplit Heat Pump – (Ductless) -

E-Bike – Electric bike

EEA - Massachusetts Executive Office of Energy and Environmental Affairs

EEAC - Energy Efficiency Advisory Council

EIA - US Energy Information Administration

EPA – US Environmental Protection Agency

EUI – Energy use intensity

EVs - Electric Vehicles

FCEV – Hydrogen fuel cell electric vehicles

FlexFuel - Flexible fuel vehicles (FFVs) have an internal combustion engine and are capable of operating on gasoline and any blend of gasoline and ethanol up to 83%.

Fossil Fuel - Fossil fuels are made from decomposing plants and animals. These fuels are found in the Earth's crust and contain carbon and hydrogen, which can be burned for energy. Coal, oil, and natural gas are examples of fossil fuels.

Fuel Cell - A fuel cell uses the chemical energy of hydrogen or other fuels to produce electricity. If hydrogen is the fuel, the only products are electricity, water, and heat.

GHG – (Greenhouse Gas) Greenhouse gases, such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), different types of hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF6), trap heat and cause the average global air temperature to rise, thus changing weather patterns globally.

GHG Inventory - Greenhouse Gas Inventory – A list of emission sources and their annual emissions quantified using standardized methods.

Ground-Mount Solar - Solar panels that are set up on the ground to capture energy from the sun to create electricity. Rooftop solar is solar panels that are installed on top of buildings.

Ground-Source Heat Pump – (Ground)

GW - Gigawatt

GWSA - Global Warming Solutions Act, signed into law in Massachusetts in 2008

Heat Pump - Like your refrigerator, heat pumps use electricity to transfer heat from a cool space to a warm space, making the cool space cooler and the warm space warmer. During the heating season, heat pumps move heat from the cool outdoors into your warm house. During the cooling season, heat pumps move heat from your house into the outdoors.

HDV – Heavy duty vehicle (>26,001 lbs. Gross Vehicle Weight Rating)

HVAC - Heating, ventilation, and air conditioning system

HEV (Hybrid) – A vehicle that runs on electricity and an internal combustion vehicle

Hydrogen – The fuel used to run fuel cell electric vehicles

ICE – Internal Combustion Engine

ISO-New England - Independent System Operator-New England

kBtu – 1,000 British Thermal Units (Btus)

kW – 1,000 Watts. A unit of measurement for electricity capacity/volume

kWh – 1,000 Watt Hours. A unit of measurement for electricity use or output

LDV – Light duty vehicle (<10,000 lbs. Gross Vehicle Weight Rating)

MassCEC - Massachusetts Clean Energy Center

MassDEP - Massachusetts Department of Environmental Protection

MassDOT - Massachusetts Department of Transportation

MassEEA - Massachusetts Executive Office of Energy and Environmental Affairs

MBTA - Massachusetts Bay Transportation Authority

MDV – Medium duty vehicle (10,001 – 26,000 lbs. Gross Vehicle Weight Rating)

MHDV – Medium and heavy-duty vehicles (> 10,000 lbs. Gross Vehicle Weight Rating)

MMTCO2e - Million metric tons of carbon dioxide equivalent – This is a measure of how much greenhouse gas is emitted into our atmosphere. Emissions include carbon dioxide, methane, nitrous oxide, and other greenhouse gas emissions. An emission of 1 MMTCO2e is equivalent to burning 112,523,911 gallons of gasoline.

MSW - Municipal Solid Waste

MT CO2 Metric tons of carbon dioxide

MT CO2e Metric tons of carbon dioxide equivalent. This includes the carbon dioxide equivalent emissions from methane (CH4), nitrous oxide (N2O), different types of hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF6)

MW - Megawatts

MWC - Municipal Waste Combustors – Also known as incinerators or waste-to-energy plants.

Net Zero - Net zero refers to the balance between the amount of greenhouse gas (GHG) that's produced and the amount that's removed from the atmosphere. It can be achieved through a combination of emission reduction and emission removal

NWL - Natural and working lands as defined in Chapter 8 of the Acts of 2021.

Off-Road Vehicle - Off-road vehicles include industrial equipment, lawn and garden equipment, light commercial equipment, and construction equipment

PACE – Property-Assessed Clean Energy program

PHEV - A vehicle that runs on electricity and an internal combustion vehicle that can be plugged into an electric outlet to charge the battery

PPA – Power Purchase Agreement

PV - Photovoltaic

REC – Renewable Energy Credit

RGGI – Regional Greenhouse Gas Initiative

RPACE – Residential Property Assessed Clean Energy program

RPS - Renewable Energy Portfolio Standard

Solar PV – Solar photovoltaic electricity generating panels that convert energy from the sun into electricity

SOV – Single Occupancy Vehicle

Therm – A quantity of heat that equals 100,000 British thermal units

Ton - A ton of heating or cooling is 12,000 British thermal units

VMT – Annual Vehicle Miles Travelled

VRF Heat Pump – (VRF) Variable refrigerant flow heat pump

WWTPs - Wastewater Treatment Plants

ZEV - Zero Emission Vehicle - battery electric vehicle (BEV) and hydrogen fuel cell vehicle (HFCV)

Community Decarbonization Roadmap

Holliston is a community of about 14,996 (in 2020) residents located in Massachusetts. The town includes a vibrant commercial sector and an active industrial base.

From a greenhouse case emissions perspective, Holliston's residential, commercial, and industrial sectors emitted about **136,006 MT CO2e**[1] greenhouse gas emissions (GHG) per year[2] in 2017. Beginning with the Global Warming Solution Act (GWSA) signed into law in 2008 and most recently updated by *An Act Creating A Next-Generation Roadmap for Massachusetts Climate Policy* in 2021, Massachusetts has established clear greenhouse gas (GHG) emission reduction targets for the state. The state's current decarbonization targets are 50% by 2030, 75% by 2040, and net zero (85%) by 2050 below the state's greenhouse gas emissions in 1990.

As of 2017, Massachusetts reported that it had reduced statewide GHG emissions 23% below its 1990 carbon emissions baseline. The primary source for these GHG emission reductions were from cleaner electricity generation.

The two primary documents that MAPC reference in this report include the Massachusetts Executive Office of Energy and Environmental Affairs (MassEEA) December 2020 *Massachusetts 2050 Decarbonization Roadmap* and MassEEA's June 2022 *Massachusetts Clean Energy and Climate Plan for 2025 and 2030.*

This report provides background information that will help the Town of Holliston develop a community decarbonization roadmap to support Massachusetts' greenhouse gas emission reduction goals. The three primary sources of carbon emissions that we identified for Holliston were:

1. Fuel Combustion for Electricity generation;
2. Space and water heating in buildings;
3. Gasoline and diesel fuel combustion for vehicles.

[1] Metric tons of carbon dioxide equivalent

[2] Please refer to Holliston's September 8, 2022, Greenhouse Gas (GHG) Inventory report and associated spreadsheet file for more details regarding the breakout of GHG emissions by municipal sector.

Table 1 summarizes Holliston's town wide greenhouse gas emissions by community sector. Carbon emissions include electricity generation, local fuel combustion for space and water heating, and off-road purposes. Other greenhouse gas emissions include methane (CH4) from natural gas distribution and waste management, and nitrous oxide (N2O) from gasoline and waste.

Community Sector	Total Carbon Emissions (mTonsCO2e)	Emissions (%)
Buildings		
Residential	47,886	35%
Commercial	20,450	15%
Vehicles		
Gasoline	56,848	42%
Diesel	1,689	1%
Off-Road	5,697	4%
Waste	3,434	3%
Total	136,004	100%

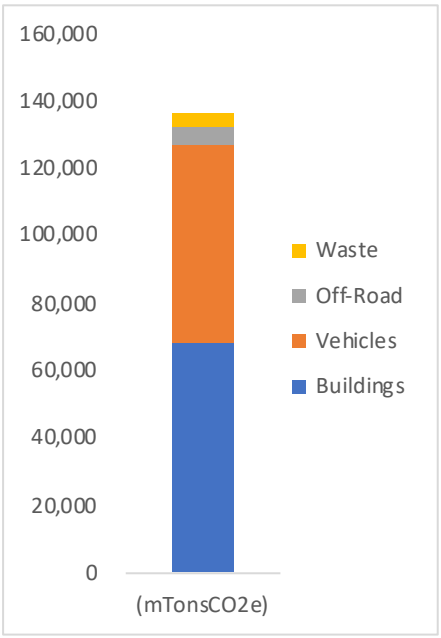


Table 1 Greenhouse Gas emissions by community sector[3]

For the buildings sector, 35% of the carbon emissions are from electricity generation and 65% are from fuel combustion. The vehicle and off-road sector emissions are 100% from fuel combustion. Waste emissions are from direct and effluent emissions. Table 2 summarizes the total town wide energy use by community sector.

Community Sector	Electricity (kWh)	Gas (Therms)	Oil (Gallons)	Gasoline (Gallons)	Diesel (Gallons)
Buildings	97,267,000	5,300,368	1,545,667		
Vehicles				6,445,258	212,157
Off-Road				548,778	
Total	97,267,000	5,300,368	1,545,667	6,994,035	212,157

Table 2. Energy use sources by community sector

[3] "All Sectors" in the lower table includes buildings, vehicles, off-road, and waste.

Recommendations

MAPC recommends that Holliston continues to reduce its greenhouse gas emissions with a series of initiatives and actions that address building, transportation, and electricity generated greenhouse gas emissions. The three primary strategies to reduce carbon emissions from these sources include:

1. Convert space and water heating systems from fuel to high efficiency electricity
2. Convert residential and commercial vehicles from internal combustion engines to electric motors
3. Convert off-road equipment from internal combustion engines to electric motors

This approach focusses on fossil fuel-fired equipment replacement with high efficiency electric equipment. Converting heavy-duty vehicles will be challenging in the near term. In addition, unknown technologies like hydrogen or biodiesel might be better long-term solutions for heavy equipment.

Figure 1 provides a vision of how Holliston can exceed a 50% GHG emissions reduction by 2030 and exceed the State's 85% GHG emissions reduction by 2050.

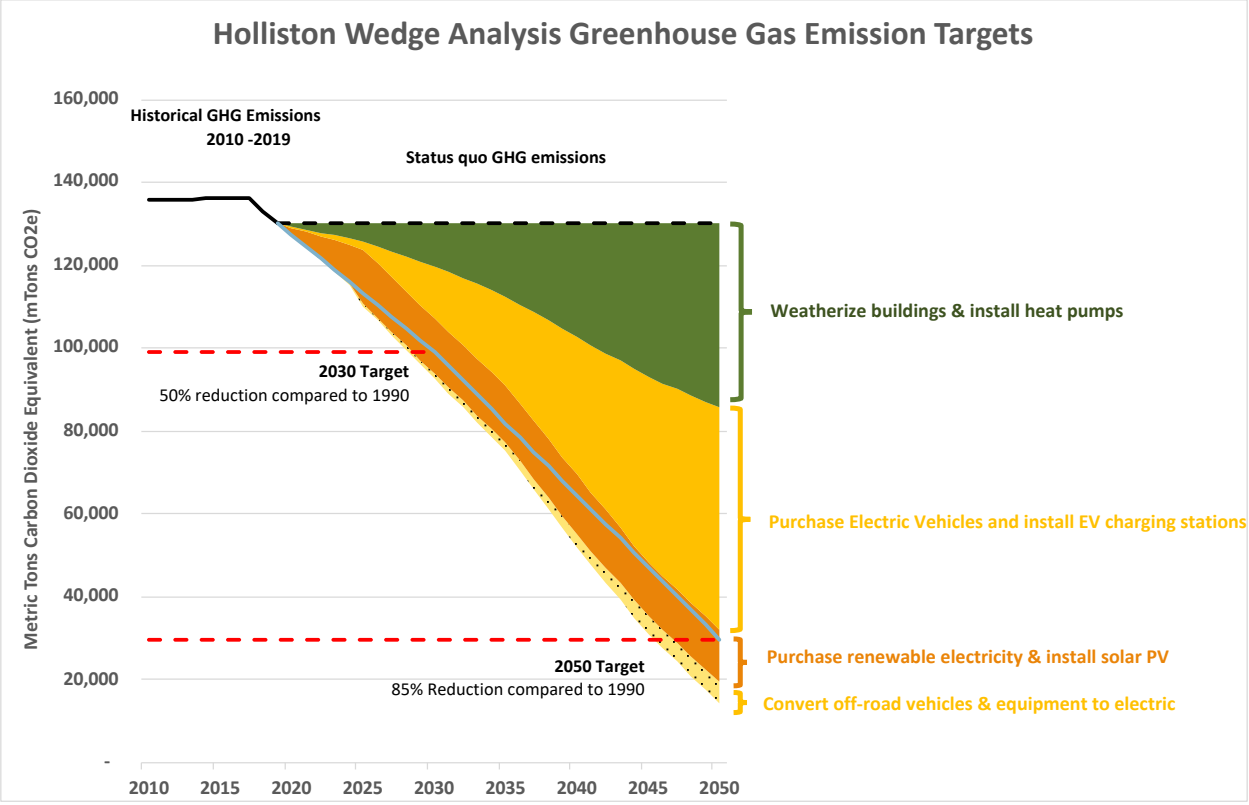


Figure 1. Wedge analysis of Holliston GHG emission reduction targets

The following sections provide supporting documentation and recommendations for these three greenhouse gas reduction strategies.

1. Convert space and water heating systems from fuel to high efficiency electricity

Residential Buildings

Holliston has about 5,171 households with a total floor area of about 13,982,660 square feet. About 51% heat with natural gas, 35% heat with oil, 3% heat with "other gas", 8% heat with electricity, and about 3% heat with wood.

To help the state meet its 50% by 2030 carbon reduction target, Holliston will need to convert 2,586 homes from natural gas and oil to high efficiency electric space and water heating between now and 2030. This is an average of 370 homes or about 7% of the town's housing stock per year for the next 7 years.

Table 3 summarizes the estimated average electricity, natural gas, and oil use per household in 2017.

Building Type	Households (#)	Average Household Area (SF)	Average Household Electricity (kWh)	Average Household Natural Gas (Therms)	Average Household Oil (Gallons)
Single-Family- Detached	4,361	2,977	10,634	1,077	890
Single-Family- Attached	189	2,038	7,280	737	609
Multi-Family, 2-4 Units	256	1,191	4,255	431	356
Multi-Family, 5+ Units	365	849	3,033	307	254
Mobile Homes	0				
Total	5,171				

Table 3. Average residential energy use

Table 4 summarizes the estimated total residential electricity, natural gas, and oil use by housing type in 2017.

Building Type	Households (#)	Total Area (SF)	Total Electricity (kWh)	Total Gas (therms)	Total Oil (gallons)
Single-Family- Detached	4,361	12,982,697	46,376,922	3,064,547	1,348,743
Single-Family- Attached	189	385,182	1,375,951	90,922	40,016
Multi-Family, 2-4 Units	256	304,896	1,089,153	71,970	31,675
Multi-Family, 5+ Units	365	309,885	1,106,974	73,148	32,193
Mobile Homes	0				
Total	5,171	13,982,660	49,949,000	3,300,587	1,452,627

Table 4. Total residential energy use[4]

[4] Total electricity and natural gas use for residential electric and natural gas accounts is from Eversource. Electricity and natural gas use for individual categories is estimated based on the total square feet. Total oil use is estimated based on national and state averages per household.

Commercial & Industrial Buildings

Holliston has about 2,734 employees working in commercial and industrial buildings. Combined energy use for these buildings is about 47,318,000 kWh of electricity, 1,999,781 therms of natural gas, and 93,040 gallons of oil[5].

To help the state meet its 50% by 2030 carbon reduction target, Holliston will need to convert 1,000,000 therms and 46,520 gallons of oil use to high efficiency electricity between now and 2030. This is an average reduction of 142,8842 therms of natural gas and 6,646 gallons of oil use or about 7% of the town's commercial and industrial energy use per year for 7 years.

Table 5 summarizes the estimated total energy use for the commercial & industrial categories identified in Holliston by the US Energy Information Administration (EIA).

Facility type	Number of Employees	Total Electricity (kWh)	Total Gas (therms)	Total Oil (gallons)
Commercial				
Food Service	157	2,860,580	401,904	5,625
Service	167	3,042,782	316,422	5,983
Health Care Outpatient	120	2,186,430	234,515	4,299
Warehouse And Storage	513	9,346,990	225,328	18,379
Mercantile Retail (other than mall)	65	1,184,317	197,604	2,329
Mercantile Enclosed and Strip Malls	34	619,489	195,506	1,218
Food Sales	45	819,911	108,475	1,612
Religious Worship	34	619,489	69,692	1,218
Public Assembly	133	2,423,294	57,273	4,765
Office	598	10,895,712	56,653	21,424
Lodging	75	1,366,519	32,297	2,687
Industrial				
Fabricated Metal Products	322	5,866,922	59,694	11,536
Machinery	53	965,673	33,745	1,899
Computer and Electronic Products	73	1,330,079	10,675	2,615
Miscellaneous	208	3,789,813	0	7,452
Total	2,597	47,318,000	1,999,781	93,040

Table 5. Total commercial building energy use.[6]

[5] Per MAPC GHG Inventory Tool data sources

[6] Total electricity use for commercial electric accounts is from Eversource. Electricity use for individual categories is estimated based on the number of employees. Total oil use is estimated based on national and state averages per employee. Electricity and Gas is 2021 data. Oil is 2017 data.

MA 2050 Report Guidance

In its 2050 Decarbonization Roadmap, MassEEA offers the following considerations to decarbonize buildings:

- Heat pumps are the most cost-effective decarbonization strategy for buildings
- The most cost-effective time to install a heat pump is during routine home improvements or when an older HVAC system must be replaced
- HVAC systems generally turn over once every 15 to 30 years leaving relatively few opportunities to decarbonize buildings
- Ideally, almost every building would get some degree of envelope improvement, with at least two-thirds receiving deep energy efficiency improvements[7]
- New and expanded financing strategies will be needed to defray upfront costs
- The transition to widespread electrification will disrupt the current gas and oil distribution network
- New state and local policies will be needed to manage the equitable drawdown of fossil fuel use and infrastructure. Higher costs cannot be borne by the consumers least able to pay, and steps must be taken to provide for an orderly and equitable transition.

Figure 2 represents MassEEA's vision for the total number of heating systems and fuel sources through 2050 as presented in the 2025 and 2030 Clean Energy Climate Plan.

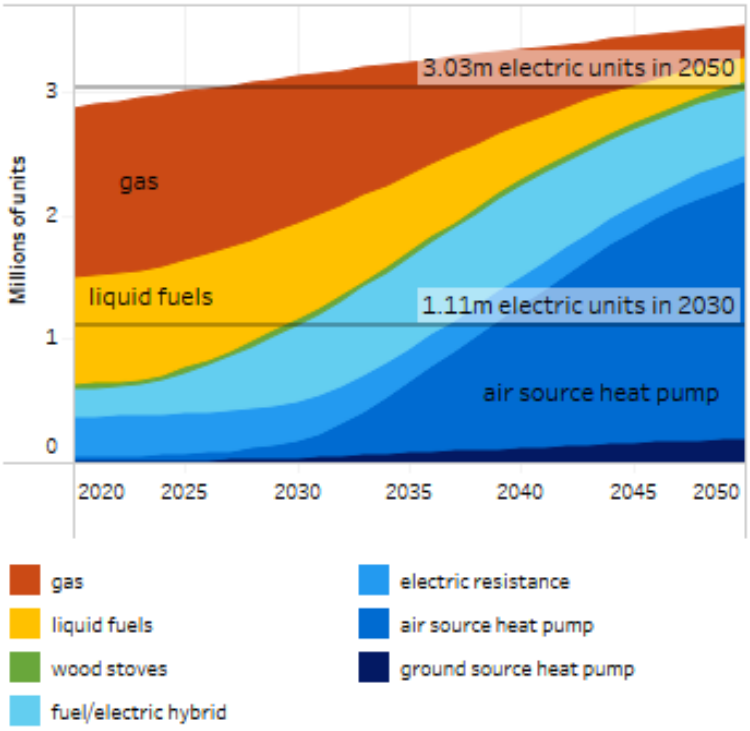


Figure 2. Target number of heating systems and fuel source through 2050

[7] Deep energy efficiency improvements include above-code roof and wall insulation, triple-pane windows, and Passive House air tightness and energy recovery ventilation. The cost for deep energy improvements can vary from about $20,000 as part of a concurrent home improvement project or about $50,000 for a stand-alone deep energy efficiency project.

Fuel to Electricity Conversion Cost Implications

Converting Holliston's residential, commercial, and industrial buildings from fuel combustion to high efficiency electric space and water heating systems is key to the town's decarbonization efforts. Carbon emission rates will remain high until fossil-fueled space and water heating equipment is replaced.

The first two heat pump technologies listed in Tables 6 and 7 are air-source. Ductless heat pumps are used both in residential and commercial applications and are the most cost-effective fuel conversion option. Variable Refrigerant flow (VRF) heat pumps are primarily used in commercial applications.

The third heat pump option is ground-source heat pumps (Ground) sometimes referred to as geothermal. Ground-source heat pumps are either open loop systems that require a large water source in the form of a pond, stream, or well or closed loop that circulate a brine or other solution through piping that runs through a pond, stream or down a well. Ground source heat pumps are used both in residential and commercial applications.

Ductless heat pumps serve one or two rooms and require multiple systems to serve a large room. VRF and ground source heat pumps serve multiple rooms. The cost for VRF and ground source heat pump systems is higher than ductless heat pump systems because they include the cost to install custom heating and cooling distribution components and advanced control systems. Ductless heat pumps are essentially "plug and play".

All three heat pump options provide heating and cooling at very high efficiency. Holliston should assume that all existing HVAC equipment should be removed or abandoned in place when new heat pump technology is installed. All three heat pump technologies will provide better occupant comfort in buildings with adequate insulation and airsealing. Temperature recovery from night or vacation temperature setbacks or power outages will take longer with heat pump systems than fossil fuel-fired systems. Table 6 and Table 7 assume that the three alternative heat pumps are 250% efficient.

Table 6 lists very preliminary estimated costs per ton[8] and total costs to install three alternative types of high efficiency electric heat pump equipment[9] in Holliston's residential buildings.

Facility name	Homes (#)	Estimated Electric Equipment Output (Tons)	$7,500 Ductless Cost ($)	$15,000 VRF Cost ($)	$25,000 Ground Cost ($)
Single-Family- Detached	4,361	25,244	189,330,998	378,661,996	631,103,326
Single-Family- Attached	189	749	5,617,238	11,234,475	18,724,125
Multi-Family, 2-4 Units	256	593	4,446,400	8,892,800	14,821,333
Multi-Family, 5+ Units	365	603	4,519,156	9,038,313	15,063,854
Mobile Homes	0	-	-	-	-
Total	5,171	27,189	$203,913,792	$407,827,583	$679,712,639

Table 6. Residential building estimated fuel conversion equipment costs

Table 7 lists very preliminary estimated costs per ton and total costs to install three alternative types of high efficiency electric heat pump equipment in Holliston's commercial and industrial buildings.

Facility type	Number of Employees	Estimated Electric Equipment Output (Tons)	$7,500 Ductless Cost ($)	$15,000 VRF Cost ($)	$25,000 Ground Cost ($)
Commercial					
Food Service	157	1,421	10,655,554	21,311,108	35,518,513
Service	167	1,119	8,389,185	16,778,369	27,963,949
Health Care Outpatient	120	829	6,217,630	12,435,260	20,725,433
Warehouse And Storage	513	797	5,974,040	11,948,080	19,913,467
Mercantile Retail (other than mall)	65	699	5,239,016	10,478,032	17,463,387
Mercantile Enclosed and Strip Malls	34	691	5,183,374	10,366,749	17,277,914
Food Sales	45	383	2,875,956	5,751,912	9,586,521
Religious Worship	34	246	1,847,721	3,695,443	6,159,071
Public Assembly	133	202	1,518,456	3,036,912	5,061,520
Office	598	200	1,502,016	3,004,031	5,006,719
Lodging	75	114	856,272	1,712,544	2,854,241
Industrial					
Fabricated Metal Products	322	211	1,582,641	3,165,283	5,275,471
Machinery	53	119	894,663	1,789,326	2,982,210
Computer and Electronic Products	73	38	283,024	566,047	943,412
Miscellaneous	208	-	-	-	-
Total	2,597	7,069	$53,019,548	$106,039,096	$176,731,827

Table 7. Commercial building estimated fuel conversion equipment costs

[8] A ton of heating or cooling is 12,000 Btus

[9] Actual equipment costs will vary significantly depending on site specific conditions. The emphasis here is that ductless heat pumps are significantly less expense to install than VRF and ground source heat pumps. Estimated costs per ton are preliminary and should only be used to assess the rough level of scale for potential investments.

Domestic Hot Water Conversion Projects

In addition to heating system conversion opportunities, residential, commercial, and industrial customers can convert their domestic hot water systems. Water heating conversion options include solar, heat pump, and electric resistance water heating systems. Solar and hybrid heat pump domestic hot water systems are better for high-use commercial systems. Small well insulated electric resistance or heat pump domestic hot water systems are better for low-use settings.

Energy Efficiency Projects

In parallel with electric conversions, Holliston should assist residents and commercial and industrial businesses with energy efficiency investments. Energy efficiency investments such as additional insulation, heat recovery ventilation, high efficiency motors, building controls, and efficient lighting are the most cost-effective solution to reduce total energy use in Holliston's residential, commercial, and industrial buildings. Energy efficient buildings are often more comfortable, durable, and healthier to work in than less efficient buildings. In addition, energy efficient buildings require smaller heating systems and are less susceptible to high energy use and cost spikes caused by extreme weather or other energy-related conditions than less efficient buildings.

A reasonable high performance energy target for new construction is about 25 kBtu[10] per square foot for all energy use. This metric is termed energy use intensity (EUI). The actual target EUI will vary significantly by specific building type. We can use this value to identify potential energy efficiency opportunities for residential and commercial buildings with EUIs higher than 25 kBtu/SF. Energy efficiency measures can be implemented as part of scheduled building maintenance and/or major renovation and rehabilitation investments. Existing buildings require a significant financial investment to achieve these energy performance standards.

[10] Thousand British Thermal Units

2. Convert residential and commercial vehicles from internal combustion engines to electric motors

In 2014[11], Holliston had about 11,286 vehicles. Most of the vehicles had gasoline and diesel internal combustion engines (ICE). Table 8 summarizes the total annual estimated miles travelled (VMT) and total annual fuel used by these vehicles.

Passenger Vehicles

Vehicle type	Quantity (vehicles)	Average Daily Vehicle Miles	Average Fuel Economy (MPG):	Annual Vehicle Miles Travelled (VMT)	Annual Diesel/ Gasoline (Gallons)
Gasoline	9,945	31.5	20.3	114,208,693	5,629,788
Diesel	109	34.5	20.6	1,374,019	66,759
FlexFuel	406	32.7	18.4	4,841,782	263,285
Hybrid	264	38.0	39.7	3,658,384	92,193
Electric	3				
Total	10,727			124,082,879	6,052,025

Commercial Vehicles

Vehicle type	Quantity (vehicles)	Average Daily Vehicle Miles	Average Fuel Economy (MPG):	Annual Vehicle Miles Travelled (VMT)	Annual Diesel/ Gasoline (Gallons)
Gasoline	438	37.0	17.8	5,919,427	369,222
Diesel	57	29.4	12.6	611,263	96,989
FlexFuel	58	37.7	15.0	798,765	53,387
Hybrid	4	26.6	26.4	38,887	1,475
Electric	2				
Total	559			7,368,342	521,072

Table 8. Passenger and commercial vehicle miles & fuel use

The information listed in Table 8 comes from a relatively old 2014 vehicle database. MAPC requested more recent data from MA DOT. As of Monday, March 3, 2023. There are 14,512 total vehicles registered in Holliston. 205 vehicles are BEV, 505 are HEV, and 96 are PHEV.

Light-Duty Vehicles

Light-duty vehicles are the primary source of gasoline fuel consumption in Holliston. Affordable electric motor vehicles are available to replace the town's light-duty vehicles that are scheduled for retirement in the next few years. The replacement cost for electric-powered light-duty vehicles has dropped significantly, and some electric vehicle car costs are close to or on par with internal combustion engine vehicle costs.

[11] 2014 is the most recent year of complete vehicle data.

Heavy-Duty Vehicles

Heavy-duty vehicles are the primary source of diesel fuel consumption. Few affordable electric-powered vehicles exist to replace heavy-duty vehicles.

Heavy-duty vehicle conversions will most likely need to wait until the electric-powered and fuel-cell powered heavy-duty vehicle market develops further. Interim retrofit options exist for heavy-duty vehicles including brake-assist and engine idling management systems.

Charging Stations and Load Management

Part and parcel with converting vehicles from fuel to electricity, Holliston needs to anticipate how to pay for, locate, and manage associated electric charging stations. Holliston will need to purchase and place electric charging stations in convenient locations and get approval to connect them to the utility grid.

We recommend that Holliston develop a charging station plan for 100% community-wide electric-vehicle market penetration for the town. Holliston can then work backwards to determine the location for Holliston's first waves of electric charging stations. Rapid changes in EV vehicle technology combined with the investment in EV charging stations included in the recently approved Infrastructure Bill will undoubtedly create a long-term need for more electric charging stations. On the flip side, most homes might install their own EV chargers and public charging stations may be less important than they are now.

Holliston will need to develop a load management plan with Eversource with this information and coordinate a phased installation plan with the utility company. Charging multiple vehicles rapidly and concurrently will add significant electrical load to the existing utility distribution infrastructure. On a more positive note, connecting multiple electric vehicles with large batteries to the utility distribution system will also offer significant load management opportunities.

Electric Vehicle Replacement Schedule

To achieve the state's 50% decarbonization by 2030 target, Holliston will need to replace about 5,643[12] internal combustion engine vehicles with electric or other zero emission vehicles. This is about 806 vehicles per year or 7% of the residential and commercial vehicles garaged in Holliston.

MA 2050 Report Guidance

In its 2050 Decarbonization Roadmap, MassEEA recommends the following considerations to decarbonize vehicles:

- The primary strategy to reduce light-duty transportation emissions is switching from fossil-fueled vehicles to zero emissions vehicles.
- Other priorities include maintaining and supporting existing public transit systems, reducing single occupancy vehicle use where possible, making complementary land use decisions, and supporting active transportation infrastructure such as bike lanes and sidewalks
- most vehicles will be replaced only twice between now and 2050
- the current pace of EV adoption in the Commonwealth lags the pace necessary to achieve interim decarbonization targets compliant with the GWSA

[12] Based on 2014 data

- The majority of EV charging typically happens at home where most vehicles are parked overnight
- the transition from ICE to EV may initially be easiest and cheapest for vehicle owners living in single family or multifamily homes with access to a garage or off-street parking
- Deployment of battery electric vehicles (BEVs) and hydrogen fuel cell electric vehicles (FCEVs) in the medium-duty and heavy-duty vehicle (MHDV) classes will require retrofits to depots and fueling stations to provide charging and/or hydrogen services.
- Addressing issues including siting, permitting, interconnecting, rate design, and distribution system improvements are required to increase MDHDV BEV and FCEV adoption.

3. Convert off-road equipment from internal combustion engines to electric motors

The State's Clean Energy and Climate Plan for 2025 and 2030 does not offer guidance on how to reduce off-road equipment GHG emissions. However, in many communities like Holliston, off-road equipment generates measurable GHG emissions. Table 9 summarizes the estimated carbon emissions from off-road energy use and the assumptions associated with these carbon emission estimates.

Emissions Source	County-Level Emissions Allocated to City/Town By:	City/Town Allocation Category Count	Off-road CO2 Emissions (MT CO2)
Industrial Equipment	Manufacturing Jobs	657	1,831
Lawn and Garden Equipment	Square Feet of Landscaped Area	64,261,299	2,959
Light Commercial Equipment	All Sectors Jobs Excl. Manufacturing	6,889	811
Construction Equipment	Square Feet of Construction	0	0
Off-road Emissions Attributable to Manufacturing Industries Subsector:			1,831.3
Off-road Emissions Attributable to Commercial & Institutional Buildings			3,769.8
Off-road Emissions Attributable to Construction Subsector:			0.0
All Off-Road Emission Sources			5,601.1

Table 9. Off-Road Carbon Emissions

A more detailed survey of these off-road categories would be cumbersome but could clarify actual off-road carbon emissions in Holliston. Like buildings and vehicles, Holliston will need to identify opportunities to convert fuel-based equipment to high efficiency electric equipment. For this report, we assume that Holliston can make this transition at the same rate as buildings are converted from fuel-based equipment to high efficiency electric equipment.

Potential Fuel Decarbonization Path

Figure 3 summarizes Holliston's potential fuel-based (natural gas, oil, gasoline, and diesel) energy use reduction plan through 2050. The chart assumes 5-year building and vehicle conversion rates from fuel use to high efficiency electricity use of about 2% by 2025, 8% by 2030, 15% by 2035, 20% by 2040 and 2045, and an additional 15% conversion in 2050 for a total conversion rate of about 80% by 2050. Assuming this level of market penetration, Holliston will fall short of the state's 50% GHG emissions reduction by 2030 target but exceed the state's 85% GHG emissions reduction by 2050 target.

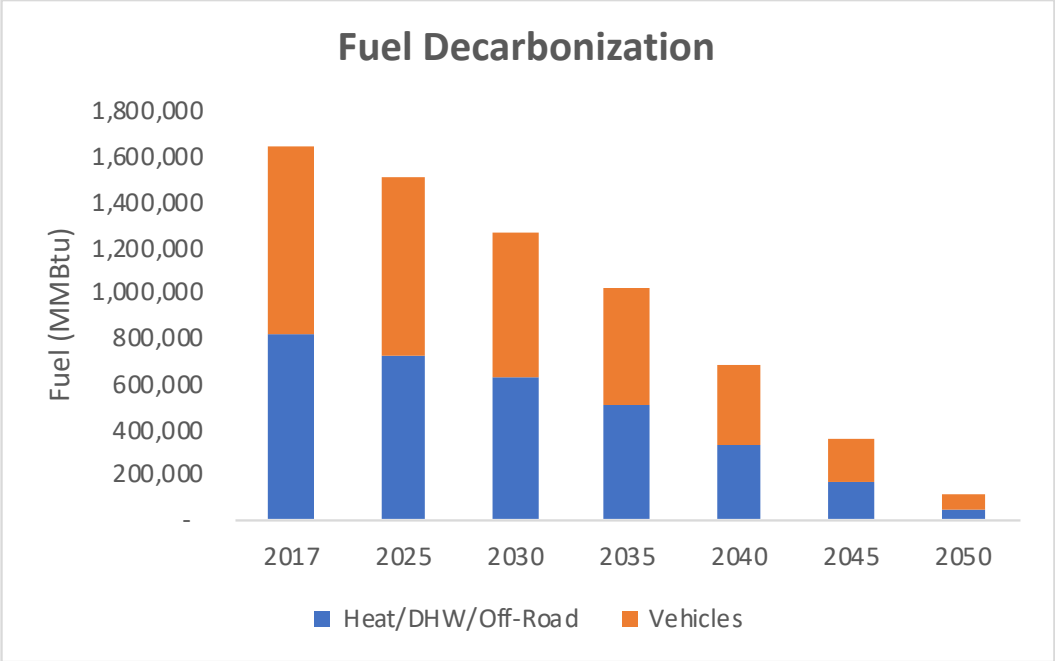


Figure 3. Potential Fuel Decarbonization Plan through 2050

Potential Electricity Decarbonization Path

Total community-wide electricity purchased from Eversource in fiscal year 2017 was about 44,942,000 kWh for residential account customers and about 33,465,000 kWh for commercial account customers. MAPC estimates that the total electricity use by Holliston electricity customers will increase by about 160% by 2050. This includes additional electricity use for proposed fuel to electric space and water heating conversions and proposed vehicle fuel to electricity conversions. It also takes into consideration proposed energy efficiency projects. Other variables that will affect future electricity use include the economy and the electricity industry's historic 3% per year increase. Recent events have disrupted and will most likely continue to disrupt small, predictable annual electricity use increases.

Electricity that Holliston customers purchased from Eversource in 2017 included electricity generated from fossil-fuel and multiple grades of renewable energy electrical generation plants. Eversource's electricity generation sources in 2019 were 76% fossil fuel (mostly natural gas) and 24% renewable energy. In 2023, the generation sources are 46% fossil fuel and 54% "clean energy".

Table 10 summarizes the projected increase in the default electricity supply that utility companies must provide customers. RPS stands for Renewable Energy Portfolio Standard and CES stands for Clean Energy Standard. Please refer to Appendix C for more detailed information about these two energy standards.

Year	RPS Class I Renewable	Other New Clean Generation	RPS Class II Renewable	RPS Class II Waste	Clean Existing Generation	Total Clean Generation
2019	14.0%	4.0%	2.7%	3.5%	0.0%	24.2%
2025	27.0%	3.0%	3.6%	3.7%	20.0%	57.3%
2030	40.0%	0.0%	3.6%	3.5%	20.0%	67.1%
2035	45.0%	5.0%	3.6%	3.5%	20.0%	77.1%
2040	50.0%	10.0%	3.6%	3.5%	20.0%	87.1%
2045	55.0%	13.0%	3.6%	3.5%	20.0%	95.0%
2050	60.0%	7.9%	3.6%	3.5%	20.0%	95.0%

Table 10. Renewable Energy and Clean Energy Portfolio Standard generation targets

State legislation requires Eversource to increase the percent of renewable energy generation by 2% each year until 2029 when the increase is reduced to 1% each year. The state added a formulaic (starting at 20%) clean existing generation standard in 2021. Other electricity suppliers offer higher levels of renewable energy. The State's 2050 Decarbonization Report suggests a 95% renewable energy target that reserves about 5% for utility grid electricity generation and load stability control.

Grid Electricity

Variables to consider regarding grid-level renewable energy procurement include class, source (local, regional, or national), and renewable energy credit (REC) status. Class I local renewable energy that have not sold the renewable energy credits are the highest quality. Holliston electricity customers can consider transitioning from "lower quality" to "high quality" renewable energy over time to keep grid-level renewable energy procurement more cost-effective. Holliston has about a 80% participation rate with its 100% renewable municipal aggregation supply program.

Figure 4 on the next page summarizes one potential scenario for Holliston's electricity use and mix of electricity generation transition through 2050. The chart assumes 5-year building and vehicle conversion rates of about 12% by 2025, 12% by 2030, 15% by 2035, 20% by 2040 and 2045, and an additional 15% conversion in 2050 for a total conversion rate of about 94% by 2050. The chart assumes default electricity from Eversource.

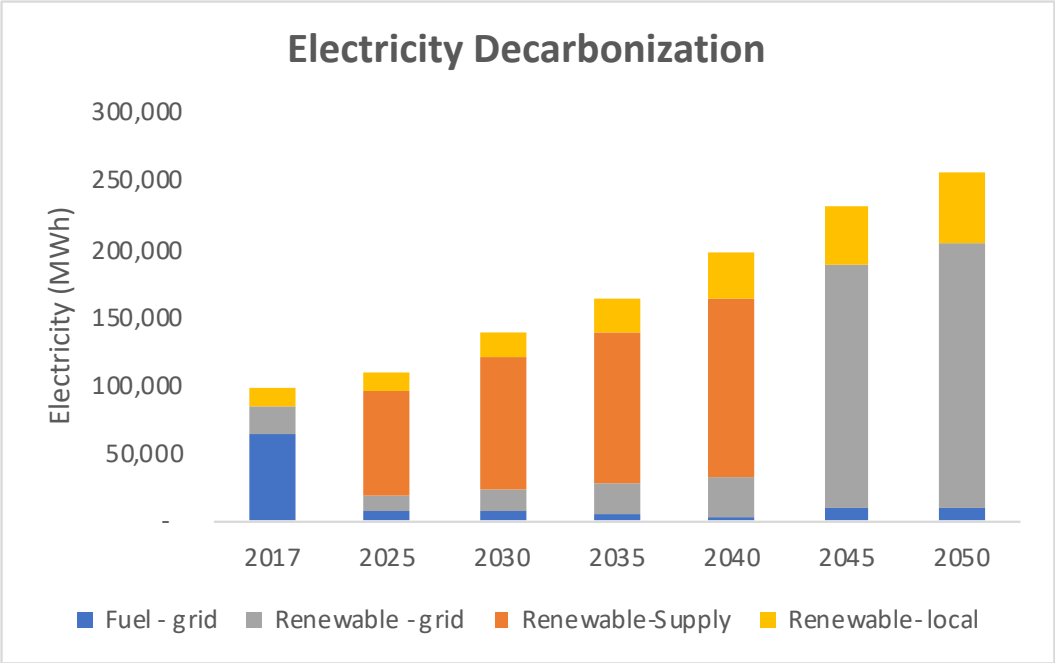


Figure 4. Potential electricity load and fuel mix scenario

Figure 4 demonstrates a steady decline in fossil fuel grid electricity and highlights the potential impact of roof-mounted (20% of all residential properties), parking lot, and commercial ground-mounted local renewable energy solar PV initiatives.

Local Renewable Electricity

According to US EPA[13], "on-site power generation provides communities with the most direct access to renewable energy. In addition to the overall benefits, on-site projects also provide a hedge against financial risks and improve power quality and supply reliability." Overall benefits from local and regional renewable energy include:

- Reduced demand on our regional electricity and gas utility infrastructure to generate and supply electricity from large fossil-fuel power plants
- Direct public health benefits from reduced fossil fuel power plant operation
- Direct economic benefits from local jobs created to install local and regional renewable energy systems

With significant effort on the part of residential, commercial, and industrial customers that elect to install solar PV, the source of Holliston's electricity could shift away from grid-provided renewable electric generation sources to as much as 20% local renewable generation by 2050. Holliston would continue to connect to the local and regional ISO NE[14] electric grid but the source of electricity could shift significantly to local sources.

[13] https://www.epa.gov/statelocalenergy/local-renewable-energy-benefits-and-resources

[14] **ISO New England Inc.** (ISO-NE) is an independent, non-profit organization that oversees the operation of New England's bulk electric power system and transmission lines.

Table 11 identifies potential solar PV installation locations on Holliston's residential facilities, private and town-owned land, and independent power purchase agreements. The estimated roof area is based on 20% of homes with roofs that face south, an average house with 2 stories, and 50% of the roof available for solar PV collectors. The estimated total cost does not consider potential federal, state, utility incentives, or tax credits.

Facility name	Available Roof Area (SF)	Available Land Area (Acres)	Estimated Solar PV Peak Output (kW)	$3,496 < 250 kW Roof ($)	$5,000 < 1 MW Parking ($)	$1,200 >1 MW Ground ($)	Total Solar PV ($)
Single-Family- Detached	1,298,270		12,983	45,386,664			45,386,664
Single-Family- Attached	38,518		385	1,346,571			1,346,571
Multi-Family, 2-4 Units	30,490		305	1,065,897			1,065,897
Multi-Family, 5+ Units	30,989		310	1,083,338			1,083,338
Parking lots		5.0	658		3,289,474		3,289,474
Parking lots		5.0	658		3,289,474		3,289,474
Commercial PPA		30.0	3,947			4,736,842	4,736,842
Commercial PPA		30.0	3,947			4,736,842	4,736,842
Commercial PPA		30.0	3,947			4,736,842	4,736,842
Commercial PPA		30.0	3,947			4,736,842	4,736,842
Total	1,398,266	130.0	17,105	$48,882,470	$6,578,947	$18,947,368	$74,408,786

Table 11. Solar PV area, peak output, and potential costs

Table 12 suggests target installation dates and potential annual electricity generation (kWh).

Facility name	2025 Solar PV Electricity (kWh)	2030 Solar PV Electricity (kWh)	2035 Solar PV Electricity (kWh)	2040 Solar PV Electricity (kWh)	2045 Solar PV Electricity (kWh)	2050 Solar PV Electricity (kWh)	Total Solar PV Electricity (kWh)
Single-Family- Detached	827,647	2,482,941	2,482,941	3,310,588	3,310,588	2,482,941	14,897,645
Single-Family- Attached	24,555	73,666	73,666	98,221	98,221	73,666	441,996
Multi-Family, 2-4 Units	19,437	58,311	58,311	77,748	77,748	58,311	349,868
Multi-Family, 5+ Units	19,755	59,266	59,266	79,021	79,021	59,266	395,103
Parking lots	838,816						838,816
Parking lots			838,816				838,816
Commercial PPA			5,032,895				5,032,895
Commercial PPA				5,032,895			5,032,895
Commercial PPA					5,032,895		5,032,895
Commercial PPA						5,032,895	5,032,895
Total	1,730,210	2,674,184	8,545,894	8,598,473	8,598,473	7,707,078	37,893,823

Table 12. Solar PV installation dates and electricity output

We recommend that Holliston prepare or hire a consultant to prepare to assess all potential solar PV sites on municipally owned or controlled land for public review. Sites to review include rooftops, parking lots, and potential open land sites. The assessment should include aerial surveys of the sites, potential electricity peak output and annual electricity generation, estimated costs, and solar site ratings.

Holliston will need to stay attuned to potential grant opportunities, rapidly changing Federal and state incentive programs, and the price of large-scale renewable energy installations.

MA 2050 Report Guidance

In its 2050 Decarbonization Roadmap, MassEEA recommends the following considerations for the electric grid:

- As more end uses rely on the electricity system, the carbon intensity of emissions from the electricity system will need to approach zero at the same time as installed generating capacity more than doubles
- Offshore wind and solar must be deployed at scale (15-20 GW of each installed) in the Commonwealth over the next 30 years
- Specific reliability resources (infrequently used thermal capacity without carbon capture, and/or new bulk storage) will be needed
- Wind and solar resources will be complemented by imports of hydroelectricity and renewables from neighboring states and regions, and a modest amount of in-state generation from fossil fuels.
- Storage and other flexible loads will also contribute to the future grid
- Bringing large volumes of offshore wind onshore and delivering it to demand centers will require substantial upgrades to the onshore bulk power grid
- Solar deployment involves several challenges such as land use concerns and the need to interconnect and manage many small, distributed energy resources on the grid
- Limits to solar development in Massachusetts will likely encourage solar deployment in other states, especially in Northern New England where the cost of land is lower.
- the strategic implementation of solar more locally may result in distribution system benefits, including line loss savings and reduced costs to build out and maintain transmission and distribution infrastructure, as well as improved local resilience
- A variety of different demand-side technologies – many in use today – can help to manage hourly and daily flows and peaks in electricity demand
- The abundant hydropower available in New England, New York, Quebec, and New Brunswick represents a valuable resource for New England. The cumulative quantity of stored energy in dammed reservoirs is a key solution to balance and manage a regional electricity system with high penetrations of renewable generation.
- If offshore wind resources cannot be fully realized, new nuclear resources would be an economically viable alternative for supplying low-carbon electricity
- Currently, the lowest cost method for maintaining reliability on the few days each year with very low renewable energy production is the intermittent use of thermal power plants, primarily gas-fired power plants
- Restricting either regional transmission buildout or retiring existing thermal capacity – in the absence of a technological, cost, and commercialization breakthrough in long-duration energy storage or another dispatchable resource – could have significant cost and resource tradeoffs

2025 and 2030 Decarbonization Targets – Transportation

In June 2022, Massachusetts released its Clean Energy and Climate Plan for 2025 and 2030. This plan provided more detail than the 2050 Decarbonization Roadmap Report. MAPC has translated the recommendations and proposed implementation targets in this report into two tables, one for transportation and one for buildings.

Table 13 summarizes Holliston's 2017 historical, and state recommended 2025, and 2030 transportation decarbonization targets. The state's 2025 and 2030 targets are a 33% GHG emissions reduction by 2025 and 50% GHG emissions reduction by 2030 below the state's 1990 baseline GHG emissions.

Highlights from Table 13 on the next page include:

- An increase in the number of light-duty vehicles and total miles driven
- A decrease in the number of medium and heavy-duty vehicles
- A decrease in vehicle miles driven/household and single occupancy commuting trips.
- 4.3% light duty electric vehicles by 2025 and 19.2% by 2030
- 1.3% medium & heavy-duty vehicles by 2025 and 9.9% by 2030
- 32 charging ports by 2025 and 161 by 2030

Transportation Sector	2017 Historical	2025 Targets	2030 Targets
Travel Demand			
Total annual light duty VMT (miles)	124,111,802	134,068,533	136,847,155
Total light-duty vehicles	10,727	11,154	11,259
Total medium- and heavy-duty vehicles	559	449	507
Light-duty vehicles per household	2.1	2.0	1.9
Total households	5,171	5,658	5,881
Vehicle miles traveled (VMT) per household (miles)	24,002	23,695	23,269
Share of commuting trips by single-occupancy vehicles	72%	n/a	60%
Vehicle Electrification			
Number of light-duty electric vehicles (EVs)	3	480	2,162
EV Share of light-duty vehicles	0.03%	4.3%	19.2%
Number of zero emissions trucks and buses	0	6	50
EV share of MHDV fleet	0.0%	1.3%	9.9%
Public-Access Chargers (ports)	-	32	161

Table 13. Transportation decarbonization targets

Figure 5 provides this information in graph format.

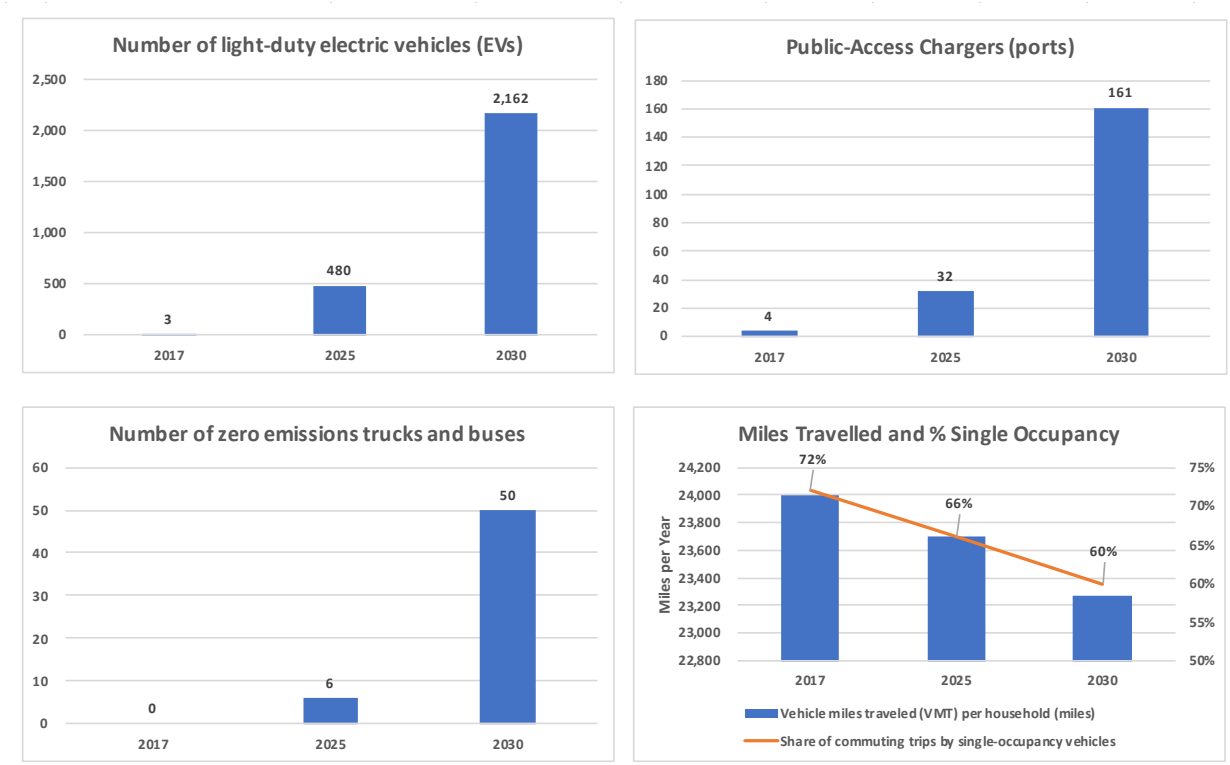


Figure 5. Transportation decarbonization targets

2025 and 2030 Decarbonization Targets - Buildings

Table 14 summarizes Holliston's 2017 historical and 2025 and 2030 building decarbonization targets. The 2025 and 2030 targets assume that Holliston achieves the same level of decarbonization proposed statewide in the Commonwealth's 2025/2030 Clean Energy and Climate Plan.

Highlights include:

- An increase in the projected number of households
- 654 homes with partial-home heat pump space heating by 2025 and 1,228 by 2030
- 102 homes with whole-home heat pump space heating by 2025 and 282 by 2030
- 26% households electrified by 2025 and 38% by 2030
- 101 households fully weatherized by 2025 and 466 by 2030

Buildings Sector	2017 Historical	2025 Targets	2030 Targets
Total households	5,171	5,658	5,881
Primary Electric Space Heating			
Total homes with electric space heating	724	1,471	2,235
Homes with electric resistance space heating	unknown	674	624
Homes with partial-home heat pump space heating	unknown	654	1,228
Homes with whole-home air source heat pump space heating	unknown	102	282
Homes with whole-home ground source heat pump space heating	unknown	41	81
Share of total households electrified (estimated)	14%	26%	38%
Weatherization			
Total households with upgraded envelopes	unknown	101	466

Table 14. Building decarbonization targets

Figure 6 provides this information in graph format.

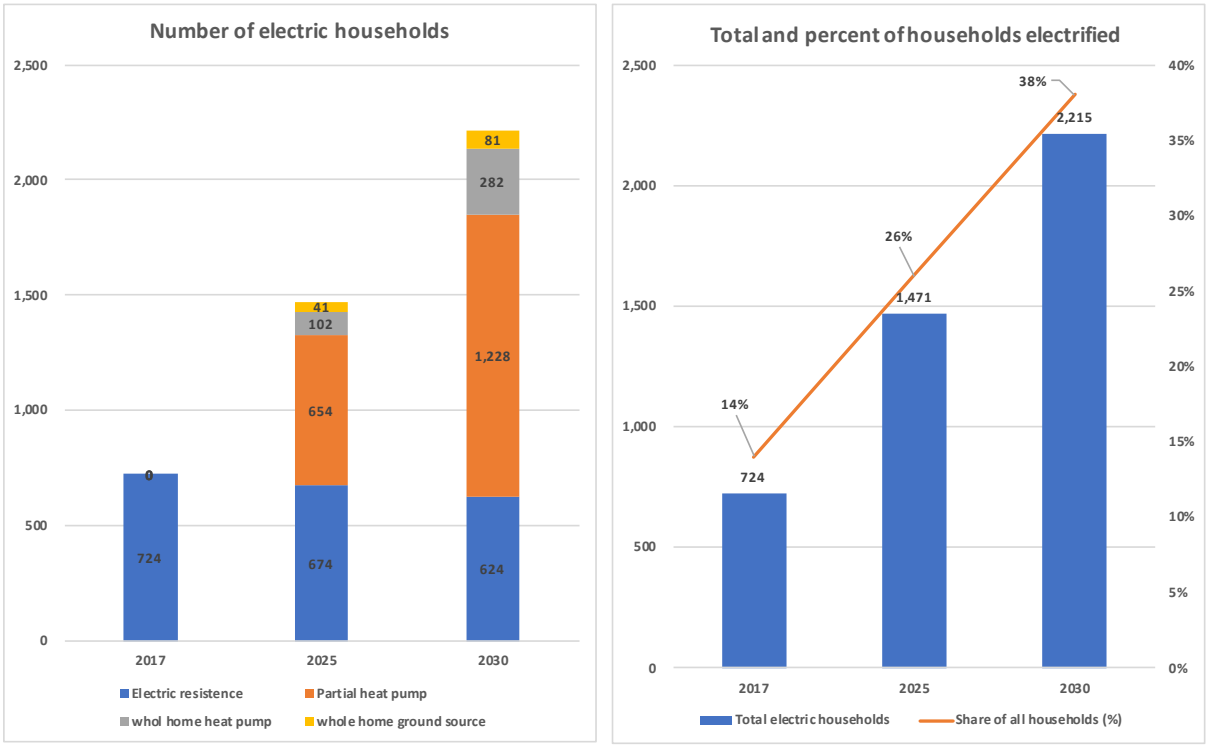


Figure 6. Building decarbonization targets

Net Carbon Emissions Reduction

The preliminary schedule of investments suggested in this report will reduce Holliston's overall greenhouse gas emissions by about 32% in 2030 and about 90% by 2050 below the town's 2017 baseline GHG emissions. This exceeds the state's 50% decarbonization by 2030 target and exceeds the state's 85% decarbonization by 2050 carbon reduction target.

The difference in Holliston's proposed schedule of GHG emissions reductions and the state's target GHG emissions reductions reflects Holliston's assessment of current market conditions and the potential for Holliston residents and businesses to procure high efficiency electric equipment and energy efficiency measures. As mentioned earlier, Holliston needs an average of 7% carbon emissions reduction per year for the next 7 years to meet the 50% by 2030 carbon emissions reduction target. This level of market penetration for new technology is a very high bar to set.

Carbon Emissions Reduction

Figure 7 represents the cumulative impact of the measures discussed in this report on Holliston's potential electricity, building, vehicle, off-road, and waste carbon emissions through 2050. Building, vehicle, and off-road emissions are for fuel only.

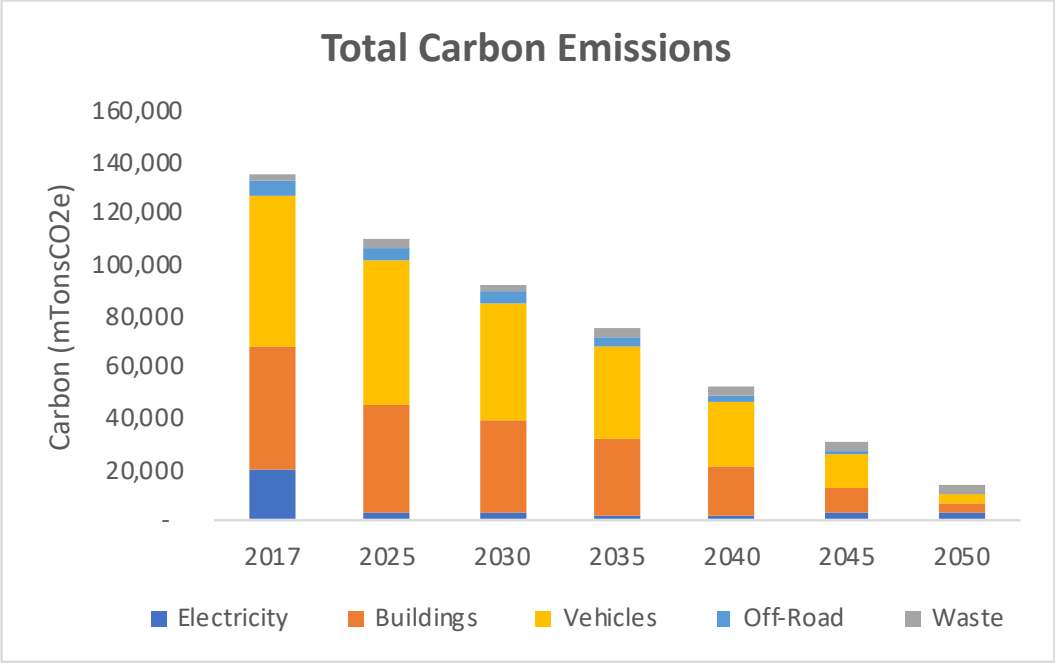


Figure 7. Total carbon emissions reduction

In 2017, about 65% of Holliston's carbon emissions were from building and vehicle-related fuel combustion and about 35% of the carbon emissions were from electricity generation fuel consumption.

Fuel-related carbon emissions will drop in close correlation with the speed and scale that Holliston can convert fuel-based combustion equipment to electric-powered equipment. Electricity-related carbon emissions will drop in relation to the amount of additional electricity that Holliston electricity customers use and how quickly renewable energy can be added to the local and regional electricity generation mix.

Carbon Capture

Massachusetts is working on a plan (unreleased) to incorporate carbon sequestration opportunities in forests and fields to offset carbon emissions with the state's decarbonization initiatives. In addition, MA DER and Mass Audubon have developed supporting material for municipal carbon offset initiatives.

We recommend that Holliston monitor opportunities to enroll town-owned or controlled land into carbon sequestration-focused forest management programs. The minimum recommended size for a formal carbon offset project is about 3,000 acres. Other programs may come online in the future for smaller land parcels. Carbon offset projects would allow Holliston to prepare a sequestration forest management plan.

Holliston could choose to sell the carbon credits to offset the cost of the forest management plan and sequestration forest management tasks. Selling the carbon credits would allow a buyer the opportunity to continue emitting carbon but offset the emissions with Holliston's carbon sequestration efforts. MA Audubon is the best resource to contact for more information and regional examples of successful projects. and qualify for in-house or voluntary carbon market credits.

MA 2050 Report Guidance

In its 2050 Decarbonization Roadmap, MassEEA recommends the following considerations to capture carbon:

- Massachusetts forests are projected to have the capacity to sequester about 5 MMTCO2e per year from now through 2050
- Encouraging dense development and best management practices for commercial timber harvesting can increase forest carbon sequestration, but only minimally
- A more complete accounting of land use impacts on human and natural systems is needed to understand the long-term systemic effects and the balance of ecosystem benefits

Next Steps

1. **Share this background documentation with Holliston's technical and financial partners at MA DOER, Eversource, and MAPC**

The Green Communities program run by MA DOER is the primary conduit between municipalities and the state's decarbonization efforts. Sharing this roadmap with Holliston's Green Community Regional Coordinator is an opportunity to help inform the state how Holliston and other community's decarbonization efforts align with the state's net zero (85%) Decarbonization by 2050 plan. MAPC can assist with this communication.

In addition, the Town of Holliston and its residents and businesses will need additional technical and financial support to plan for and implement the building, vehicle, and renewable energy actions recommended in the roadmap. MAPC can continue to help apprise Holliston of technical and financial planning resources as they become available. Specific planning needs for building, vehicle, and renewable energy actions recommended in the roadmap include:

a. Buildings

Each residential and commercial building in Holliston should receive a detailed technical and financial analysis for one of two options. The first option is to replace the existing fossil fuel mechanical equipment with high efficiency electric mechanical equipment. The second option is to install high efficiency electric equipment and install comprehensive measures to upgrade the building's thermal performance.

Building energy reports should document each building's current energy performance, utility bill rates and cost, existing equipment, and provide budget level cost estimates for the proposed equipment and building energy performance upgrades that include net zero upgrades. The reports should include examples of comparable upgrades to similar buildings in Massachusetts and lessons learned. Mass Save is the primary conduit for financial and technical support for building-related energy upgrades in Massachusetts.

b. Vehicles

Holliston will need to align the implementation of its vehicle conversions with the state's EV infrastructure upgrades, vehicle procurement, and vehicle incentive programs. The state's EV deployment plan is available at https://www.mass.gov/doc/transportation-sector-technical-report/download

EV incentive programs are available for light, medium, and heavy-duty vehicles at https://www.mass.gov/service-details/mor-ev-rebate-program

c. Renewable Electricity

Holliston should request technical and financial support to develop a solar PV blueprint for the town. The blueprint would identify potential local solar PV sites on rooftops, parking lots, and open space and rank them based on community-developed criteria. Criteria can include but not limited to potential electricity generation, ease of construction, competing land use values, and visual impact.

2. Work closely with Eversource and Mass Save to shape, manage, and fund Holliston's transition to high efficiency electric space and water heating equipment and electric vehicles.

Eversource serves two roles in the net zero (85%) decarbonization by 2050 implementation process. The first role is faciliatory. Eversource can help identify and coordinate technical and financial support that's available through Mass Save and Eversource. The second role is to help coordinate the nuts-and-bolts details of connecting proposed projects to the local electric grid.

The proposed actions in this roadmap will have a significant impact on the local electrical grid. Advanced discussions with Eversource about the proposed scale and timing of these actions will assist Eversource with their local grid upgrade plans. Local and regional electrical grid upgrades often require 2-5 years to implement. The State and Eversource will need to anticipate and plan for similar actions by Holliston's citizens and businesses as well.

3. Develop a financial model to implement the state's 85% Decarbonization by 2050 roadmap

Financing and procuring the projects and equipment necessary to achieve the state's net zero (85%) decarbonization by 2050 goals will be a major challenge and test Holliston's residents and commercial businesses financial resiliency. We recommend that town officials continue identifying funding and technical resources to assist residents and commercial buildings with this transition.

Financial alternatives should include but not be limited to grants, green energy loans, and energy incentive resources, residential and commercial property assessment financing (PACE, CPACE), lease-to-own, and related power purchase agreement options.

4. Communicate the findings and recommendations

The scale of the transition proposed by the state's 85% decarbonization by 2050 report are significant[15]. Effective, transparent communication with the town's citizens, businesses, and industry will be critical to the success of these projects.

In addition, the pace of implementation necessary to meet the state's 50% decarbonization by 2030 target is greater than historic levels of energy project implementation. For example, Mass Save, one of the nation's most successful energy efficiency programs, addresses energy efficiency investments in about 3% of MA households per year. As suggested in this report, The state and Town of Holliston need to address large scale energy-related investments in at least 7% of the town's population per year.

Town support and communications will be important tools and resources to help residents and commercial businesses make the transition from fossil fuel equipment and vehicles to high efficiency electric equipment and vehicles. Recent research about social change points to the importance of clusters of success – neighborhood by neighborhood transitions and the importance of achieving 25% tipping point[16]. See Appendix E for more information.

[15] https://www.mass.gov/info-details/ma-decarbonization-roadmap
[16] https://www.yesmagazine.org/issue/what-the-rest-of-the-world-knows/2020/11/03/how-social-change-happens

Conclusion

Holliston's community facilities and operations emitted about 136,006 MT CO2e greenhouse gas emissions in 2017. Methodical replacement of fossil fuel-powered equipment with electric-powered equipment and fuel-generated electricity with local renewable energy-generated electricity provides a framework for the town to reduce carbon emissions 32% from 2017 levels by 2030 and 90% by 2050.

Our report recommends that the town further refines this decarbonization roadmap to align with the State's 2025 and 200 plans. Ultimately, as the town pursues the energy reduction and clean energy projects, it will comply with the Massachusetts decarbonization standards and continue transitioning towards an economically and environmentally sustainable, resilient, and functional community for years to come.

Appendix A: Commonwealth's Clean Energy and Climate Plan for 2025 and 2030

In June 2022, the Massachusetts Executive Office of Energy and Environmental Affairs (MA EEA) released the Commonwealth's Clean Energy and Climate Plan (CECP) for 2025 and 2030. MA EEA is required by law to provide similar reports every 5 years as the Commonwealth works to achieve net zero carbon emissions by 2050. The CECP report provides an opportunity for the town of Holliston and its citizens to align the community with the actions and funding proposed by the Commonwealth's clean energy and climate plan.

Following is a summary of the CECP report and supporting documentation with the proposed carbon emission strategies set by the state.

Transforming our Transportation System

STRATEGY T1: PROMOTE ALTERNATIVES TO PERSONAL VEHICLE TRAVEL

- A recent change to the state zoning law requires 175 communities within the MBTA service area to have at least one zoning district of reasonable size where multifamily uses are allowed as of right. The Department of Housing and Community Development (DHCD), in consultation with MBTA and Mass DOT, will issue final guidelines this year (2022) advising communities on how to comply with this new requirement.
- State agencies will continue to support Massachusetts cities and towns to address some of the additional barriers to smart growth and transit-oriented development, such as excessive parking requirements, minimum lot size requirements, set-asides, and limits on accessory dwelling units, particularly as these rules limit housing production near public transit. The Commonwealth will continue to provide a Smart Growth / Smart Energy Toolkit that provides local government with technical support in achieving smart growth goals. A package of zoning reforms proposed by the Governor and signed into law in January 2021 has created a more predictable process at the local level for the adoption of housing best practices.
- MBTA buses - convert its entire bus fleet to battery electric buses by 2040
- Massachusetts will assess commuter rail electrification options.
- Through Mass DOT's Complete Streets and Shared Streets and Spaces municipal grant programs, Massachusetts cities and towns create dedicated lanes for bikes or buses, better sidewalks, better accessibility for people with disabilities, better community places and spaces, and street designs that promote pedestrian safety. on bike lanes and sidewalks. With additional funding, Massachusetts could expand and accelerate the work of all these programs.
- Massachusetts will look to achieve sustained reductions in vehicle miles travelled (VMT) below baseline projections, as the Massachusetts' economy and population continue to grow.
- Reduce Single-occupancy vehicle (SOV) commuting - MassDEP currently implements the Massachusetts Rideshare Regulation (310 CMR 7.16), which requires certain facilities to implement and maintain measures designed to achieve a non-binding goal of reducing single-occupancy vehicle (SOV) commutes by 25% and to produce annual reports detailing steps taken to achieve that goal. MassDEP will evaluate the role telework may play in the future of the Commonwealth's economy and its GHG and VMT reduction strategies.
- Launch an e-bike incentive Program. Studies confirm that e-bikes can potentially replace car trips for some commuters. Making the most of this technology will require both incentives and

continued improved bike infrastructure to ensure the safety of e-bike users and pedestrians. EEA will look to complement these investments with a statewide e-bike incentive. At the same time EEA, Mass DOT, and DCR will work with the legislature to update the underlying statute, and the Executive branch will develop e-bike regulations that promote safety for all road users.

Potential Municipal Action(s)

- **Request the Planning Board to assess by right multifamily and smart growth zoning district opportunities.**
- **Holliston should continue participating in the Complete Streets Program.**
- **Request the Planning Board and DPW to monitor MassEEA's e-bike incentive programs and potential e-bike related infrastructure upgrades.**

STRATEGY T2: IMPLEMENT COORDINATED ADVANCED CLEAN VEHICLE EMISSIONS AND SALES STANDARDS

- California is now moving forward with post-2025 regulations that would for the first time set a pathway for 100% of all passenger vehicle sales to be zero-emission, as well as new sales requirements on medium- and heavy-duty vehicles. The Commonwealth is in the process of following suit by the end of 2022. 100% passenger EV's by 2035. Truck emission regulations have been in place as of 2021. ZEV Truck sales begin in 2025.

No municipal action required except community outreach.

STRATEGY T3: EXPAND ELECTRIC VEHICLE INCENTIVES

- Massachusetts will reform the current EV incentive programs to increase accessibility. One key reform will be to make incentives available to consumers at the dealership when they purchase the vehicle, rather than waiting for their rebate after the purchase. Massachusetts will target incentives toward low- and moderate-income purchasers and less expensive vehicle models, where incentive dollars can impact more consumer decisions.
- Medium- and heavy-duty vehicles represent less than 10% of the vehicles on the road, but they are responsible for about 40% of total GHG emissions.[25] Massachusetts launched its first incentive for electric medium- and heavy-duty vehicles in 2020, MOR-EV Trucks, which provides purchase incentives for medium- and heavy-duty vehicles in Massachusetts, from Class 2b trucks to Class 8 tractor trailers and buses.

No municipal action required except community outreach.

STRATEGY T4: ACCELERATE ELECTRIFICATION IN FLEETS WITH CRITICAL EQUITY AND PUBLIC HEALTH IMPLICATIONS

- Electrification of vehicles for hire can be an opportunity to increase utilization of charging infrastructure in communities with low-income and EJ population, paving the way for broader adoption. The Commonwealth will implement a program to electrify this subsector, including expanded incentives, support for infrastructure, and outreach and education. The Commonwealth will consider how to use and access incentives at Logan Airport; about half of all taxi and a large proportion of ride hailing trips start and end at Logan Airport.
- E-commerce sales have increased by 34% since the start of the COVID-19 pandemic. Over 40% of restaurants have added delivery options to their services and 21% of consumers have tried using a delivery service for their groceries for the first time. MassCEC will continue to develop programs that provide incentives to businesses to decrease emissions from high-mileage, low-

radius fleets. Alternatives to traditional fleet expansion include vehicle conversion to zero-emission technologies, duty cycle management, route planning, zoning, and idle reduction.

- MassCEC will provide infrastructure and technical support to ensure that Massachusetts schools are well prepared to take advantage of federal funds to support rapid electrification of school bus fleets.
- Through the ACT4All program, EEA and MassCEC are directly partnering with community organizations to support efforts to reduce transportation emissions with a focus on expanding mobility and improving air quality in EJ communities and diversifying the EV consumer base.

Potential Municipal Action(s)

- **Request the School Department to contact MassCEC and develop a plan to electrify its school buses that it owns or contracts out.**
- **Identify and support potential EJ community air quality and EV procurement opportunities developed through MassEEA and MassCEC's ACDT4All program.**

STRATEGY T5: BUILD ELECTRIC VEHICLE CHARGING STATIONS AND ENCOURAGE SMART CHARGING

- The Infrastructure Investment and Jobs Act (IIJA) provides approximately $60 million over five years to Massachusetts to fund fast charging stations along major highway corridors. Mass DOT and EEA are working together to develop and implement plans to support the build out of these fast-charging stations. The IIJA also provides the Commonwealth with competitive grant funding opportunities to support community-based charging locations.
- Encourage private investment through competitive bids for community-based DC current fast charge stations with pilot grants. EEA and DOER will leverage pairing charging stations with solar PV and electrical storage systems
- EEA and DOER will develop a model building code for municipalities that requires make-ready charging in all new commercial and residential buildings. DOER will develop model municipal building codes for new construction. Stretch code will require 10% EV-ready parking spaces.
- The Commonwealth is currently evaluating options and programs proposed by the electric distribution companies to make installing home charging stations as affordable and convenient as possible for customers who are willing to sign up for managed charging. In addition, the state or electric utilities' program will help support building charging stations in apartment buildings and thereby support, in some cases, tenants who wish to charge at home. smart residential charging in a is reviewing utility proposals for affordable, convenient, managed home charging stations.

Potential Municipal Action(s)

- **Assign a task force with representatives from the Facilities Department, DPW, Sustainability Department and Eversource to assess and recommend a municipal-wide EV charging station plan. The task force will review options to accelerate multifamily, community-based fast charge DC stations, fleet EV stations, and managed home charging stations.**
- **Request DPW to investigate and submit IIJA-related grant applications for highway fast charging stations.**
- **Request DPW to solicit private sector bids for community-based DC fast charge stations paired with solar PV and electrical storage systems.**

- **Adopt MassEEA and MassDOER's model building code that requires make-ready charging in all new and major renovation commercial and residential buildings.**

STRATEGY T6: ENGAGE CONSUMERS AND FACILITATE MARKETS

- MassCEC has developed a fleet advisory service program that can help inform fleet operators as they transition to EVs. It will complement this fleet advisory service program with direct infrastructure support to ensure that the transition to EVs is cost-effective for public and commercial fleets.
- MassCEC will aim to assist outreach to all purchase decision-makers, particularly focusing on low- and moderate-income consumers.
- MassCEC is conducting a workforce needs assessment to support the 2030 targeted technology rollout. One anticipated outcome of this study will be a framework for workforce development needs that will help integrate lessons learned into follow-on programming to train and re-train workers in the growing clean transportation sectors.
- Rail, on-road heavy or long-distance freight, and port and marine vehicles are difficult and/or very expensive to electrify. Massachusetts will develop strategies to decarbonize these transportation modes and pilot technology approaches as appropriate. Advanced synthetic fuels and hydrogen may be viable paths as discussed in the 2050 Roadmap Study.
- Electrified short-haul aviation equipment options are nearing commercial readiness. Electrified Aviation (EA) infrastructure, which includes charging stations and energy storage, will be necessary to support the growth of this segment.

No municipal action required except community outreach.

Transforming our Buildings

STRATEGY B1: CAP ON EMISSIONS FROM HEATING

- The 2021 Climate Law charges the MassDEP with promulgating "regulations regarding sources or categories of sources that emit GHG to achieve the GHG emissions limits and sub limits." Before the end of 2022 Mass DEP will initiate a stakeholder process with a goal of finalizing regulations by the end of 2023 for early 2024 implementation.
- MassDEP will develop a high-level program and a set of draft regulations. One of these regulatory options being considered by the Commission on Clean Heat (the Commission) is to develop a Clean Heat Standard for buildings.

Potential Municipal Action

- **Follow MassDEP's building heating emissions regulations that are in process during 2023.**

STRATEGY B2: PERFORMANCE BENCHMARKS & STANDARDS

- As "directed by the 2021 Climate Law, DOER is promulgating a high-efficiency **specialized opt-in energy code** for which municipalities can choose to adopt starting in December 2022. The specialized code reflects more stringent energy standards that align with the Commonwealth's long-term building decarbonization goals. In addition, DOER is updating the **stretch energy code** which most municipalities have currently adopted as a prerequisite to enrolling in the **Green Communities Grant Program**."
- In 2022, DOER will begin administrative processes to revise the APS program to align with the Commonwealth's 2025 and 2030 limits and sub limits.

- Before the end of 2023, if recommended by the Commission, DOER will develop a uniform building performance reporting approach and related technical resources.

Potential Municipal Action(s)

As summarized by MassDOER;

- **"There will be 2 versions of the stretch code – so a total of 3 energy code options once the stretch and specialized codes are finalized later this year – so municipalities have a choice. The base energy code is the IECC2021 with modest MA amendments, the Stretch code builds on that to increase the energy efficiency requirements, and the new Specialized code goes further and requires pre-wiring or full electrification and on-site solar requirements for buildings that choose to use fossil fuels."**
- **"For communities that have already adopted the stretch code they would not need to take any municipal action to transition from the outgoing stretch code to the incoming stretch code."**
- **"For communities interested in adopting the new Municipal Opt-in Specialized Stretch code (Specialized Code), that would require a municipal vote – a town meeting bylaw or City council ordinance."**
- **"The Green communities Division is working on model bylaw/ordinance language to provide guidance on how to do this consistently."**
- **The Town will have to opt-in for the specialized Municipal Stretch Code. Holliston will get the Stretch Code updates by virtue of the original Stretch Code adoption by the town.**

STRATEGY B3: DELIVERING RESULTS AT SCALE

- As a part of the Commission on Clean Heat's deliberation and preliminary recommendation, **climate finance** programs can help address a portion of the cost barrier and expedite the deployment of clean heat solutions.
- The Commission on Clean Heat has discussed and suggested that the Commonwealth explore setting up a **centralized clean heat clearinghouse** to access consistent guidance, technical assistance, and grant financing to drive enrollment of "clean square feet."
- Mass Save is currently the best resourced and farthest-reaching policy tool that the Commonwealth can leverage to achieve GHG emission reductions from the building sector. Mass Save's 2022-2024 Energy Efficiency Plan is forecast to reduce GHG emissions by about 845,000 MTCO2e. The required GHG emissions reduction between 2025 and 2030 is 5,100,000 MTCO2e. The scope and nature of Mass Save may need to be updated to fully meet the emissions sub limits for 2030. The Commission will deliberate if legislation may be needed to update the role and charge of Mass Save.
- **Massachusetts Environmental Policy Act (MEPA)** reviews include the environmental impacts of any large construction projects and develop approaches to mitigate environmental damage. These approaches include but are not limited to enhanced building designs that can reduce GHG emissions from energy consumption.
- For existing large buildings, clean energy retrofits often require expensive upgrades which may have very long payback periods. MassDevelopment, in coordination with DOER, has begun to offer financing options for businesses and developers through its **Property-Assessed Clean Energy (CPACE)** program, which allows building owners to

finance clean energy upgrades through a long-amortization, low-interest lien placed on the property itself.

- Since 2020, MassCEC has run **Clean Energy Lives Here**, a consumer education and engagement campaign around home decarbonization. This platform supports consumers in their building decarbonization journey, from initial education to planning and implementation. MassCEC will continue to expand these efforts and coordinate with new incentives and marketing efforts around building electrification from **Mass Save**.
- In 2022, MassCEC is initiating a **Workforce Needs Assessment** based on the state's climate commitments. The study will include best practices for engaging and supporting women- and minority-owned businesses, EJ populations, and fossil fuel workers to transition to clean energy occupations.

Potential Municipal Action(s)

- **Monitor and inform the community about a potential Clean Heat Clearinghouse and MassCEC's Clean Energy Lives Here technical resources.**
- **Request municipal approval for a Property-Assessed Clean Energy (CPACE) program.**
- **Monitor and support potential legislation to update the charge of MassSave.**

STRATEGY B4: INFRASTRUCTURE PLANNING AND TECHNOLOGY INNOVATION

- Although it is unlikely that heat pump adoption would drive peak growth until sometime after 2030, investment in electric infrastructure should be planned today.
- Considering the potential implications that deep decarbonization holds for the future of gas infrastructure and gas customers, the Massachusetts DPU issued an order in October 2020 opening **Docket 20-80**, an investigation into the role of the investor-owned gas utilities in a net zero economy in 2050.
- The effort to decarbonize building heat systems and transition away from fossil fuel-based heat systems should include coordinated planning with the electric utilities to facilitate electrification alongside the targeted decommissioning of the natural gas pipeline systems.
- The DPU will work with the electric utilities and stakeholders to develop alternative **rate structures** for customers with electric heating (similar work on electric vehicle charging is ongoing) that would increase incentives for the adoption of clean technologies, while protecting energy-burdened households to ensure that everyone across the Commonwealth can reach equal and fair access to the clean technologies.

Proposed Municipal Action

- **Monitor the progress of DPU Docket 20-80. In addition, Holliston should work closely with Eversource to share Holliston's projected fuel to electricity conversation rates and scheduled and/or necessary electricity infrastructure changes that may be required.**

Transforming our Energy Supply

STRATEGY E1: EXECUTE CLEAN ENERGY PROCUREMENTS

- The New England Clean Energy Connect (NECEC) transmission project is a critical component of Massachusetts' ability to achieve its emissions limits. Massachusetts will need additional transmission capacity to deliver additional renewable electricity into the market as we approach net zero in 2050.

No municipal action required.

STRATEGY E2: CLEAN ENERGY ATTRIBUTE MARKETS

- The 2021 Climate Law raised the RPS minimum standard to 40% by 2030. Subsequently, MassDEP has proposed to increase the CES minimum standard to 60% by 2030 (20% incremental above the RPS). In addition, the CES for existing resources (CES-E) provides support for existing nuclear and large hydroelectric resources in New England. As currently promulgated, the CES-E would apply to about 20% of retail load in 2030 over and above the proposed 60% for CES.
- The Commonwealth has additional regulations and programs that aim to reduce GHG emissions in the electricity sector. The Electric Generator Units (EGU) emissions cap (310 CMR 7.74) sets a declining cap on carbon dioxide emissions from large power plants physically located in the Commonwealth. Emissions from power plants in Massachusetts are also subject to the emissions limits set by RGGI.

No municipal action required.

STRATEGY E3: DEVELOP AND COORDINATE REGIONAL PLANNING AND MARKETS

- Regional cooperation on electricity system planning and advancing wholesale electricity market reforms will be necessary. The required changes include:
    - Develop market-based mechanisms, in concert with state policymakers, that facilitate growth in clean energy resources and enabling services, while fully accounting for ongoing renewable energy investments made pursuant to enacted state laws.
    - Conduct best-in-class system planning activities that proactively address state clean energy needs.
    - Ensure grid resiliency and reliability at least cost in a manner that is responsive to state and consumer needs.

No municipal action required.

STRATEGY E4: SUPPORT OFFSHORE WIND AND SOLAR INDUSTRY DEVELOPMENT

- To support widespread electrification, New England likely will need more than 40 GW of solar resources by 2050. The supporting pathways analysis for the 2025/2030 CECP found this amount would exceed the total area of available rooftops in the region. To further assess the siting considerations for solar development, DOER initiated a Technical Potential of Solar Study in 2022. The study will help to identify suitable sites for solar development and educate the public about the need to foster solar growth in Massachusetts while protecting our important natural and working lands.

- The deployment of solar resources faces two significant challenges: interconnection of distributed energy resources and impacts on natural and working lands. Further policy will be needed to ensure sufficient solar deployment and to manage how such necessary development interacts with both of those systems.
    - DOER, DPU, and MassCEC will continue to work with solar and storage developers and with the electric utilities and ISO-New England to remove or minimize any potential barriers in interconnecting new solar and storage resources.
    - DOER will work closely with environmental protection agencies and stakeholders to ensure that the incentives provided to solar and storage projects do not unintentionally harm valuable natural and working lands and forests. In addition, DOER will continue to encourage deploying solar and storage projects on "built" landscapes.
- The Commonwealth has adopted the Energy Storage Initiative Target, which calls for 1,000 MWh of storage by 2025. 300 MWh of energy storage has been installed as of the end of 2021 and over 800 MWh is in the pipeline.
- Offshore wind represents one of the most reliable clean energy resources available to Massachusetts and is critical to the development of a low-cost decarbonized electricity system for the Commonwealth and for New England. Massachusetts will work with neighboring states, federal agencies, and ISO-New England in developing a regional plan for offshore wind transmission.

No municipal action required.

STRATEGY E5: INCORPORATE DECARBONIZATION GOALS INTO DISTRIBUTION SYSTEM MODERNIZATION

- Distribution system planning and grid modernization will be required to maintain a reliable and resilient system as clean energy policies increase the number of DERs interconnected to the grid. A more dynamic, bi-directional distribution system will allow for greater electrification and optimize the integration of DERs. With input from DOER and other stakeholders, the DPU is currently reviewing the utilities' proposed Grid Modernization Plans
- The deployment of AMI is a key technology to enable flexible electricity load including shifting electricity demand away from peak periods that are the most expensive and highest emitting. Grid modernization includes using advanced data analytics to monitor and potentially control electricity usage and provide this information to customers.

No municipal action required.

STRATEGY E6: DRIVING A JUST CLEAN ENERGY TRANSITION

- To effectively integrate environmental justice and equity in the energy transition plan, the Commonwealth will need to undertake efforts including but not limited to: (a) ensuring that siting and permitting decisions consider the impact of energy projects on communities with EJ population, (b) incorporating the voices of those who have been traditionally underrepresented in policy and regulatory processes and decisions, and (c) ensuring that well-paying jobs and economic development benefits flow to those who have traditionally not benefited from those investments.

No municipal action required.

GHG Emissions from Non-Energy Sources & Industrial Use

STRATEGY N1: TARGET NON-ENERGY EMISSIONS THAT CAN BE ABATED OR REPLACED

- The Commonwealth will minimize the growth of non-energy emissions, particularly emissions of high-GWP gases associated with uses that are expected to grow through the next decade: HFCs used in refrigeration, air conditioners, and heat pumps, and SF_6 used in gas-insulated electrical infrastructure switchgear.
- Methane leaks from the natural gas distribution network are substantial but are being reduced significantly because of existing policies. In addition to leaks from distribution system pipes, natural gas also leaks in small volumes from customer meters and customer-owned "behind the meter" piping and appliances.
- As a part of this 2025/2030 CECP, by the end of 2024, DPU will review and propose changes to the existing Gas System Enhancement Plans (GSEPs) for upgrades to leaky pipes that includes an economic evaluation of alternatives to full replacements in geographic areas with low anticipated natural gas utilization.

No municipal action required.

STRATEGY N2: IMPLEMENT BEST PRACTICES AROUND RESIDUAL NON-ENERGY EMISSIONS

- The major source of emissions from solid waste disposal is the seven municipal waste combustors (MWCs) operating in the Commonwealth.
    - the Massachusetts 2030 SWMP articulates a commitment to the longer-term goal of reducing the Commonwealth's solid waste disposal to 4 million tons by 2030 and by about 90% (to 570,000 tons) by 2050 and diverting recoverable material from disposal to higher uses.
    - MassDEP will make a concerted effort to improve the performance of existing combustion capacity and analyze the potential approaches to reduce carbon dioxide emissions from municipal waste combustors, including capping the emissions from MWCs.
- Transitioning more residences from stand-alone septic systems to managed sewer systems would likely reduce methane emissions from septic tanks.
- Expanding the use of anaerobic digesters at wastewater treatment plants (WWTPs) would avoid many of the methane emissions from WWTPs and have the compounded advantage of converting sewage sludge into usable fuel. However, at this time, no additional policies are set in this plan to expand anaerobic digesters at WWTPs.
- For agricultural emissions, which are very small in Massachusetts, improved practices can contribute to emissions reductions or stabilization.
- Since 1990, GHG emissions from the combustion of fossil fuels for industrial energy demands have fallen significantly. Much of this reduction is due to background trends, such as increasing globalization that has left fewer facilities operating within the borders of the Commonwealth.

Potential Municipal Action

Request DPW, Facilities, and the Planning Board to assess opportunities to construct or expand managed sewer systems in place of stand-alone septic systems.

Protecting our Natural and Working Lands (NWL)

STRATEGY L1: PROTECT NWL (KEEP NWL AS NWL)

- The Commonwealth aims to double the state's current pace of NWL conservation of ~10,000 acres per year to 21,000 acres per year.
    - By the end of 2023, EEA and associated agencies will review and update evaluation criteria of state land acquisitions and land conservation programs to **prioritize protection of forests vulnerable to development, carbon-rich forests, wetlands, and open space upstream of wetlands, including marsh migration corridors**
    - EEA will seek to **increase the annual budget of land protection grants and programs through state and federal funding sources**
    - EEA may potentially seek additional state funding to **expand the Agricultural Preservation Restriction (APR) Program beyond its current model**
    - By the end of 2024, EEA will develop and seek to advance new legislation to support the goal of No Net Loss of Forest and Farmland. This will include amendments to the Chapter 61 and 61A
    - EEA will also **partner with municipalities, land trusts, and other conservation organizations to encourage additional NWL conservation** above and beyond the state conservation goals for 2025 and 2030, including the pace of conservation restrictions.
- The Commonwealth will look to provide incentives and pursue the regulatory changes described below that aim to decrease NWL conversion to development.
    - EEA will seek an increase in the Land Planning Grants annual budget that would provide expanded grant funding to municipalities and regional planning agencies to **enhance the adoption of Natural Resources Protection Zoning (NRPZ) and tree protection bylaws and incentives**.
    - By the end of 2022, the MEPA Office will deliberate with the MEPA advisory committee, which was formed to advise on MEPA's 2021-2022 regulatory review effort, the potential to add a review threshold in regulation that would **require projects engaging in a certain level of forest clearing to undergo an environmental review process**.
    - By the end of 2023, DOER will provide **guidance for future solar siting through the Technical Potential of Solar Study.** Such guidance is expected to help minimize environmental impacts and forgone carbon sequestration on NWL while meeting renewable energy needs for electrification of building heating and transportation.
    - By the end of 2024, MassDEP will investigate approaches to increase statewide protection of wetlands and, at minimum, the first 50 feet of the 100-foot wetland buffer zone.

Potential Municipal Action(s)

- **Request the Conservation Commission to identify additional NWL conservation opportunities for 2025 and 2030 and propose a plan to increase municipal land protection.**
- **Request the Conservation Commission and the Planning Board to monitor and recommend how to implement additional NWL protection through the MEPA, solar**

siting, and wetlands buffer DEP programs that are under consideration for 2022-2024.

- **Request the Planning Board to review Open Space Residential Design (OSRD) provisions to a by-right process to help foster such developments, which help decrease development footprints and increase preserved open space.**

STRATEGY L2: MANAGE NWL

- A little over 200,000 acres of forests in Massachusetts—approximately 11% of all privately owned forest lands in the Commonwealth—are currently enrolled in the Chapter 61, 61A, and 61B tax programs, which allow privately owned forest lands to be taxed at the current use value of the property instead of the fair market or development value of the land. The goal is for 20% of privately-owned forests and farms to adopt climate smart management practices.
    - By the end of 2023, DCR will seek to **launch a new Forest Resilience Program** as part of the agency's Working Forest Initiative, which already offers cost-share payments for forests.
    - By the end of 2026, EEA will seek an amendment to the Massachusetts Forest Tax Law to modify the Chapter 61 and Chapter 61A programs or to **establish a new Chapter 61C program.**
    - Beginning in 2024, MDAR will seek to provide additional financial incentives to farmers through the MA Coordinated Soil Health Program for implementing healthy soils practices that increase carbon storage in agricultural soils.

Potential Municipal Action(s)

- **Request the Conservation Commission to monitor and support DCR's new Forest Resilience Program, EEA's new Chapter 61C program, and MDAR's MA Coordinated Soil Health Program.**

STRATEGY L3: RESTORE NWL

- Completing at least 16,100 acres of riparian and urban tree planting will require significant expansion and pace of current tree planting programs in Massachusetts.
    - By the end of 2023, DCR will seek to **launch a Riparian Tree Planting Program** to significantly expand tree cover along rivers, streams, lakes, and ponds, as well as retain edge/transitional habitat along farm fields.
    - EEA will seek additional increases to the annual budget of the **Greening the Gateway Cities program** to accelerate urban tree plantings in EJ neighborhoods.
    - Beginning in 2024, EEA will dedicate at least $3 million per year in the Municipal Vulnerability Preparedness (MVP) Program Action Grant funding for greening and nature-based projects to lower heat island impacts and increase urban carbon storage.
- Achievement of no net loss of stored carbon in wetlands will require conserving not only the wetlands but also the land adjacent to and upstream of wetlands, as land management upstream and around the wetlands can significantly disturb and degrade the wetlands.
    - By the end of 2024, MassDEP will **implement a no net loss of stored carbon requirement** in the Bordering Vegetated Wetlands (BVW) General Performance Standards (310 CMR 10.55(4)(b)) and **a minimum of 2:1 replacement to loss ratio** to 310 CMR 10.05(10) to memorialize the longstanding requirement of projects seeking variance.
    - By the end of 2024, MassDEP and the MEPA Office will investigate and identify ways to **streamline permitting and environmental impact review for wetland restoration**

projects that restore tidal wetlands, remove tidal flow restrictions, and restore salt marsh functionality.

Potential Municipal Action(s)

- **Request the Conservation Commission to identify potential riparian tree planting locations.**
- **Request the Conservation Commission to identify potential EJ and heat island locations for additional tree planting.**

STRATEGY L4: INCENTIVIZE LONG-LIVED, DURABLE WOOD PRODUCTS

- While harvesting forests results in short term losses of forest carbon, careful planning and management can ensure Massachusetts' working forests can continue to sequester carbon while also storing carbon in useful wood products over long periods of time.
    - Starting in 2023, DCR will pilot a program to collect information on where wood harvested on privately-owned and state-owned forests in the Commonwealth is processed.
    - Starting in 2023, DCR will commission a mill recovery study to assess common end uses of timber harvested in Massachusetts.
    - Starting in 2023, DCR will commission a study to identify potential opportunities to support a local market for durable wood products in Massachusetts from sustainably harvested wood.
    - By the end of 2024, DCR will seek to **expand the Forest Viability Program** to fund technical assistance and financial incentives for increasing efficiency in timber processing and expanding the market for low quality wood to be used as durable wood products.

No municipal action required other than to follow these efforts and potentially adopt these programs as they take effect.

STRATEGY L5: EXPLORE ADDITIONAL CARBON SEQUESTRATION

- It will be necessary to develop regionally consistent sequestration measurement, accounting, and market frameworks that will allow Massachusetts to purchase additional, least-cost sequestration services from other states in the region to allow the Commonwealth to achieve net zero GHG emissions in 2050.
    - By 2025, develop an accounting framework for achieving net zero GHG emissions in state and with other jurisdictions outside of Massachusetts.
    - By 2025, develop a framework design of the necessary elements (e.g., eligibility, registry, measurement, crediting, monitoring, and enforcement) of a viable carbon sequestration market

No municipal action required. However, opportunities may exist for local carbon sequestration projects.

Appendix B: Community Greenhouse Gas Reduction Resources

Appendix B includes descriptions and internet links for several efficiency and greenhouse gas emission reduction-related programs and resources that may be useful to consider for community decarbonization efforts. The categories include Massachusetts program support resources, potential municipal program support resources, Eversource program support resources, and private sector technology resources.

Massachusetts Programs and Initiatives

Massachusetts Decarbonization Roadmaps and Legislation

Massachusetts formally acknowledged global warming and the need to reduce greenhouse gas emissions in 2008. The first major legislative act passed in 2008 was called the Global Warming Solutions Act. This act set target carbon reductions of 20% by 2020 and 80% by 2050 below 1990 carbon emission levels.

More recently in December 2020, Massachusetts approved and released its 2050 Decarbonization Road Map. The road map charts a "no regrets" path to by 2030 and 85% decarbonization by 2050. in March 2021, Massachusetts updated its greenhouse gas emission reduction targets for the state. The state's decarbonization targets are now 50% by 2030, 75% by 2040, and net zero by 2050.

- Global Warming Solutions Act: https://www.mass.gov/service-details/global-warming-solutions-act-background
- MA 2050 Decarbonization Road Map and supporting documents: https://www.mass.gov/info-details/ma-decarbonization-roadmap
- 2021 Act: *An Act Creating A Next-Generation Roadmap for Massachusetts Climate Policy*

Massachusetts Energy Efficiency Advisory Council (EEAC)

The Massachusetts Energy Efficiency Advisory Council (EEAC) was enabled by the 2008 Global Warming Solutions Act. EEAC is charged with monitoring the performance of and guiding the state's energy efficiency programs. EEAC's website is the best source of information for the direction, priorities, and funding levels for the state's energy efficiency and greenhouse gas reduction programs.

In its March 16, 2022, meeting, EEAC provided a Mass Save program performance (2019-2021) update and program forecast (2022-2024) presentation. The presentation states that Mass Save's efficiency and heat pump installation programs are going to accelerate over the next three years. In addition, the presentation states that Mass Save's program performance will be measured in greenhouse gas emission reductions instead of energy savings. Moving forward, Mass Save's programs will be designed and funded ($4 billion over 3 years) to align as closely as possible with the state's updated 2030 – 2050 greenhouse gas emission reduction goals and the financial investment required to achieve these goals.

- March 16, 2022 EEAC Mass Save performance and forecast presentation: https://ma-eeac.org/wp-content/uploads/Q4-Presentation-3.16.pdf.

Mass Save FY 2022-2024 Program Priorities – Residential

Mass Save is the state's primary resource for residential energy efficiency and heat pump-related energy information and financial support. For the 2022-2024 program approved by the MA Department of Public Utilities on January 31, 2022, EEAC (mentioned above) will be monitoring the following key residential performance indicators:

- Progress towards residential program design enhancements.
- Consideration and implementation of whole-home, performance-based retrofit program, or similar new approach to emphasizing the co-delivery of weatherization and heat pumps.
- Integration of home energy scorecards.
- Implementation of an all-electric new construction offer for the 1-4 unit market segment.
- Updates on the number of units enrolled in Passive House multi-family new construction offering.

Specifically for Low-income[17] eligible weatherization, EEAC will be monitoring:

- Electrification efforts for the Income Eligible sector, including installation of heat pumps for space and water heating.
- Efforts to increase installation of envelope measures.
- Enhanced strategy for serving small multi-family buildings including "naturally occurring" low-income housing.
- Development and implementation of a statewide computerized audit tool as recommended in the Low-Income Process Evaluation.
- Affordable multi-family decarbonization/deep energy retrofit offering.
- Development and implementation of a mixed income protocol for multi-unit buildings, including 5+ unit buildings.

Mass Save FY 2022-2024 Program Priorities – Commercial

In addition to its residential initiatives, Mass Save is the state's primary resource for commercial energy efficiency and heat pump-related energy information and financial support. For the 2022-2024 program approved by the MA Department of Public Utilities on January 31, 2022, EEAC will be monitoring the following key performance indicators:

- Development of strategies for municipal building participation in the deep energy retrofit offering.
- Launch of an all-electric new construction offering for the C&I sector.

[17] "Low-income residents — defined as anyone who makes less than 60 percent of the state median income — can have the state cover 100% of the cost of efficiency-boosting home measures and appliances. If you receive a low-income electric rate or food stamps, you likely fall into this category."
Moderate-income customers - "those who make between 60 and 80 percent of the state median income, qualify for the state's Income Eligible Program. That includes some free upgrades, as well as other savings. And residents whose income is 80 percent or more of the state's median still qualify for some savings plans." Source: https://acadiacenter.org/what-the-new-mass-save-rewrite-means-for-you/

- Pursuit of non-lighting measures in the commercial sector, especially HVAC, refrigeration and process controls, and operational savings given the PAs plans to not expand their SEM demonstration into a formal program offering.
- Efforts to increase GHG reductions in the C&I sector, including launch of the deep energy retrofit offering.

Mass Save Rebates and Incentives

- All residential rebate and incentive programs are available at: https://www.masssave.com/en/saving/residential-rebates
- All business rebate and incentive programs are available at: https://www.masssave.com/saving/business-rebates

Mass Save Heat Loan

Homeowners can request a 0% interest energy loan for up to $25,000 of energy-related investments. In partnership with Mass Save, the loans are processed through approved local lending institutions. Homeowners are only allowed to apply for a single heat loan so homeowners should include all the energy measures that they might be interested in financing in the application. Additional measures or loans will not be accepted.

- Mass Save Heat Loan website: https://www.masssave.com/saving/residential-rebates/heat-loan-program.

Mass Save ConnectedSolutions – Smart Thermostat and Battery Storage Program

Mass Save manages a residential and small business smart thermostat and battery incentive program called ConnectedSolutions. Homeowners and small businesses with qualifying smart thermostats and/or battery systems that have less than 50 kW peak output qualify for this program. Mass Save's website has more information about this program. Smart thermostats and battery storage equipment qualifies for Mass Save's 0% interest Heat Loan.

- Connected Solutions website: https://www.masssave.com/saving/residential-rebates/connectedsolutions-batteries

Mass Clean Energy Center (MA CEC)

The Mass Clean Energy Center (MA CEC) jump starts and oversees all Massachusetts clean energy initiatives. Early pilot programs sponsored by MA CEC have supported municipal group procurement programs including MA Solarize and MA HeatSmart. MA CEC has an excellent summary of clean energy incentives and programs that is available at the URL listed below. In addition, MA CEC has what it calls the Solarize/Heat Smart toolkit. This section of its website includes interviews and guidance from participants in earlier municipal group procurement initiatives.

- MA CEC summary of residential, business, and government/non-profit solar incentives and programs: https://www.masscec.com/get-clean-energy
- MA CEC Solarize and Heat Smart Toolkit: https://www.masscec.com/solarize-heatsmart-toolkit

Massachusetts Offers Rebates for Electric Vehicles (MOR-EV)

As stated on its website, "the Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) program aims to provide air pollution emission reductions for the Commonwealth by increasing the use of electric vehicles." Current rebates for light duty vehicles are $1,500 for hybrid vehicles and $2,500 for battery electric vehicles. Current rebates for heavy duty vehicles are $7,500 - $90,000 depending on the weight class of the vehicle.

- Website: https://mor-ev.org

Municipal Programs and Initiatives

Cities and towns have several potential programs that they can enact to support the state's greenhouse gas reduction targets. Potential programs include approving property assessed clean energy financing, adding home energy scores in assessor data, and enacting local legislation and regulations.

Property Assessed Clean Energy (PACE)

As described on the MA Development website, the idea behind property assessed clean energy (PACE) is "to finance energy improvements through PACE Massachusetts, a property owner agrees to a betterment assessment and lien on their property, which repays the financing. This approach enables owners to undertake more comprehensive energy upgrades with longer payback periods of up to 20 years. At property sale, the assessment stays with the property and is transferred to subsequent property owners."

Individual cities and towns must approve this financing mechanism before it can be used. Approval requires a majority vote by the town Council or Board of Selectmen. As of April 2022, 52 cities and towns have endorsed the use of PACE in their communities. This program is only available for commercial and multifamily properties with more than 20,000 square feet and is often referred to as C-PACE (C stands for commercial). A residential program (R-PACE) is under consideration (as of April 2022) by the state legislature.

- Mass Development's website for more information about this program: https://www.massdevelopment.com/pace

Home Energy Scores

The US Department of Energy (US DOE) has created and supports a home energy score program designed for energy auditors and building assessors. The idea behind the energy score program is that building assessment data can provide accurate energy scores for single family homes. This program is an excellent potential resource for communities that would like to provide energy performance information for all households. In addition, with permission from each household, information collected as part of the energy score process can be used to inform the town about the community's residential building energy upgrade needs. Future building assessments would be able to monitor the community's transition to lower residential sector carbon emissions.

The links below include more information about US DOE's Home Energy Score, a white paper regarding the legality of and opportunities for home energy scores tied to assessor databases, and an article that describes Newton's Home Energy Ratings assessor database initiative.

- US DOE Home Energy Score website: https://betterbuildingssolutioncenter.energy.gov/home-energy-score

- 2013 White Paper on Assessor databases and energy scores: https://d1o0i0v5q5lp8h.cloudfront.net/earadv/live/assets/documents/Publications/EnergyRatingsOnPropertyTaxRecords-%20FINAL-140203.pdf
- Newton, MA posts home energy scores on its assessor database. Here's an article written about it: https://village14.com/2020/10/31/home-energy-scores-now-available/

Municipal Regulation & Legislation

Massachusetts municipalities have enacted several binding and non- binding energy and greenhouse gas reduction bylaws and regulations. Following are a few examples:

- Acton, MA - Climate emergency - 0% GHG emissions by 2030 https://www.actonclimatecoalition.org/emergency/. Lexington has a similar proposal for Town Meeting with a 2035 0% emissions target.
- Bedford, MA Electricity aggregation – Offer more renewable electricity https://www.bedfordma.gov/home/news/bedford-community-choice-aggregation
- Boston, MA – Building Emissions Reduction and Disclosure Ordinance (BERDO). Reporting requirements for commercial facilities larger than 20,000 square feet. Greenhouse gas emission reduction requirements are in development and scheduled to begin in 2022. https://www.boston.gov/departments/environment/berdo-regulations-development
- Lexington, MA - Gas-powered lawn equipment ban approved in 2021. https://www.lexingtonma.gov/sites/g/files/vyhlif7101/f/uploads/motion_art_10_noise_landscape_revised_11.18.21_11.03pm_final.pdf.
- Lexington, MA – and other communities are voting locally to assess opportunities to require clean heating, cooling, and domestic hot water equipment for new installations. Home Rule for Clean Heat (2022) https://www.cleanheatlexington.org/resources/HomeRuleCleanHeat
- Lincoln MA - Town Facilities Energy Performance Standard (2011), a measure for new construction and major renovation energy performance criteria with a sliding scale net-zero fossil fuel target by 2030. https://www.lincolntown.org/DocumentCenter/Index/43
- Lincoln MA - Solar PV zoning bylaw (2016) http://www.lincolntown.org/DocumentCenter/View/26987/Solar-energy-bylaw-amendment-proposal-12212016?bidId=
- Wellesley, MA - and other communities are developing green zones for municipal land that comply with the American Green Zone Alliance (AGZA) https://theswellesleyreport.com/2021/02/wellesley-dpw-eyes-parks-as-green-zones/

Eversource

Eversource Commercial Services

Eversource offers custom support for small, medium, and large businesses and multifamily buildings (more than 5 apartments). All their programs are available at: https://www.nationalgridus.com/MA-Business/Energy-Saving-Programs/

In addition, Eversource is beginning to work with individual communities to develop nonbinding community energy efficiency initiatives. The MOUs list specific energy reduction targets over a set period – usually 3 three years. Newton has published its MOU with Eversource and Eversource at: https://www.newtonma.gov/home/showpublisheddocument/78256/637743892757170000

Appendix C: Renewable Energy Portfolio Standard (RPS) and Clean Energy Standard (CES)

A major variable in community decarbonization planning is the amount of renewable and clean energy that will be available from the electrical grid. Massachusetts has increased the amount of renewable energy and clean energy dramatically beginning with the Electricity Restructuring Act of 1997. Following is a summary of the state's legislative efforts to date as reported by MA DOER in its 2019 Annual Compliance Report (November 16, 2021)[18].

Legislation

"The Renewable Energy Portfolio Standard (RPS) Class I is a statutory obligation created by the Electricity Restructuring Act of 1997 and activated by regulations in 2002. The statute was first revised by the Green Communities Act of 2008, which added a second class of RPS, Class II, and the Alternative Energy Portfolio Standard (APS).

The RPS and APS statutes were further modified by the Competitively Priced Electricity Act of 2012, the Renewable Thermal Act of 2014, the Energy Diversity Act of 2016, the Act to Advance Clean Energy of 2019 [and *An Act Creating A Next-Generation Roadmap for Massachusetts Climate Policy* of 2021].

In 2018, the Clean Energy Standard (CES) was successfully introduced to complement the other standards. The CES is administered by the Massachusetts Department of Environmental Protection (MassDEP).

The Clean Peak Standard (CPS), part of An Act to Advance Clean Energy which was signed into law in August 2018, provides incentives to clean energy technologies that can supply electricity or reduce demand during seasonal peak demand periods."

Minimum Standards

"The RPS requirements began in 2003 with an obligation of 1% of total retail electricity sales and increased 0.5% annually until it reached 4% in 2009. From 2010 to 2019, the RPS Class I obligation has increased 1% annually. The RPS Class I minimum standard was 14% in 2019.

Since 2010, the RPS Class I minimum standard has included a SCO [solar carve out] obligation for in-state solar generation. The minimum standard obligation for the SCO and its 2014 successor program, SCO II, change annually by formulas set in regulation.

The RPS Class II renewable energy obligation changes annually per a schedule and formula set in regulation, with a cap of 3.6%. The RPS Class II waste-to-energy obligation is fixed at 3.5% annually. The APS obligation, which was 4.75% in 2019, increases by 0.25% per year. The total obligation for the CES was 18% in 2019, though it is inclusive of the RPS Class I minimum standard. Therefore, the additional obligation from the CES was 4% in 2019. The CES increases by 2% per year."

Eligible Resources

"Eligible RPS Class I resources include post-1997 renewable generation units located in New England or in adjacent electricity control areas. Eligible resources for RPS Class II Renewable

[18] https://archives.lib.state.ma.us/bitstream/handle/2452/855691/on1300228336-2019.pdf?sequence=1&isAllowed=y

Energy include pre-1998 renewable plants (primarily small hydropower) located in New England or in adjacent electricity control areas. Eligible Class II waste-to-energy Generation Units must be pre-1998 waste-to-energy plants located in Massachusetts and meet certain MassDEP recycling requirements."

2019 Renewable Energy and Clean Energy Minimum Standards and Compliance

The table below summarizes the minimum standards and compliance by all Massachusetts utility companies and 64 supply vendors in 2019 as reported by MA DOER:

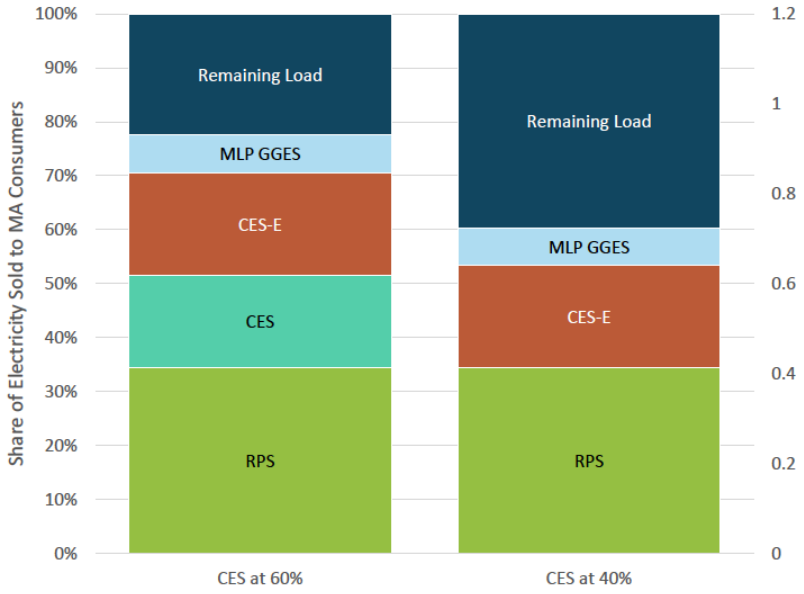
Summary of Minimum Standards, Certificates Used to Meet Obligation, and Alternative Compliance Payments in 2019 (Net of non-compliant Suppliers)

RPS/APS Class	Minimum Standard *	Total Obligation (MWh)	Certificates Used to Meet Obligations (MWh)	ACP Credits Used to Meet Obligations (MWh)	Alternative Compliance Payments
RPS CLASS I (NET)	8.4912%	3,796,084	3,723,951	9	$ 634
RPS SCO *	1.7455%	780,339	741,343	23,868	$ 9,642,672
RPS SCO II *	3.7633%	1,682,417	1,642,310	46,763	$ 15,572,079
RPS CLASS II Renewable	2.6884%	1,201,860	1,165,729	12,602	$ 364,324
RPS CLASS II Waste-to-energy	3.5001%	2,123,562	1,511,623	22,552	$ 262,289
APS	4.7501%	2,073,066	2,073,066	8,880	$ 208,864
CES **	3.2759%	1,464,505	1,406,167	23,675	$ 1,429,842
TOTAL***	**28.2145%**	**13,121,833**	**12,264,189**	**138,349**	**$ 27,480,704**

* Solar carve out requirements are subsets of the overall RPS Class I requirement of 14%
** CES total obligation is 18%. The RPS Class I obligation counts towards meeting the overall obligation making the Incremental minimum standard 4%.
*** Total number of certificates and ACP credits does not exactly match total obligation due to 1) rounding of individual obligations, and 2) the non-compliance of four suppliers (See Appendix Two: COMPLIANCE FILINGS, REVIEW, AND VERIFICATION) Certificates Used to Meet Obligations includes banked certificates from prior compliance years.

2019 MassDEP Proposal to Increase Clean Energy Standard Electricity

The table below represents additional (higher) Clean Energy Standard (CES) electricity requirements proposed by MassDEP in 2022. CES includes nuclear and large-scale hydro.



Appendix D: Table and Figure Sources and Assumptions

Appendix D describes the sources and assumptions behind the information shared in this report. The primary source for greenhouse gas (GH emission information comes from the Metropolitan Area Planning Council's (MAPC) greenhouse inventory tool. Holliston filled out the necessary input information prior to this report. MAPC has a step-by-step instruction guide for the Excel spreadsheet at:

http://www.mapc.org/wp-content/uploads/2020/03/04102020_MAPC-Step-by-Step-GHG-Inventory-Guide.pdf

The guide includes descriptions of the source information that we have included below. In addition, MAPC generated its own spreadsheet to leverage the greenhouse gas information in MAPC's tool into the tables and charts that we've included in this report

Table 1 Greenhouse Gas emissions by community sector

Greenhouse Gas emissions for table 1 come directly from MAPC's GHG inventory tool that MAPC filled out in February 2022. "The Tool includes default annual emissions factors from MassDEP's GHG emissions reporting summaries."

Table 2. Energy use sources by community sector

Energy use information for table 2 comes from MAPC's GHG inventory tool that MAPC filled out in February 2022.

> **Electricity and Natural Gas –** "As of 2015, all of the investor-owned utilities ("IOUs") in Massachusetts have been publishing electricity and natural gas consumption data broken out by municipality online. MassSaveData provides community-wide kWh and therm usage by year. [The data is] broken out by **Residential and Low Income** and **Commercial and Industrial** customer segments."
>
> https://www.masssavedata.com/public/home
>
> **Other energy use** – Other energy use is estimated based on state and federal average use per home or per employee.

Tables 3 & 4. Residential energy use

The number of homes in specific housing types and the source of residential heating use comes from two tables in US Census Bureau data on household heating fuel from the American Community Survey. The number of homes by residential category type comes from the data table **Housing Tenure by Units in Structure, aggregated at the municipal level**. The percent of homes heated by specific fuel types comes from the data table **Housing Tenure by Fuel Type.**

Electricity and natural gas use per residential building category comes from dividing the total energy use by the number of homes listed for each residential building category.

Table 5. Total commercial building energy use

The number of commercial and industrial employees comes from Massachusetts Executive office of Labor and Workforce Development (EOLWD) Employment and Wages (ES-202) data.

"For commercial and industrial heating fuel oil use the Tool calculates a share of the statewide heating oil usage, based on number of businesses and industries located within the municipality."

Electricity and natural gas use per commercial and industrial building category comes from dividing the total energy use by the number of employees listed for each commercial and industrial building category.

Table 6. Residential building estimated fuel conversion equipment costs

The residential fuel conversion equipment design load is calculated based on 35 Btus per square foot and 150% heat pump design condition efficiency. The design load is then multiplied by the cost per ton listed at the top of each column. The average design load assumes a significant investment in energy efficiency upgrades. The cost for the efficiency upgrades is not included in the conversion cost. The cost per ton figures are rough rules of thumb and will vary significantly for individual projects.

Table 7. Commercial building estimated fuel conversion equipment costs

MAPC's GHG Inventory tool doesn't have access to commercial and industrial total floor area. To calculate the commercial and industrial fuel conversion equipment design loads, we've used the total MMBtu to design heat pump output ratio for multifamily buildings and applied it to the commercial and industrial buildings. The design load is then multiplied by the cost per ton listed at the top of each column. The average design load assumes a significant investment in energy efficiency upgrades. The cost for the efficiency upgrades is not included in the conversion cost. The cost per ton figures are rough rules of thumb and will vary significantly for individual projects.

Table 8. Passenger and commercial vehicle miles & fuel use

The number of vehicles and associated miles and fuel use data are from Massachusetts Vehicle Census on MAPC's online Data Common resource. The most recent data is from 2014.

Table 9. Off-Road Carbon Emissions

According to MAPC's GHG Inventory guidebook, "GHG emissions from off-road mobile activities are categorized according to how they occur. There are two sources of off-road mobile emissions that are of primary concern locally – these are emissions from landscaping, construction, and manufacturing activities. These GHG emissions are included in the Stationary Energy sector because the combustion of fuel is localized and occurs off public roadways." The data was generated by US EPA and made available by MAPC.

> **Commercial, Industrial, and Manufacturing data** are derived from the U.S. Census Data Set "CB1700CBP" titled "All Sectors: County Business Patterns by Legal Form of Organization and Employment Size Class for U.S., States, and Selected Geographics: 2017"
>
> **Estimated landscaped area** square footage data on MAPC's MAPC's online Data Common resource. The most recent data is from 2017.
>
> **County level carbon emissions** data is from the MOVES emissions data on MAPC's online Data Common resource. The most recent data is from 2017. The GHG tool then reduces the county data to town data based on the percent of jobs or landscape area associated with the individual town or town.

Figure 3. Potential Fuel Decarbonization

This chart reflects the net reduction in fuel-based energy use in MMBtus assume fuel-based energy use conversions to high efficiency electric equipment and vehicles at the 5-year conversion rates listed in the report.

Table 10. Renewable Energy and Clean Energy Portfolio Standard generation targets

See the detailed description of the Renewable Energy (RPS) and Clean Energy (CES) Portfolio Standards in Appendix B.

Figure 4. Potential electricity load and fuel mix scenario

This chart assumes 5-year building and vehicle conversion rates of about 12% by 2025, 12% by 2030 15% 2035, 20% by 2040 and 2045, and an additional 5% conversion in 2050 for a total conversion rate of about 20% by 2050. In addition, the chart assumes default electricity from Eversource. Building equipment electricity use conversions assume an average 250% equipment efficiency. Vehicle electric use conversions assume an average 40% gasoline engine efficiency, 45% diesel engine efficiency, and a 90% electric motor efficiency.

Tables 11 & 12. Solar PV area, output, and potential costs

We've used the National Renewable Energy Lab's (NREL) PVWatts online calculator to determine the estimated electricity output of potential solar PV installations: https://pvwatts.nrel.gov. Costs per peak kW are the range of recent solar PV solar projects that the author was able to identify.

> **Residential Solar PV –** The total solar PV area estimate for all potential residential solar PV assumes 20% of the total floor area divided by 2 (floors) is available for solar PV.
>
> **Parking Lot Solar PV –** Parking lot area is a target figure for preliminary discussion. Actual parking lot solar PV sites will need to be identified and total area confirmed.
>
> **Commercial Solar PV -** Commercial-scale ground mounted lot area is a target figure for preliminary discussion. Actual ground-mounted lot solar PV sites will need to be identified and total area confirmed. The sites can be single 100-acre locations or multiple lots of 5-10 acres or more. We assume that these sites would be financed, and the electricity offered as part of a power purchase agreement (PPA) or community solar project.

Figure 7. Total carbon emissions reduction

This chart summarizes the total carbon emissions reduction impact based on all the assumptions and actions included in this report.

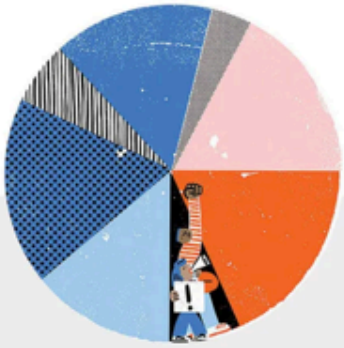
Appendix E: Social networking and the 25% tipping point

Appendix E summarizes recent research and analysis regarding social networks and change. YES magazine[19] prepared the following graphics based on research and several books and journal articles written by Damon Centola at the University of Pennsylvania. If Massachusetts is going to achieve its ambitious decarbonization goals, it will need to develop a strong local presence with multiple interconnections. The state will need to claw its way to 25% decarbonization but after that, the transition will accelerate rapidly. Cities and towns are all about community and neighborhoods. If Centola's message is correct, cities and towns are in an extraordinary position to effect change in the Commonwealth's decarbonization efforts.

[19] https://www.yesmagazine.org/issue/what-the-rest-of-the-world-knows/2020/11/03/how-social-change-happens

The tipping point for social change is precise: 25%.

Social scientist Damon Centola's new research shows a cascade of change is triggered when 25% of a population embraces an idea. Minority views of what is acceptable quickly become majority views. Historically, majority-rules economic thinking assumed change happened when 51% of a population wanted it. But in 1977, Harvard University's Rosabeth Moss Kanter studied tokenism in the workplace. She found that women as small minorities were subject to an oppressive culture of discrimination and harassment. But when women occupied 20%–35% of leadership roles, work culture shifted.



TIPPING POINT

Failure ← → Success

17% 19% 19% 20% 21% | 25% 27% 28% 28% 31%

Percentage of activists in each trial

Change happened fastest

THE EXPERIMENT:

EVERY PERSON COUNTS

Centola's 2018 small-group experiments show how sensitive the tipping point is. Sometimes adding just a single person to the committed minority meant hitting 25%—and the transition from failure to success. Varying numbers of activists were planted into groups in 10 trials. Their goal was to sway the larger population to adopt a new norm.

Source: "Experimental Evidence for Tipping Points in Social Convention," Centola, et al, *Science 360*, 2018

CASE IN POINT:

SOLAR REVOLUTION

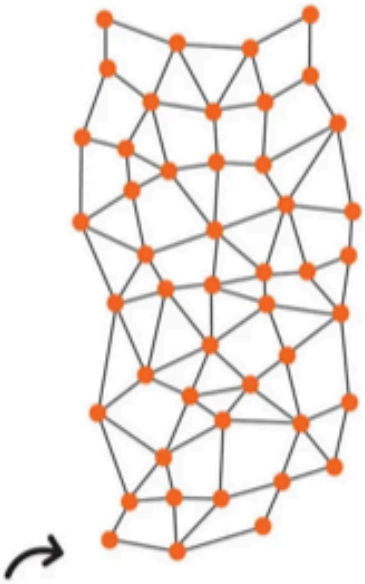
Germany is a world leader in solar energy production per capita. How did that happen?

1992: 2,000 solar homes
2009: 576,000 solar homes

A 2016 study of the German initiative found that neighborhood social relationships tipped the social norms. When advertising or incentives weren't sufficient to trigger change, a federal program to activate a specific number of people in each neighborhood was able to trigger a nationwide cascade of adoption.

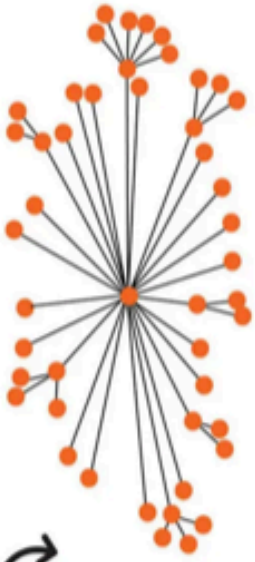
How do you get critical mass? Strong social ties ...

The key accelerant for conversion to new ideas is social reinforcement: strong ties among friends and neighbors, even friends of friends, and across different social groups. Extensive reach is less important than close relationships and redundancy.



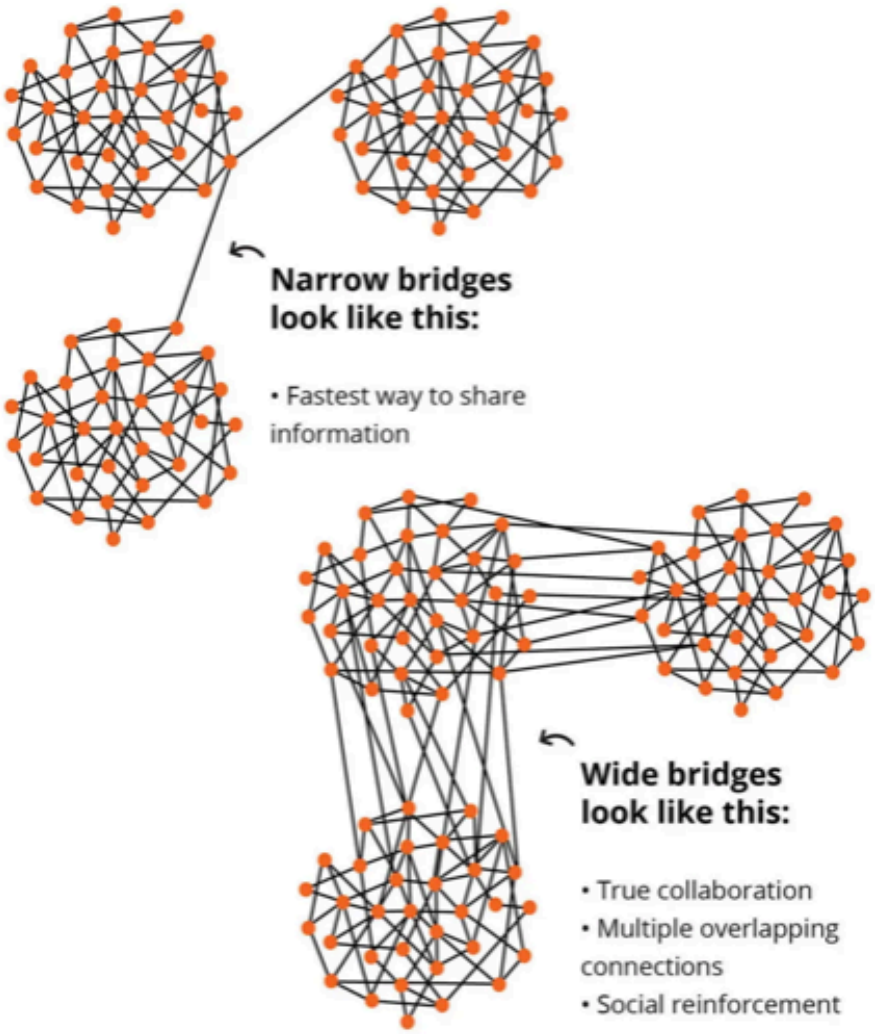
Strong social ties look like this:

- Abundance of social redundancy with each person connected to friends of friends
- Trust and intimacy
- A foundation for cooperation or solidarity



Weak social ties look like this:

- Acquaintances and long-distance relationships
- Each person has little redundancy of connections
- Information travels quickly — but not persuasion



4

... and wide, inclusive bridge-building.

Lots of groups have some level of representation in society yet alone can't make an impact on a large scale. Bridges are tenuous connections between people in diverse social groups. By targeting "wide bridges" among different communities and political constituencies, even small groups can build coalitions, and coordinated actions to reach a critical mass.

Appendix F: Electric Vehicles and Charging Stations

The evolution of lithium-ion batteries and concern regarding carbon emission-related climate change have inspired a major transition from internal combustion engine powered vehicles to high efficiency powered vehicles. This section provides a short description of electric vehicles (EV), EV charging stations and opportunities to install EV charging stations in Holliston.

Electric Vehicles and Charging Stations 101

Electric vehicles currently come in three forms, hybrid (HEV), plug-in hybrid (PHEV), and full battery (BEV). A hybrid vehicle generates electricity from the vehicle's internal combustion engine. A plug-in hybrid vehicle generates electricity from the vehicle's internal combustion engine and from an electric outlet. A battery electric vehicle receives energy exclusively from an electric outlet. Figure 1 below represents a full battery electric vehicle.

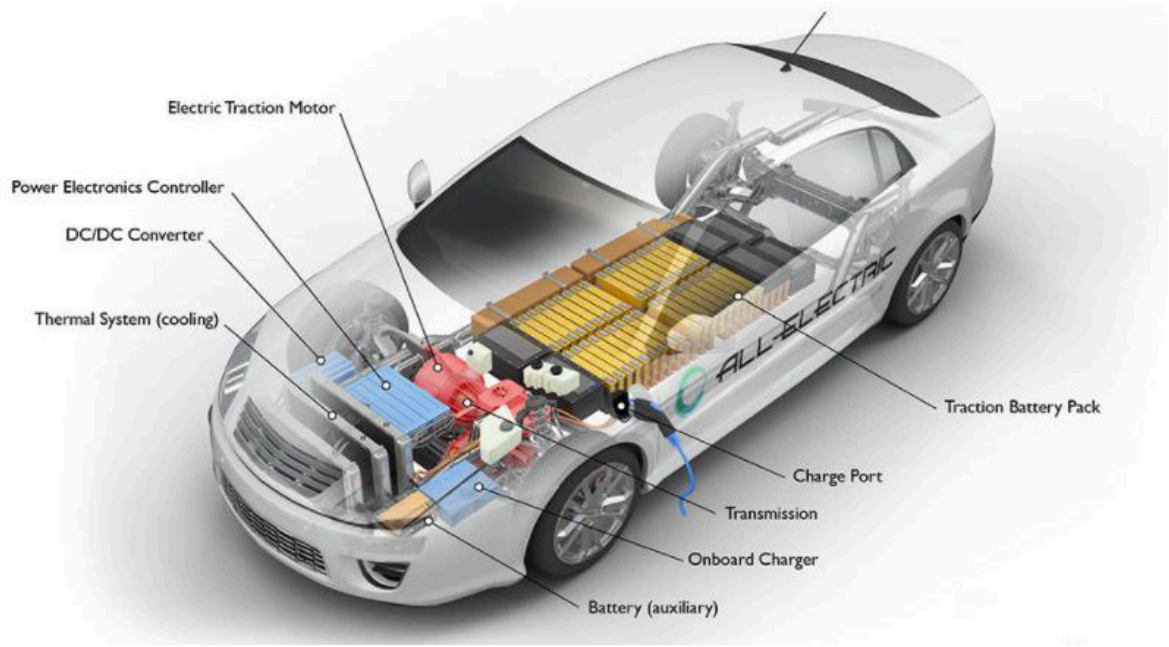


Figure 1. Battery Electric Vehicle [20]

PHEV and BEV cars and trucks require special electric plugs to charge their batteries. Figure 2 explains the most common types of electric charger connections and the charging speed for each charger type.

[20] U.S. Department of Energy. How Do All-Electric Cars Work, https://afdc.energy.gov/vehicles/how-do-all-electriccars-Work

	Level 1	Level 2	DCFC		
Description	120 volt (V) alternating current (AC) plug, single phase service 12-16 amp (A)	208/240V AC plug, single phase service 12-80A	208/480V AC circuit, three-phase service connection 50-200A		
Connector Type(s)					
	J1772 charge port Standard Wall Outlet	J1772 charge port	Combined Charging System (CCS)	CHAdeMO	Tesla
Typical Use Cases	Light-duty EVs; residential, workplace	Light and medium-duty EVs; residential, workplace, public charging, fleets	Light, medium, and heavy-duty EVs; public charging, fleets		
Typical Charge Time (for light-duty EVs, varies based on battery size)	2-5-miles/1 hour of charging PHEVs can be fully charged in 2-7 hours; BEVs in 14-20+ hours.	10-20 miles/1 hour of charging PHEVs can be fully charged in 1-3 hours; BEVs in 4-8 hours.	60-80-miles/20 min of charging BEVs can be fully charged in 30-60 minutes.		

Figure 2. EV charger connections and charging speeds [21]

Electric Vehicle Charging Stations in Holliston

The challenge for Holliston with EV charging stations will be to anticipate when to install and how to pay for, locate, and manage enough electric charging stations to serve all the town's vehicle owners and visitors. Holliston will either need to purchase and place electric charging stations in convenient locations or support other public/private efforts to install electric charging stations and get approval to connect them to the utility grid.

We recommend that Holliston develop a charging station plan for 100% community-wide electric-vehicle market penetration for the town. Holliston can then work backwards to determine the location for Holliston's first wave of electric charging stations. Rapid changes in EV vehicle technology combined with the investment in EV charging stations included in the recently approved Infrastructure bill will undoubtedly create a long-term need for more electric charging stations.

As part of its EV charging station deployment plan, Holliston will need to develop a load management plan with Eversource with this information and coordinate a phased installation plan with the utility company. Charging multiple vehicles rapidly and concurrently will add significant electrical load to the existing utility distribution infrastructure. On a more positive note, connecting multiple electric vehicles with large batteries to the utility distribution system

[21] U.S. Department of Energy. Developing Infrastructure to Charge Plug-In Electric Vehicles, https://afdc.energy.gov/fuels/electricity_infrastructure.html

will also offer significant load management opportunities. Total electricity use will increase but the number of electricity generation sources may be possible to manage with smart EV charging practices and electricity storage.

EV Charging Station Needs

The four primary groups of vehicle use, and related EV charging needs include residential, workplace, municipal, and opportunity charging. The figure shows the residential, commercial, and industrial zoning districts in Holliston.

Residential

Most residents will charge their electric vehicles at home. Holliston has four residential zoning districts. Figure 5 is a copy of Holliston's 2011 zoning map.

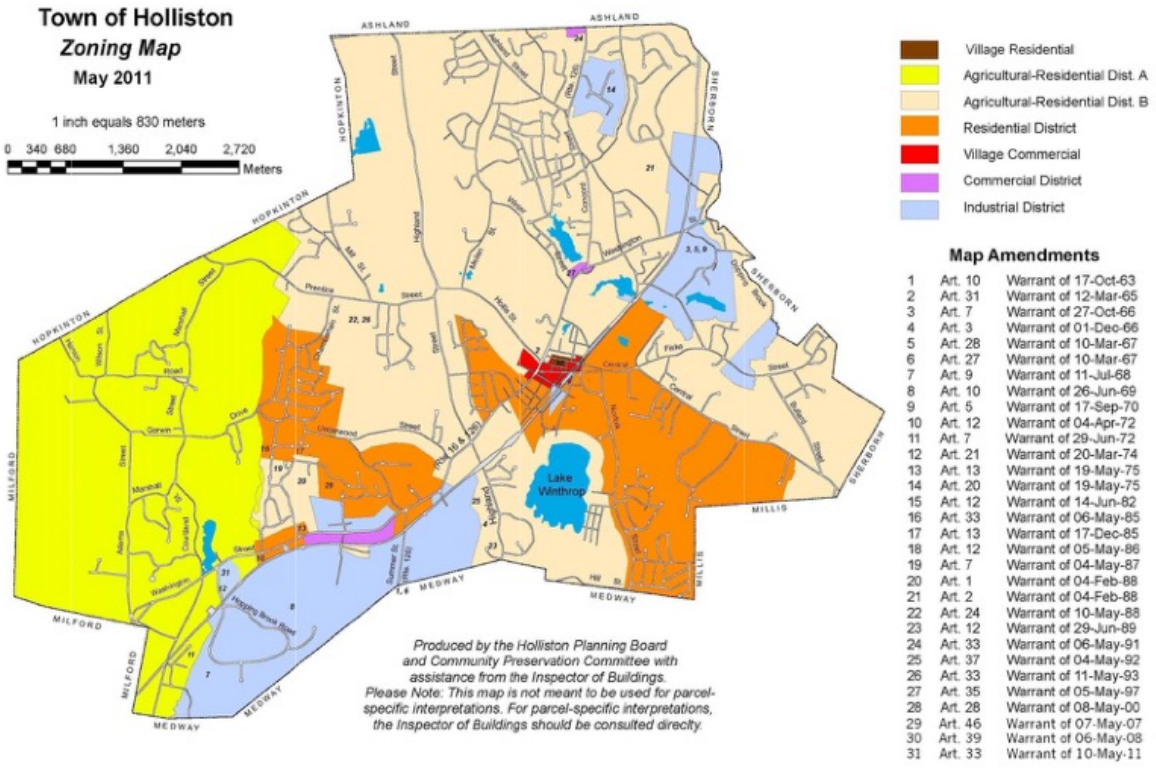


Figure 5. Holliston 2011 zoning map

Most residents will charge their electric vehicles at home. However, not every resident in Holliston has access to off-street parking. Residents without off-street parking will need to find alternative means to charge their cars.

Figure 8 is a street view of Mechanic Street. As the photograph indicates, the residences have on-street parking.

Figure 8. Mechanic Street on-street parking

Workplace

Workplaces offer electric vehicle charging opportunities for employees, visitors, and workplace-related vehicles and off-road equipment. Holliston has several commercial and industrial zoning districts. Figure 9 includes a street view of downtown Holliston.

Figure 9. Downtown Holliston

Municipal

Holliston has its own fleet of vehicles to consider and transition to electric and other zero emissions vehicles. Concord, MA prepared an implementation study[22] for its municipal vehicles that can serve as an example of how Holliston can plan to install EV chargers for its municipal fleet.

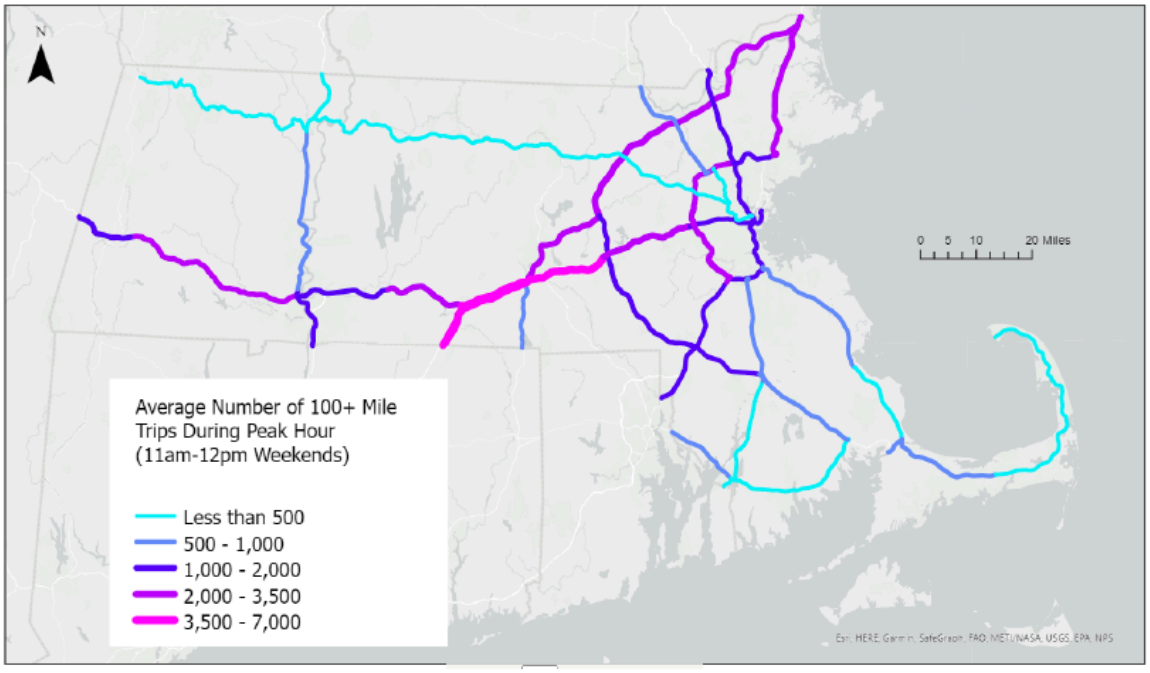
Opportunity

Holliston is a destination point for tourists and other local and regional visitors. The town has already installed Level 2 EV charging stations in its municipal parking garage for visitors. In addition, Holliston is strategically located near the I495 route 126 transportation corridors. Level 2 chargers will offer short-term visitors a slight increase in their electric vehicle range. However, Holliston will require more robust level 3 chargers to meet the in-transit needs of fully electric vehicles.

[22] https://concordma.gov/DocumentCenter/View/36769/Concord-Electric-Vehicle-Charging-Infrastructure-Study-Final?bidId=

Figure 11 indicates that Holliston is near I495 and I90 with high numbers of 100+ mile trips during peak weekend travel hours.

Figure 12: AFC Network Corridors by Volume of Long-Distance Trips



Source: StreetLight Analytics and MassDOT

Figure 11. Network Corridors by Volume of Long-Distance Trips [23]

Community EV Charging Station Planning and Criteria

From a project management and public acceptance perspective, Holliston may want to augment broad, even EV charger distribution with concentrated support for individual neighborhoods and businesses that offer to step forward and accelerate electric vehicle adoption. The goal of this approach would be to accelerate the path to 25% EV market penetration for individual neighborhoods and the associated tipping point of full electric vehicle acceptance.

Financial Assessment

The economics of EV charging remains challenging. The three categories of EV charging stations include Level 1, Level 2, and Level 3. Figures 13 &14 include graphic representation of these three levels of charging and the associated charging range per hour that each charging level offers.

[23] https://www.mass.gov/service-details/deployment-plan-for-massachusetts

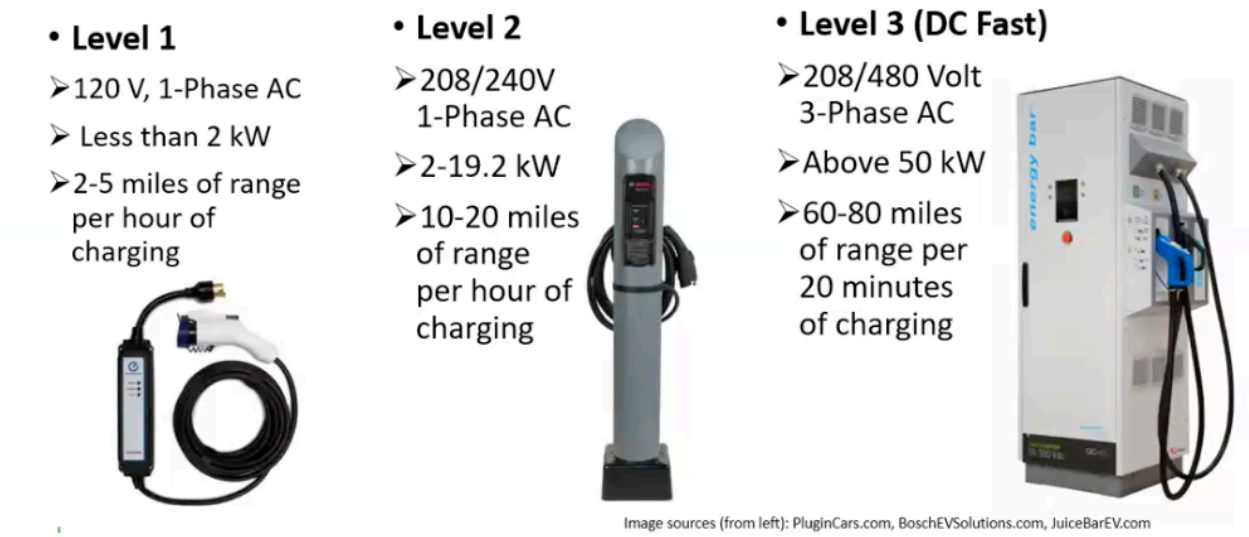


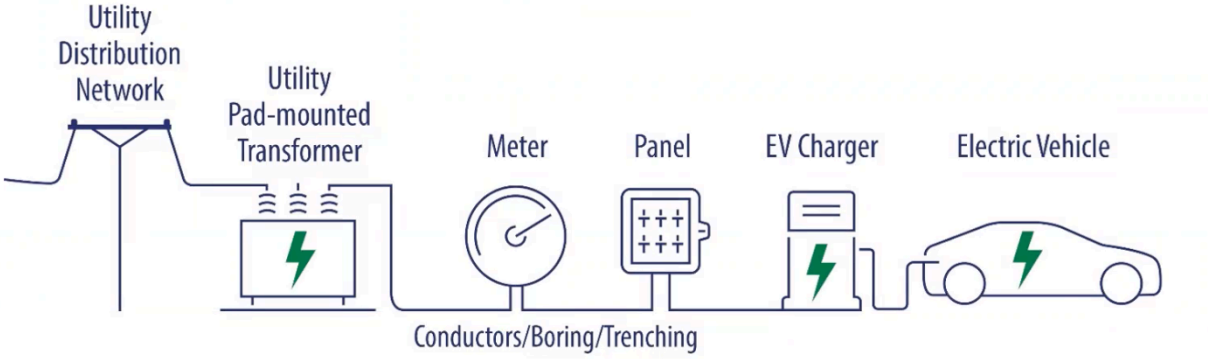
Figure 13. Examples of Level 1,2,3 charging stations

Item	Minimum Cost Estimate (Per EVSE)	Maximum Cost Estimate (Per EVSE)
Level 2	$400 (Residential), $2,500 (Commercial)	$6,500
DCFC (50 kW)	$20,000	$35,800
DCFC (150 kW)	$75,600	$100,000
DCFC (350 kW)	$128,000	$150,000

EVSE = electric vehicle supply equipment

Figure 14. 2020 EV charger cost estimates

In addition to charger procurement costs, EV charger stations have utility-related and vendor installation costs. Figures 15&16 include these cost considerations.



Unit Cost Estimate for a 25 kVA Transformer	Unit Cost Estimate for a 2500 kVA Transformer
$3,853	$164,550
Minimum Cost Estimate for Reconductoring	**Maximum Cost Estimate for Reconductoring**
$260 per foot	$780 per foot

Figure 15. Utility company costs for EV chargers

Installation Costs

Item	Minimum Cost Estimate	Maximum Cost Estimate
Level 2 Charger Installation	$600/EVSE (Residential)	$6,650/EVSE (Commercial)
DCFC Installation	$20,000/EVSE	$94,000/EVSE

Misc. Equipment and Services Costs

Item	Minimum Cost Estimate	Maximum Cost Estimate
Data Contract	$84/year/EVSE	$240/year/EVSE
Network Contract	$200/year/EVSE	$250/year/EVSE
Credit Card Reader	$325/unit	$1,000/unit
Cable Cost	$1,500/unit	$3,500/unit

Figure 16. 2020 EV charger installation and miscellaneous equipment and service cost estimates

The other financial consideration is the cost that EV drivers pay to charge their cars. The Boston Globe recently highlighted cost increases and differences in charging rates for Level 3 chargers in Massachusetts.[24] The authors found wide discrepancies in the rate that EV Charger owners charged customers and the mechanism for charging customers. We assume that charging rates will be an ongoing work in progress but should be something that the town should keep an eye on for potential communications or municipal action.

[24] https://www.boston.com/news/the-boston-globe/2023/03/27/electric-vehicle-charger-pricing/?p1=hp_secondary

Policy Assessment

Massachusetts has three key strategies to expand the number of electric and alternative fuel vehicles in the state that Holliston should be aware of:

1. The Commonwealth's goal is to follow California's lead and require 100% passenger EV's by 2035. ZEV Truck sales begin in 2025.
2. The Commonwealth will reform and expand its electric vehicle incentives.
3. The Commonwealth will implement programs to electrify vehicles for hire and local delivery services.

Simply put, Massachusetts intends to have as many electric vehicles as possible on the road as soon as possible. In addition, Massachusetts has strategies to build electric vehicle charging stations and encourage smart charging.

- The Infrastructure Investment and Jobs Act (IIJA) provides approximately $60 million over five years to Massachusetts to fund fast charging stations along major highway corridors. The IIJA also provides the Commonwealth with competitive grant funding opportunities to support community-based charging locations.
- Massachusetts will encourage private investment through competitive bids for community-based DC current fast charge stations with pilot grants. EEA and DOER will leverage pairing charging stations with solar PV and electrical storage systems.
- EEA and DOER will develop a model building code for municipalities that requires make-ready charging in all new commercial and residential buildings.
- The DPU recently approved[25] $400m for electric utility companies to pay for all or most of the cost to install EV charging stations in public and many private locations.

Holliston should and can anticipate a surge in electric vehicle use soon and should adopt municipal regulations to support this transition. In addition, Holliston should communicate directly with residents in support of the state's efforts to increase electric vehicles. Potential Municipal Action(s) include:

- Assign a task force with representatives from the Planning Department, DPW, Facilities and Sustainability Departments, and Eversource to assess and recommend a municipal-wide EV charging station plan. MAPC may be able to assist as well with its regional EV charger planning tool. The task force will review options to accelerate multifamily, community-based fast charge DC stations, fleet EV stations, and managed home charging stations.
- Solicit private sector bids for community-based DC fast charge stations paired with solar PV and electrical storage systems.
- Adopt MassEEA and MassDOER's model building code that requires make-ready charging in all new and major renovation commercial and residential buildings.

The StanCOG study offers the following additional suggestions:

- Develop supportive parking and zoning bylaws.
- Streamline permitting of EV charging equipment.

[25] https://blog.greenenergyconsumers.org/blog/400-million-for-electric-car-charging-in-massachusetts

Further afield, the UK[26] offers these observations and municipal policy suggestions:

- Local authorities are responsible for overarching planning policies in their areas, including street alternations and parking.
- In Great Britain, they also own lampposts and bollards, which can be adapted to incorporate public charging, as already demonstrated in many areas.
- Many local authorities also own local car parks, which can be adapted to include local charging infrastructure.
- Importantly, local authorities understand the transport needs of their local population, which they should be considering as part of transportation planning.

Sample municipal language is available at:

- Southern Main Council of Governments model municipal bylaws:

  https://www.mainecleancommunities.org/municipal-ev-toolkit

- Cape Cod Commission model municipal bylaws

  https://www.capecodcommission.org/our-work/model-municipal-electric-vehicle-bylaw

Holliston should be aware that EV charging station issues do arise and sometimes require follow up attention. Vandalism is a potential concern, network system failures occur, and multiple charging station ownership can lead to poor EV Charging station interoperability. These issues should resolve themselves over time, but the EV charging station industry is still early in its development.

Creative EV Charging Solutions

While researching information for this report, we identified several promising and creative EV charging solutions. They include telephone pole-mounted EV charging stations, bollard-stye EV charging stations, and vehicle-to-grid EV charging stations.

Pole-mounted EV charging stations

National Grid and Melrose, MA piloted a good example of telephone-pole mounted EV chargers.

[26] https://www.gov.uk/guidance/electric-vehicle-charging-infrastructure-help-for-local-authorities

Figure 17 includes a photograph of one of these EV charging stations.

Figure 17. Melrose pole-mounted EV charger

From a utility company's perspective telephone-pole mounted EV chargers are an obvious choice to bring to municipal EV Charger programs. The equipment is installed close to power lines that it owns and on poles that they either own or share ownership. The equipment is less vulnerable to vandalism but can still be accessed by standard electric distribution system equipment. The installation cost is predictable and repeatable and faulty equipment can be swapped out easily.

From a municipal program perspective, handing over ownership and servicing to a utility company provides an easy solution for communities that are not equipped to handle these services. Communities can also offer these services on municipally owned telephone poles with a third-party provider. Examples of this opportunity include telephone poles located in municipal parking lots or other municipally owned land.

Streetlight and Bollard-style EV charging stations

Municipal streetlights and bollards offer another opportunity for cities to install EV charging stations. In the UK, Siemens Energy has worked closely with an EV Charging company called Ubitricity to install charging stations in municipally owned streetlights and bollards. In this example, Ubitricity installs charging equipment in existing streetlights or bollards. Residents scan a QR code on the pole, connect their own cable provided by Ubitricity to their car and the

pole charger, and then lock their car. Charging stops when the resident unlocks their car. In this model, Municipal electric accounts cover the cost of the EV charging electricity and are reimbursed through Ubitricity's network service.

Figure 18. Ubitricity EV charging station[27]

In another example based in Brooklyn, NY, Itselectric is rolling out bollard-style EV charging stations that offer a similar service to Ubitricity.

[27] https://cleantechnica.com/2020/03/24/siemens-brings-street-light-ev-charging-to-london-neighborhood/

Figure 19. Itselectric charging station[28]

Residents sign up for Itselectric's service, plug their cars into outlets on privately owned bollards using cables provided by Itselectric, and are billed directly by Itselectric. However, in this case, private building owners host a separate electric submeter that Itselectric installs on their electric account. Itselectric reimburses the building owner for the electricity used to charge cars and provides an incentive fee for hosting the system.

Vehicle-to-grid charging stations

Large battery systems and/or large numbers of battery systems in vehicles offer an important opportunity to serve as energy storage resources for buildings in addition to the vehicles. This concept is called vehicle to grid EV charging or "V2G" for short.

Ford offers this technology for its F-150 Lightning pickup truck. Ford has developed a fully integrated V2G system for homeowners who upgrade their electrical service and install Ford's V2G charging system. Using this technology, homeowners can run their homes electrical system for several hours when the power goes out by plugging into their truck.

On a larger scale, school buses offer an excellent opportunity to provide similar V2G services for school districts and municipalities. School buses require very large batteries (100-300kW) and usually operate for short durations at very predictable times of the day and during the year. Holliston can shape how this opportunity is deployed with its school buses under a direct ownership or contracted service model.

[28] https://theevreport.com/brooklyn-based-itselectric-raises-2-2m-to-offer-curbside-ev-charging-for-cities

Figure 20. Durango, Colorado school bus V2G installation [29]

EV Charger Installation Implementation

StanCOG offers eight steps required for municipalities or private entities to install EV charging stations. StanCOG's study provides additional detail and guidance for each of these implementation steps:

1. Site Prioritization: Agree on top priorities for new charging sites.
    - Review high potential sites cross-referenced against available funding programs
    - Check with utilities and charging companies for nearby planned sites
    - Secure agreement from site owner to host charging station
    - Check with site owners and other stakeholders to agree on a set of sites
2. Set budgets
    - Estimate equipment, installation and operational costs
    - Determine additional site needs (e.g., signage, security)
    - Consider including estimate for future needs (e.g., additional chargers, more power)
    - Identify funding sources and apply for funding
    - Determine business model and operational roles (e.g., site owner, government owner, charging company owner)
3. Contract vendors
    - Issue Request For Proposal(s) for site(s)
    - Consider grouping multiple sites for cost advantages
    - Choose vendors for equipment, installation, and (potentially) operation

[29] https://www.durangoherald.com/articles/durangos-electric-school-bus-is-like-a-huge-battery-on-wheels/

4. Obtain permits
    - Obtain appropriate permits (e.g., building, electrical, right of way) as needed
5. Install charging stations
    - Vendors install stations
    - Coordinate with utility for infrastructure upgrades as needed
6. Inform public
    - Publicize availability of new (and existing) charging stations
    - Review Education and Outreach section of this report for guidance
    - Confirm the station is included in the Alternative Fueling Station Locator
7. Monitor utilization
    - Track utilization of sites through network providers
    - Consider adding chargers to stations as station utilization nears 50%
8. Update priorities
    - Periodically coordinate with stakeholders to assess adequacy of public charging, determine needs for additional chargers, and prioritize sites

Appendix G: Electrical Grid Considerations and Resources

Eversource has an electric grid hosting map that are available online[30]. From a planning perspective, Eversource cannot assume that electrical storage or backup generator systems will be available during a peak draw period. Another consideration is that under current regulations, the customer who requests additional electrical service (e.g., for new heating/cooling equipment or EV chargers) that pushes electrical system needs over the limit of the existing electrical system capacity must pay for the full cost of all system upgrades. Many utility regulations are under review with a target completion date of 2025.

Figure 1 is the hosting capacity map zoomed in to Holliston. This map identifies all the electrical distribution lines in Holliston. Pink lines are 1 and 2 phase electric service lines. 1 and 2 phase electricity lines can support small scale solar PV installations that are less than 15 kW. Larger solar PV systems require 3 phase electrical service. Each feeder line is color coded to suggest the potential amount of capacity that is available on each feeder line for new solar PV installations. The colored lines in Holliston suggest limited capacity for solar PV generation connections.

Eversource recommends contacting the company directly before proceeding with any major electrical projects. There is significant engineering analysis and evaluation associated with keeping the lights on and meeting high power quality requirements for all customers. Additional energy analysis and evaluation may be required for future electrical projects.

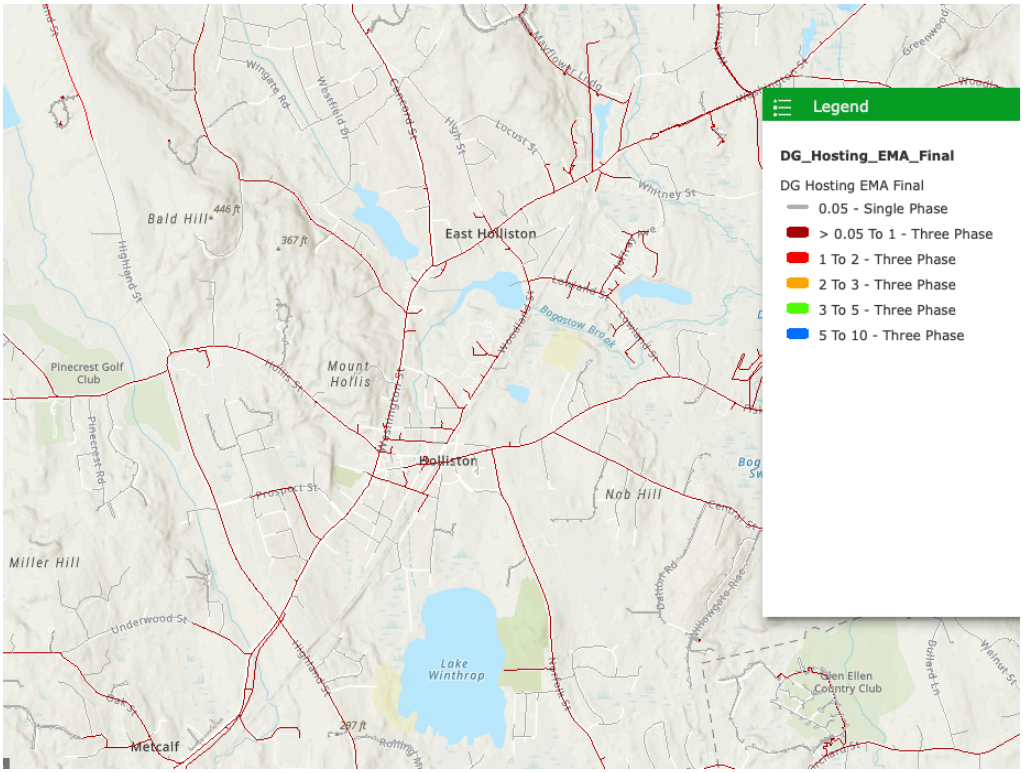


Figure 1. Eversource hosting capacity for solar PV electricity generation

[30] https://eversource.maps.arcgis.com/apps/webappviewer/index.html?id=7b13d31f908243e49406f198b359aa71

Appendix H: Decarbonization Reports

Monitoring decarbonization progress will be an important task for each community. Individual residents and businesses can use tools that are available online to monitor their own decarbonization efforts. The State has developed an online clean energy dashboard to report progress at the state level.

Cities and towns can monitor municipal facility and vehicle information on MA DOER's MassEnergyInsight tool or other online resources. Community-wide monitoring is more challenging. Following are descriptions of decarbonization monitoring resources that are available online and draft community-wide decarbonizations reports that MAPC has prepared for Holliston.

State GHG emissions

MAPC recommends that communities monitor the state's decarbonization progress using MA EEA's GHG emissions dashboard annually.

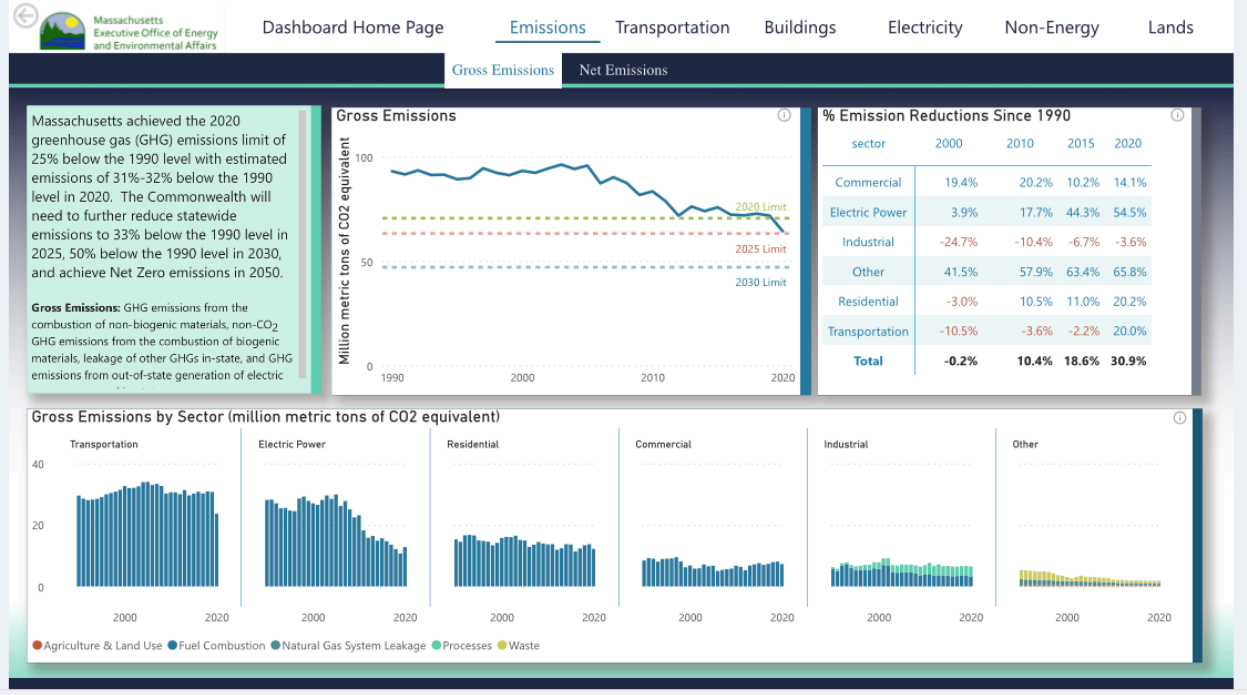


Figure 1. MA EEA's GHG emissions dashboard

https://www.mass.gov/info-details/massachusetts-clean-energy-and-climate-metrics

The Massachusetts MOR-EV program also publishes data on incentives received, by both county and zip code: https://mor-ev.org/program-statistics. Note: this is at best a proxy because not all vehicles qualify and not everybody applies for a rebate. But it's still a helpful point of comparison.

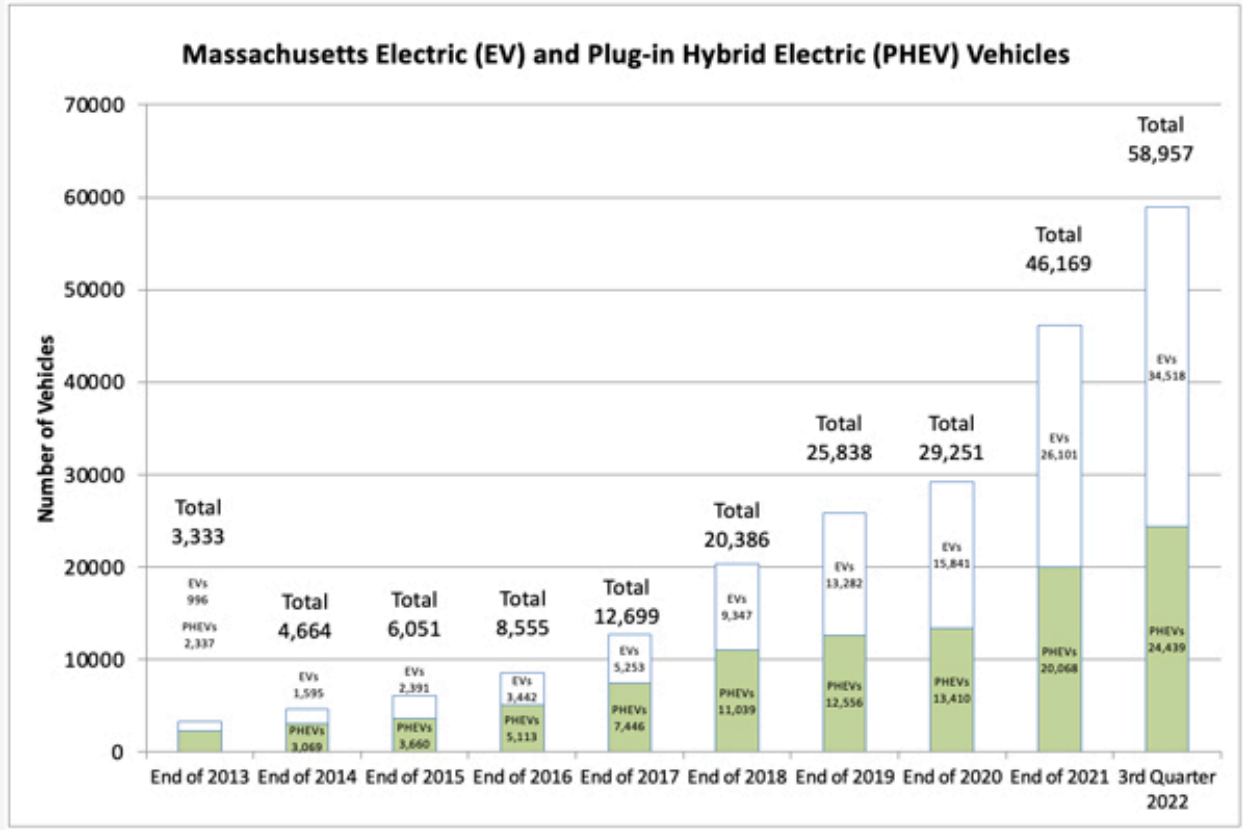


Figure 2. MA MOR-EV rebate requests

https://www.mass.gov/how-to/apply-for-massevip-fleets-incentives#:~:text=MassEVIP%20Fleets%20is%20a%20MassDEP%20rolling%20grant%20program,depend%20on%20vehicle%20type%20and%20means%20of%20acquisition.

Municipal GHG emissions

Figure 4 on the next page is a report from US DOE's MassEnergyInsight tool for Holliston's municipal facility and vehicle carbon GHG emissions reduction from FY2017 to FY2022.

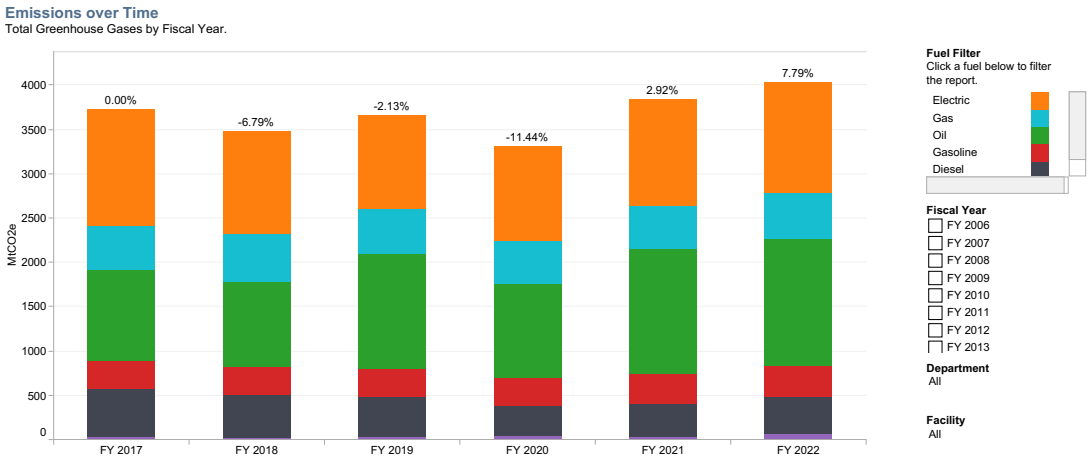


Figure 4. MassEnergyInsight – Holliston's municipal Emissions over Time report

Community GHG emissions

As mentioned earlier, community wide GHG emissions monitoring is more challenging. Following are graphs that MAPC has produced for Holliston that summarize GHG emissions by major category using readily available information. The categories include electricity and natural gas, residential and commercial heat pumps, electric vehicles and EV charging stations, and renewable electricity. The graphs include actual updated information when it was available from Holliston's 2017 base year through 2022 and proposed or potential 2025 and 2030 target levels.

Data Sources

- Electricity and Natural Gas community wide information is available from the Mass Save Data portal.
- The number of residential and commercial heat pump installations should be available through Eversource and Mass Save. This is a work in progress. The other potential source for heat pump installations is the town's assessor department or building inspection. The type of heating system and fuel source is one of the property characteristics recorded as part of a home or commercial property assessment.
- Electric vehicle data is available from MA DOT and will be even more accessible when MA DOT finishes its vehicle census dashboard:

  Liz Williams at MassDOT OTP (liz.williams@state.ma.us) has access to a data dashboard that provides counts of registered vehicles by fuel type at the municipal level. These are only the current active registrations. On 3/3/23, Liz added via email that:

  > "… we are in the final stages of developing the first iteration of the Massachusetts Vehicle Census (MVC) which sounds like it would meet your needs. The MVC will initially release municipal-level data reflecting total counts of registered vehicles as well as opportunities to filter by fuel type, use type, and vehicle type. Odometer readings will be available in the first release, but at this time I am not sure if we will have the heavy vs light duty breakdown or vehicle age in there. In

> the future we hope to really expand the vehicle attributes that we're able to include, and also include lower levels of geography, down to the census block group. The data will be updated at least annually.
>
> This first iteration of the MVC will be released on or around June 30th, barring any issues."

- EV charging station information is available online using MAPC's tool or other similar EV charging station location tools.
- The baseline electric supply generation fuel and renewable energy source data is mandated by state legislation. The required increase in clean and renewable energy is listed in this report. The town can add or estimate additional renewable energy procured through an electricity supply aggregation initiative or by individual customers separately.
- The number of residential and commercial solar PV installations is from a database available online from MassCEC.

Electricity and Gas Use

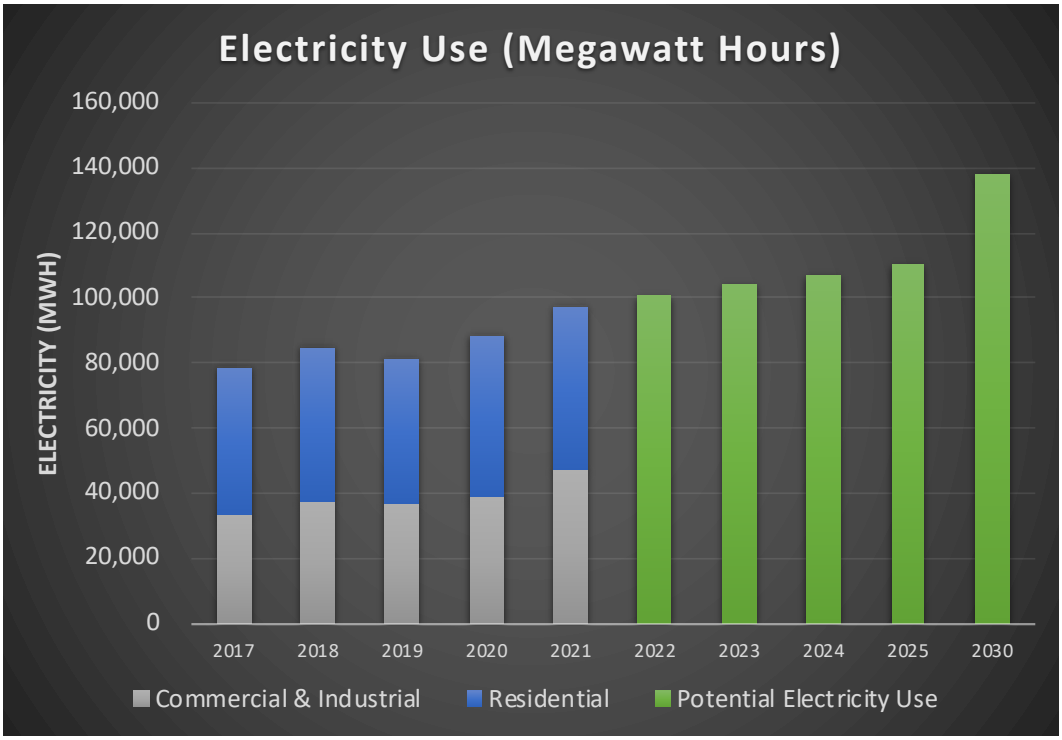


Figure 5. Residential, commercial, and industrial electricity use

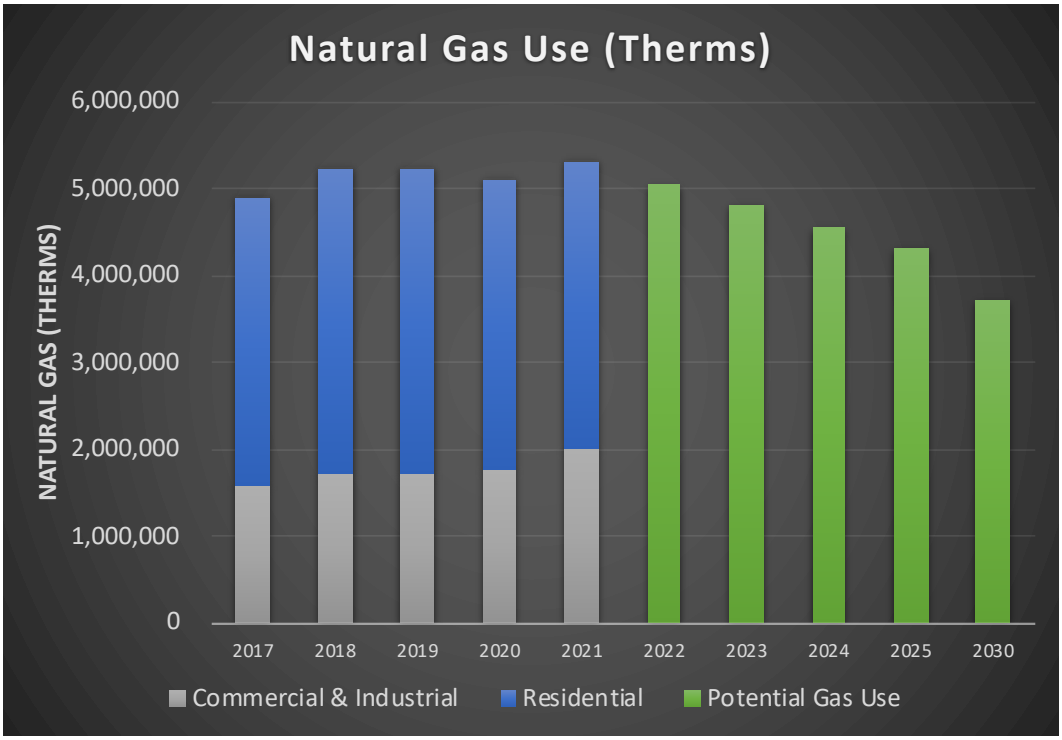


Figure 6. Residential, commercial, and industrial natural gas use

Residential and Commercial Heat Pumps

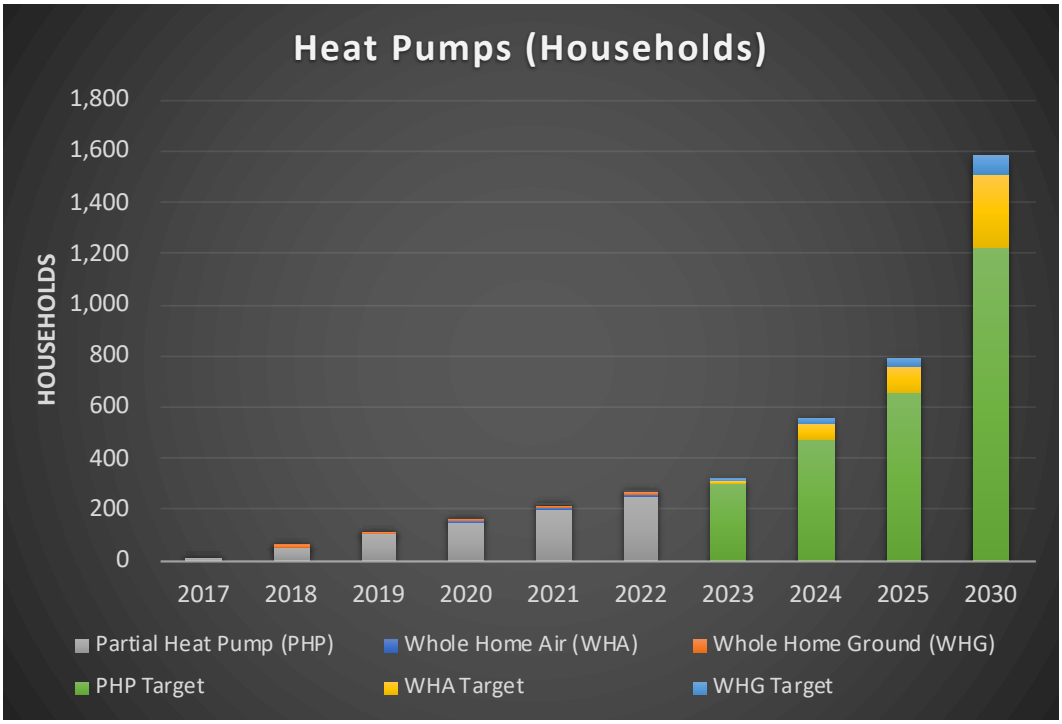


Figure 7. Residential Heat Pumps.

(source data is currently unavailable)

Figure 8. Commercial Heat Pumps.

Electric Vehicles and EV Charging Stations

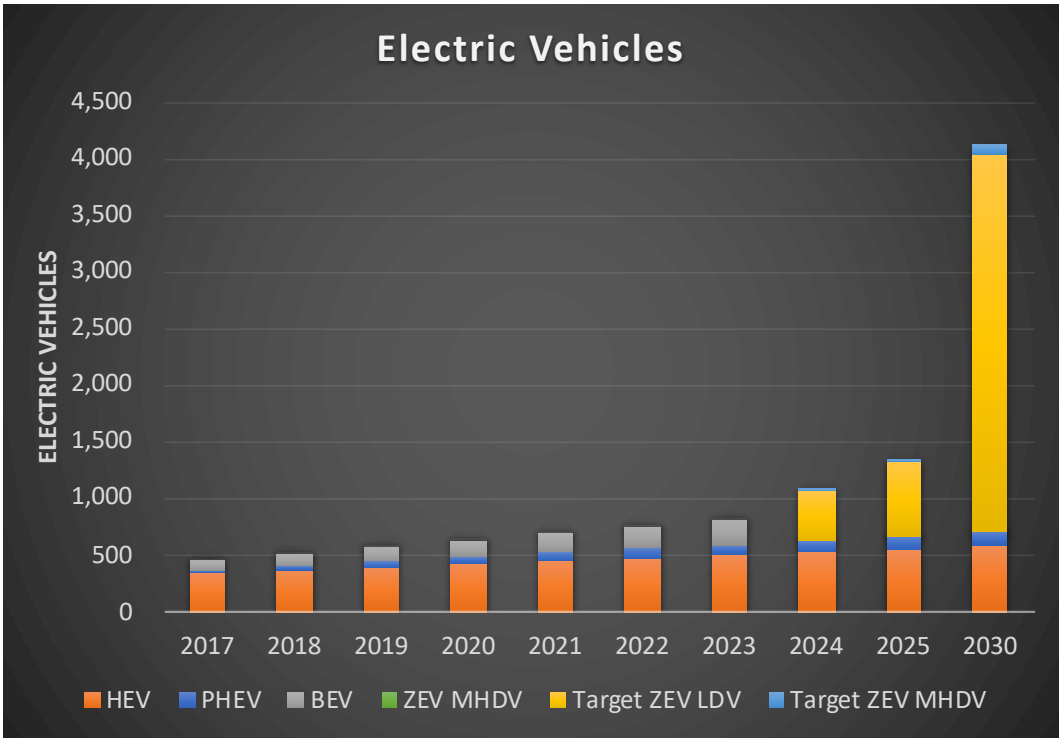


Figure 9. Electric Vehicles

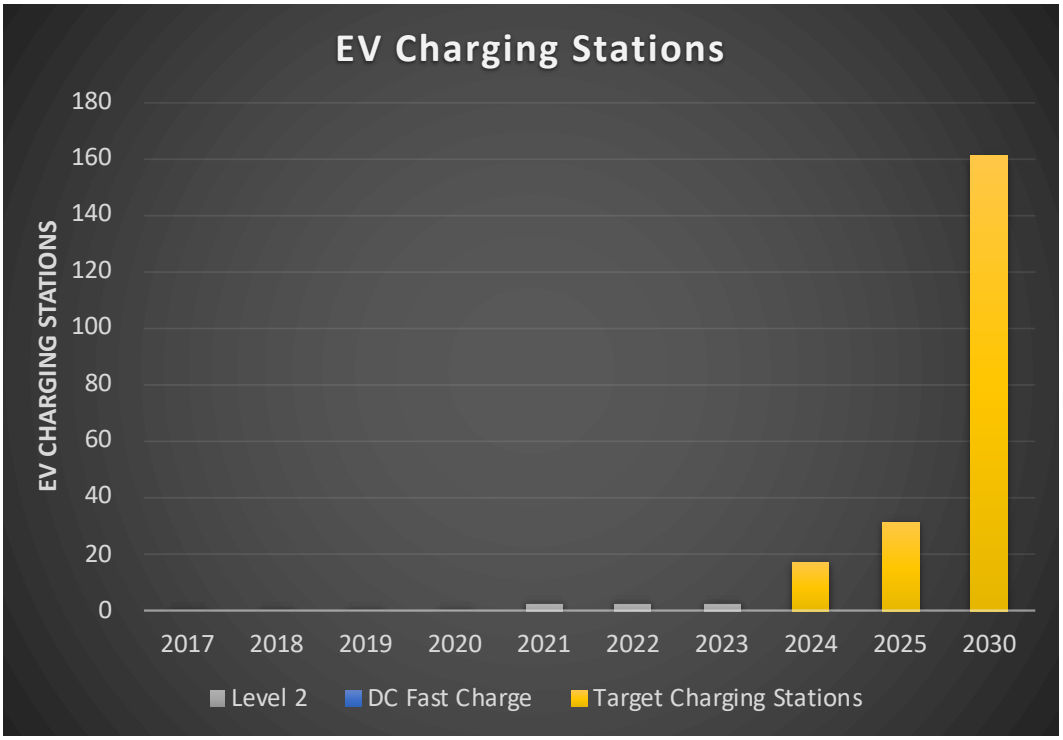


Figure 10. EV charging stations

Renewable Electricity

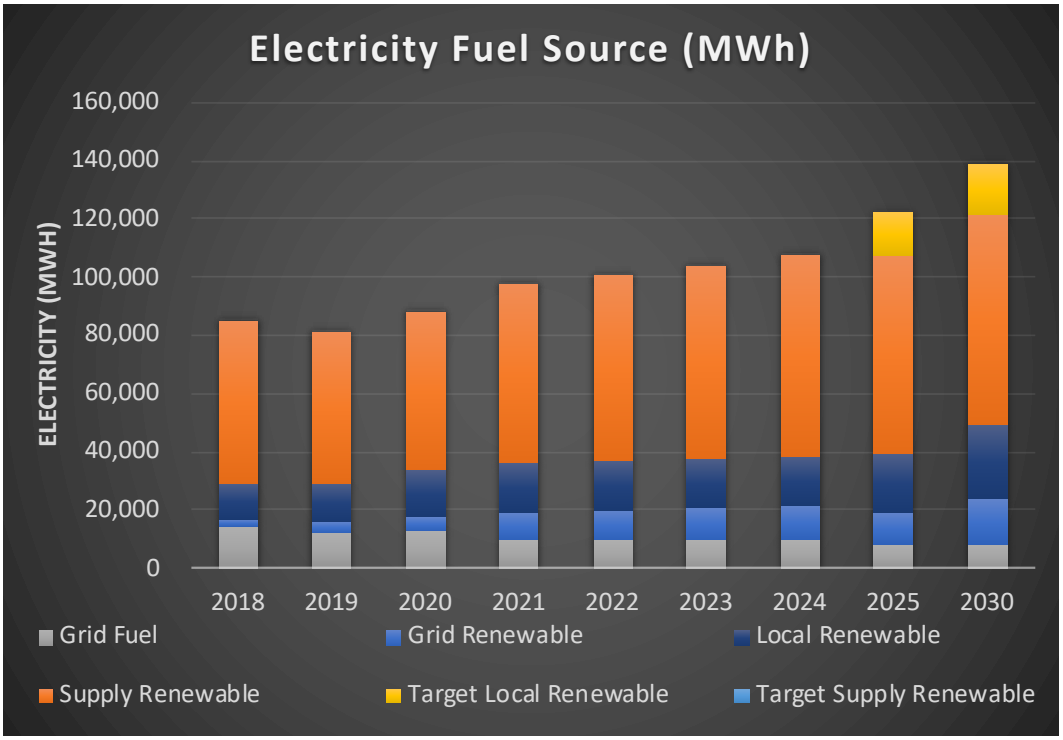


Figure 11. Electricity energy source

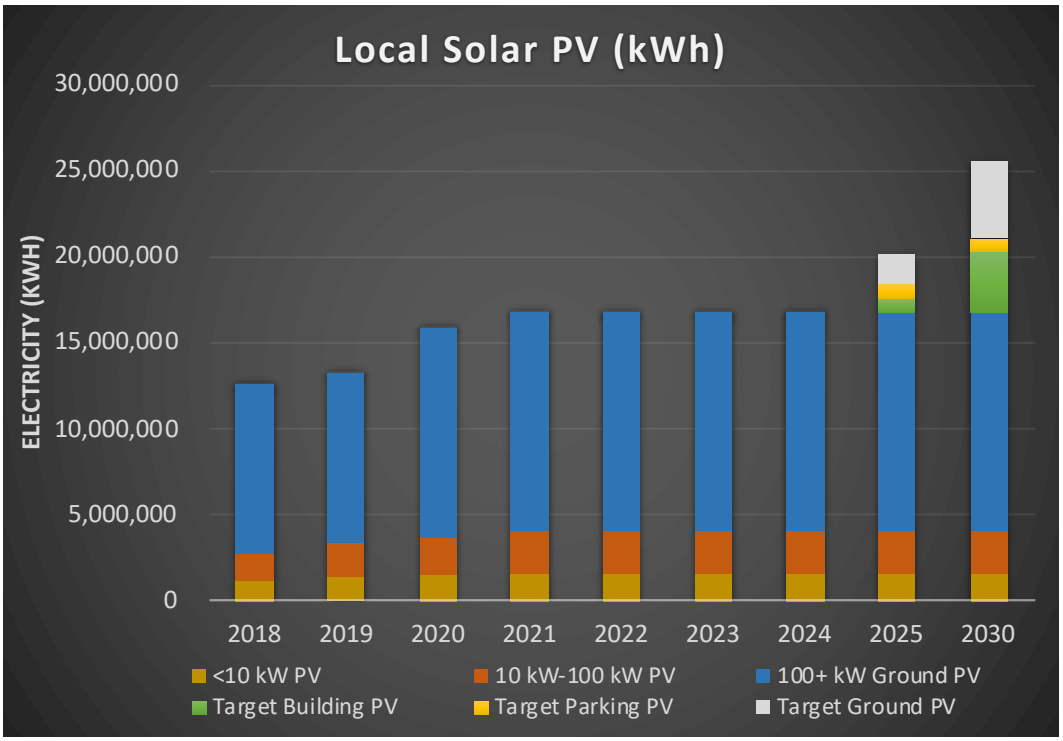


Figure 12. Local solar photovoltaic (PV) annual electricity output

Following is additional information about the solar PV systems that have been installed in Holliston through 2021. Figure 13 includes total and average installation information. Figure 14 includes a breakout of the system sizes that have been installed. The average cost per kWh ($/kWh) in figure 13 assumes 20 years of electricity production.

Holliston

Year	Count	kW DC	kWh/Year	Cost ($)	Average kW DC	Average kWh/Year	Average Cost ($)	Average ($/kWh)
2021	34	798	875,363	1,900,157	23.5	25,746	55,887	0.11
2020	40	2,576	2,594,034	5,001,608	64.4	64,851	125,040	0.10
2019	56	612	649,338	1,996,198	10.9	11,595	35,646	0.15
2018	35	323	353,413	1,183,742	9.2	10,098	33,821	0.17
2017	39	1,941	2,372,285	4,534,473	49.8	60,828	116,269	0.10
2016	58	558	598,247	2,405,179	9.6	10,315	41,469	0.20
2015	61	2,903	3,507,035	8,388,041	47.6	57,492	137,509	0.12
2014	20	4,247	5,467,875	6,219,224	212.4	273,394	310,961	0.06
2013	8	64	71,101	280,367	8.0	8,888	35,046	0.20
2012	14	120	134,010	576,661	8.6	9,572	41,190	0.22
2011	4	28	31,573	157,290	6.9	7,893	39,323	0.25
2010	2	58	64,739	277,984	28.8	32,370	138,992	0.21
2009	2	9	10,099	74,236	4.6	5,050	37,118	0.37
2008	0	0	0	0				
Total	373	14,238	16,729,112	$32,995,159				

Figure 13. Total and average information for solar PV systems installed in Holliston

Holliston

Year	kW <= 10 Count	kW 10-100 Count	kW > 100 Count	kW <= 10 kWh/Year	kW 10-100 kWh/Year	kW > 100 kWh/Year
2021	12	20	2	85,958	245,706	543,699
2020	20	17	3	152,129	210,688	2,231,217
2019	26	30	0	205,087	444,251	0
2018	21	14	0	155,197	198,217	0
2017	21	17	1	160,913	517,372	1,694,000
2016	37	21	0	288,352	309,895	0
2015	41	17	3	305,851	315,671	2,885,513
2014	13	4	3	86,316	48,470	5,333,089
2013	7	1	0	51,439	19,662	0
2012	11	3	0	58,761	75,249	0
2011	4	0	0	31,573	0	0
2010	1	1	0	7,164	57,575	0
2009	2	0	0	10,099	0	0
2008	0	0	0	0	0	0
Total	216	145	12	1,598,838	2,442,756	12,687,518
Percent	58%	39%	3%	10%	15%	76%
Total	373			16,729,112		

Figure 14. Number and size ranges of solar PV systems installed in Holliston

Appendix I: Carbon Emission Costs and Investment Approaches

Carbon Emissions

As authors Kenneth Gillingham and James H. Stock note in their Journal of Economic Perspectives article *The Cost of Reducing Greenhouse Gas Emissions*[31]:

> "Climate change is a long-term problem, and the focus of policy must be on long-term solutions. To make major progress on climate goals, like 80 percent decarbonization by 2050 in the United States, will require new technology deployed on a vast scale. Even if each technological step is evolutionary—cheaper electric vehicle batteries, connecting the grid to harness the wind potential in the Midwest, reducing the cost of offshore wind, developing and commercializing low-carbon fuels for air transport—the overall change will be revolutionary. If a price on carbon is not politically feasible—and arguably even if it is—these long-term considerations need to be incorporated into our short-term policy tradeoffs. From the perspective of the cost calculations in this paper, one clear implication is that choosing low-cost interventions without a future, including ones that lock in fossil fuel infrastructure, can result in too much emphasis being placed on what is cheapest to do today."

The authors noted that the Obama administration set the societal cost of carbon reduction at $46/mTonCO2e (in 2017). More recently, Massachusetts set the social cost of carbon at $393 per ton.[32] The societal cost of carbon will continue to be debated. In the meantime, we can use the concept of cost per ton of carbon to help prioritize the most cost-effective new technologies "that need to be deployed on a vast scale."

Figure 1 represents Holliston's total building, vehicle, and electricity GHG emissions.

Total Carbon Emissions

Year (Fiscal)	Buildings Carbon Emissions (mTonsCO2)	Vehicles Carbon Emissions (mTonsCO2)	Electricity Carbon Emissions (mTonsCO2)
2017	15,776	57,915	19,339
2025	13,898	55,456	2,475
2030	**11,998**	**44,773**	**2,400**
2035	9,632	36,061	1,901
2040	6,477	24,492	1,266
2045	3,321	12,922	2,830
2050	**955**	**4,209**	**3,094**
Emission reduction	14,821	53,707	16,246
Estimated years	15	15	20
Lifetime emissions reduction	222,311	805,601	324,910

Figure 1. Holliston community building, vehicle, and electricity carbon emissions

[31] https://pubs.aeaweb.org/doi/pdf/10.1257/jep.32.4.53

[32] https://acadiacenter.org/massachusetts-proposed-three-year-energy-efficiency-plan-would-deliver-record-setting-benefits-for-a-modern-energy-economy/

The cost to replace existing equipment solely to reduce GHG emissions is very high. MAPC recommends that communities focus on installing high efficiency electric equipment when a "trigger event" occurs such as needing to replace a heating or cooling system or a new vehicle.

Figure 2 takes the GHG emissions listed in table 1 and divides them by potential incremental cost (any additional cost to install high efficiency electric equipment instead of one-for-one replacement of existing equipment) to install heat pumps, buy electric vehicles, and procure renewable electricity. The net result is a range of potential investment decisions that the Town of Holliston and its residents can take to reduce the town's GHG emissions.

Heat Pumps (tons)		34,258
Lifetime GHG emissions/ton		6
	Incremental Cost	15 year Cost/mTonCO2e
If incremental cost/ton is:	$1,000	$154
	$5,000	$770
	$10,000	$1,541

Vehicles (#)		11,286
Lifetime GHG emissions/vehicle		71
	Incremental Cost	15 year Cost/mTonCO2e
If incremental cost is:	$10,000	$140
	$20,000	$280
	$30,000	$420

Electricity (2017 kWh)		97,267,000
Lifetime GHG emissions/kWh		0.0033
	1 year Cost/kWh	20 year Cost/mTonCO2e
If incremental cost/ kWh is:	$0.00	$0.00
	$0.02	$120
	$0.04	$239

Figure 2. Cost per metric ton of CO2 equivalent to install heat pumps, buy electric vehicles, or buy or install renewable electricity

The most cost-effective measure that Holliston can take based on these calculations is to procure 100% renewable electricity if it is the same price as the current supply electricity price. Even at an additional cost of $.02/kWh, procuring renewable energy is a cost-effective carbon reduction investment. At this moment, procuring renewable electricity should be Holliston's top carbon emissions reduction priority.

The average incremental cost for an electric vehicle in 2023 is about $16,000. According to findmyelectric.com[33]:

> "Currently, most estimates put the average price of a new EV somewhere around $64,000, which is slightly lower than the average price in the spring and summer of last year (2022). For comparison, the average price in 2023 of a new car of any kind in the US is around $48,000."

The additional $16,000 cost for an EV is equal to just under $200 per mTonCO2e.

From a societal perspective (in Massachusetts), any high efficiency electric equipment or vehicle investment that is less than $393 per ton is cost effective. As figure 2 suggests, the incremental cost to install high efficiency low/no carbon emission equipment over new fossil fuel driven equipment is often below $393 per ton. Holliston can use the charts in Figure 2 to estimate the cost/mTonCO2e benefit from any potential heat pump, vehicle, or renewable energy investment. These calculations do not consider other potential benefits such as lower maintenance costs or other high-performance benefits.

Investment Approaches

Major building and vehicle investments often occur with short notice. In anticipation of potential trigger events, residential, commercial, industrial, and municipal community members can anticipate and plan ahead for future carbon reduction investments. The more planning that can be done in advance, the more likely it will be that high efficiency electric equipment will be installed or electric vehicles purchased.

Immediate actions to take include procuring renewable electricity and requesting a quote to install building efficiency measures. Buying renewable electricity will provide an instant carbon reduction benefit. Requesting a quote to install building efficiency measures will give you an idea how much this will cost. In addition, it will potentially lower the building's energy use if the measures are installed and potentially reduce the size of the new high efficiency heat pump system that will get installed.

Immediate actions for everyone include:

1. **Organize and review one year of utility bills**
2. **Procure renewable electricity**
3. **Review electric vehicle replacement options and costs**
4. **Review high efficiency electric heat pump heating/cooling/domestic hot water options**
5. **Request a Mass Save (or other) energy audit and a quote to install building efficiency measures**

The second step is to review the timing and financial details behind these potential investments. Timing variables include the building and equipment condition and age, potential renovations scheduled, backup power and related climate resiliency considerations, and vehicle age. Financial variables include potential State and Federal economic incentives, current cashflow considerations, and potential low interest loans or property-based financing opportunities to help defray the potential higher upfront cost of new high efficiency equipment and vehicles.

[33] https://www.findmyelectric.com/blog/electric-car-prices/

Step two for homeowners includes:

1. **Review Mass Save building efficiency and high efficiency equipment incentives, related electric vehicle incentives, and off-road landscaping equipment and vehicle incentives.**
2. **Review options for a low-interest energy loan through lenders identified by Mass Save.** If your site is suitable, consider including renewable energy, battery storage, and EV charging measures in the loan package. This has been a one time only program. If this is still true, it's worth installing as many measures as possible in the loan package.

Step two for municipal facility and vehicle managers includes:

1. **Develop a municipal facility renewable energy procurement plan**

   Procuring 100% renewable energy for the town's municipal facilities is the single fastest and easiest step that Holliston can take to reduce its carbon footprint. Options include, but are not limited to, procuring 100% renewable electricity directly from a solar PV developer, joining a 100% renewable electricity procurement offered by Power Options, or including the Municipal accounts with a town-wide 100% renewable electricity procurement.

2. **Develop a municipal facility and municipally owned land solar PV development plan for Select Board and Town approval**

   As part of the Inflation Reduction Act (IRA) passed earlier this year, municipalities may be able to receive direct incentives for solar PV installations. The details for this piece of the IRA legislation are still being developed. Regardless of the financial details, the Select Board should initiate a more detailed assessment of the town's facility, parking lot, and ground-mount solar PV installation options.

3. **Develop a municipal electric vehicle (EV) procurement plan for Select Board and Town approval**

   Eversource is providing technical assistance for towns to develop detailed electric vehicle procurement plans. The Town should request this assistance from Eversource and work closely with Eversource's vendor to prepare an EV procurement plan for the town.

4. **Develop a municipal facility efficiency and high efficiency electric conversion procurement plan for Select Board and Town approval**

   Developing a municipal facility efficiency and high efficiency electric conversion procurement plan requires the most steps to complete. The steps include:

   a. Review and confirm the town's facility and technology preferences
   b. Select the first facility(s) and vehicles to upgrade
   c. Request META grant support for a facility assessment
   d. Present and submit the facility's decarbonization budget proposal to Select Board and Town for approval
   e. Submit grant assistance and related financial support requests proposed to the Town
   f. Prepare and advertise specification and construction management RFQ
   g. Review and approve construction specifications
   h. Advertise construction RFP and award contract

i. Complete construction and hand off to town staff
j. Select the next facility and repeat the process following the Town's proposed decarbonization timeline.

Municipal facility energy assessments

Facility assessments will play a key role in the transition from business as usual to lower GHG emissions in municipal facilities. MA DOER offers assistance with facility energy assessments under its META grant program. Following are MAPC's recommendations for questions that should be included and addressed as part of a comprehensive facility decarbonization assessment.

1. Which facility renovation path does the town plan to follow?
    a. New construction
    b. Major rehab, or
    c. Ongoing maintenance
2. What renewable energy sources are available for the facility?
    a. Onsite or local generation
    b. Before or after the meter
    c. Own, lease-to-own, or host and purchase
    d. State, regional, or national procurement
3. Potential sources of energy use increases?
    a. Short-and long-term climate change impacts
    b. Additional air conditioning
    c. Additional mechanical ventilation, filtration, or other air quality management
    d. Potential indoor temperature changes
    e. Potential facility use and schedule changes
    f. Future equipment (landscaping and other) charging
    g. Future light-duty vehicle charging
    h. Future heavy-duty vehicle charging or fueling
4. Utility rate analysis
    a. Potential energy use increases or decreases
    b. Potential energy demand changes
    c. Potential utility rate category changes
5. Electrical system review
    a. Backup power and electrical load management requirements
    b. High efficiency electric equipment requirements
    c. EV charging equipment requirements
    d. Utility side of meter electrical distribution system upgrade requirements
    e. Energy monitoring

6. High efficiency heating
    a. Reuse or replace the existing distribution system
    b. High temperature or low temperature system required
    c. Centralized or decentralize
    d. Air source, ground source, or VRF heat pump?
    e. Other renewable heat source?
    f. Partial or whole facility replacement
    g. Service/maintenance provider availability
    h. Major component replacement timing and costs
    i. Projected annual service costs
7. High efficiency domestic hot water
    a. How much is needed?
    b. What temperatures are needed?
    c. Where is the hot water needed and when?
    d. Heat pump or solar?
    e. Instantaneous or storage?
    f. Central or distributed?
8. Load reduction opportunities
    a. Generator
    b. Battery
    c. Thermal
    d. Equipment shutdown
9. Control system
    a. Open or proprietary system
    b. Control and equipment hardware upgrades
    c. Software upgrades
    d. Integration with individual equipment control
    e. Service provider availability and contract specifications
10. EV charging impacts
    a. Level 1 charging
    b. Level 2 charging
    c. DC Fast charge
    d. Networked?
    e. Bidirectional?
    f. EV charger rollout schedule

Municipal Financial Resources

To date, municipalities participating in MA DOER's Green Communities program have leaned on project expediters to identify, write grant applications for, and install energy efficiency measures. Expediters have walked through facilities to identify measures for potential grant funding as a cost of doing business. This process has served cities and towns well to install measures to meet the State's 20% energy use reduction targets.

However, the scale of investment needed to decarbonize municipal facilities and vehicles is much greater than multiyear energy efficiency investments. Municipalities will need to expand the scope of potential grant applications and financial tools to pay for critical decarbonization investments. Municipalities will need to strike a balance between planned project investments and opportunistic investments driven by grant funding availability.

As the carbon cost analysis above indicates, the most cost-effective time to invest in decarbonization measures is during "trigger events," times when related events are already planned like equipment or vehicle replacement. In all cases, it will be critical to have a strategic analysis of potential decarbonization investments in hand to either support a targeted funding opportunity or inform planned equipment or vehicle replacement.

The primary funding sources for municipal decarbonization investments will be State-initiated programs that align with the state's legislated 2030 and 2050 carbon reduction goals. These will be in the form of standard incentives and rebates and discreet grant funding opportunities. MA DOER's regional managers and Green Community newsletters will be the best resources for updated grant opportunities.

Additional funding will be available from the Federal Bipartisan Infrastructure Law (BIL). Funding from this federal bill has already started to flow directly to states and is beginning to flow to individual projects through competitive funding opportunity announcements. A summary of all the BIL programs that Congress approved is available at:

https://www.whitehouse.gov/cleanenergy/inflation-reduction-act-guidebook/

Common requirements across all funding for BIL includes a cost share, environmental justice considerations, community benefit plans, and made in America criteria. Federal BIL funding will continue for about 5 years.

Applying for larger-scale State and Federal funding will require additional support to develop cost estimates, write grant concept papers and full grant applications, manage project reporting, and manage construction bids, construction, and close out.