

A 2022 Greenhouse Gas Inventory Report for the Town of Harvard



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Completed in partial fulfillment of the requirements of NAS344

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Executive Summary

Harvard is a small town of 6,800 people¹ living in about 2,000 households in Worcester County. The town hosts around 180 businesses employing an average of 2,300 workers². To complete this inventory, we utilized the Metropolitan Area Planning Council's (MAPC's) Community Greenhouse Gas Inventory Tool Version 6.0³. In 2022, activity within Harvard resulted in 43,499 metric tons of carbon dioxide equivalent (MTCO₂e), or about 6.3 MT CO₂e per person. Approximately half of all greenhouse gas (GHG) emissions come from transportation, making it the biggest source of emissions. In this category, passenger cars account for more than 92% of transportation-related emissions. Buildings (aka stationary energy) make up about 47% of emissions in Harvard with residential buildings making up the largest source (59%). Emissions from solid waste and wastewater make up the remainder. Figure 1 shows the breakdown of emissions by sector.

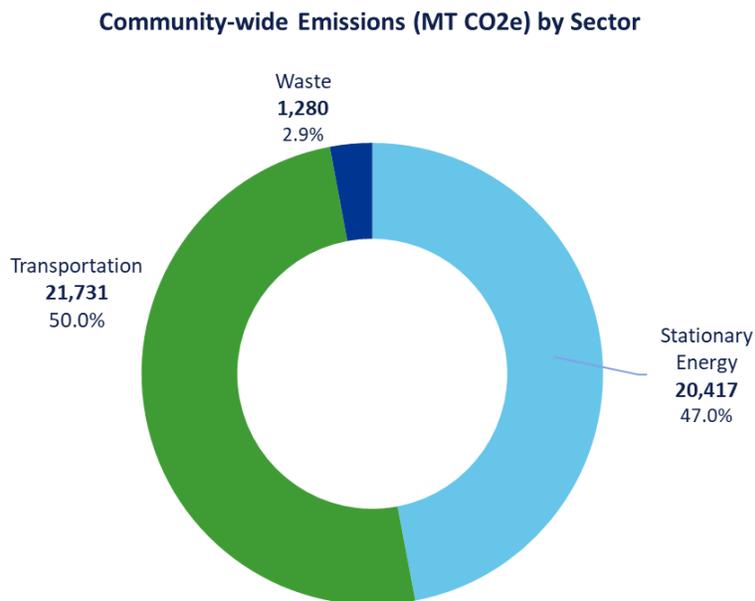


Figure 1: Breakdown of emissions for 2022 for the Town of Harvard.

Compared to the 2018 inventory, emissions in this 2022 estimate are lower though the methods between the two estimates differ. Two key differences lead to reduced emissions in the 2022 estimate. First, emissions from electricity have declined over time, reducing emissions from buildings. Second, the 2022 estimate of vehicle miles traveled is 15% lower

¹ Demographic data collected from the U.S. Census Bureau's American Community Survey's 5 year dataset, data.census.gov.

² Department of Economic Research, Executive Office of Labor and Workforce Development, <https://lmi.dua.eol.mass.gov/lmi/EmploymentAndWages>.

³ MAPC Community GHG Inventories, <https://www.mapc.org/resource-library/community-ghg-inventory-resources/>.

than the estimate used in the 2018 inventory. Additional differences in assumptions may contribute to the significant decline in transportation emissions. Many other categories analyzed in both inventories suggest small declines.

Residential participation in Harvard's Community Choice Power Supply Program is high at about 78% of all electricity purchases and most participants are enrolled in the 100% renewable electricity option⁴. About 25% of commercial electricity used in Harvard is also purchased through the program. This significantly reduces the emissions from electricity in Harvard. According to data from the Mass Save program, there are 330 accounts as of the end of 2024 with heat pumps, equivalent to about 15% of housing units. As of the end of 2023, Harvard had 3.1 MW of solar installed. There was a total of 238 residential solar, roughly equivalent to 11% of households. A total of 250 vehicles or 4.3% of all registered vehicles are battery electric or plug-in hybrid vehicles.

The town's net GHG emissions are negative if you factor in the carbon removals and storage from the trees, which annually remove about 48 kilotons of CO₂e, more than the GHG emissions of all other activity in the town.

Background

Harvard is a town in central Massachusetts with a population of 6,835 living in about 1,965 households as of 2022. Data from the Census Bureau's American Communities Survey (ACS)⁵ show the median household income in Harvard is roughly \$190,000 with 46% of households earning over \$200,000 per year and a poverty rate of 4.3%. Nearly 65% of residents have a bachelor's degree or higher. Over 90% of households own their home and about 85% of homes are single family homes. Residents' median age is 42.4 years. About 78% of the population identifies as White, 10% as Hispanic or Latinx, 6% as Black or African American, and 5% as Asian. Census data for Harvard may include part of Devens as well. The boundaries for Harvard used by Census are pictured in Figure 2.

Harvard joined the state's Green Communities program in 2010 and has received a total of \$910,924 in funding for municipal energy efficiency. Harvard has a community electricity aggregation program, Harvard Community Choice Power Supply Program⁶, which offers residents and businesses in town with the option to purchase 100% renewable electricity. Harvard also ran a HeatSmart program⁷, which encourages residents to transition away from fossil-fuel heating systems and adopt more energy-efficient, low-carbon technologies

⁴ MA Department of Public Utilities File Room, <https://www.mass.gov/dpu-file-room-administrative-services>.

⁵ U.S. Census Bureau, <https://data.census.gov/>.

⁶ Harvard Community Choice Power Supply Program, <https://colonialpowergroup.com/harvard/>.

⁷ HeatSmart Mass, <https://www.masscec.com/program/heat-smart-mass>.

such as heat pumps. The town also participated in a Solarize campaign in 2011⁸, supporting solar adoption.

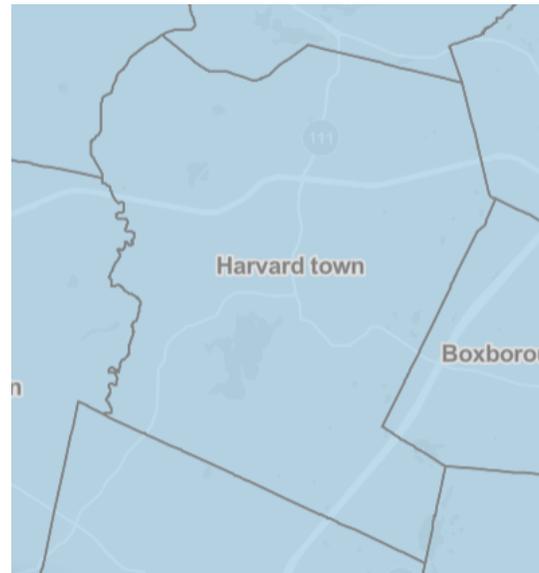


Figure 2: Census Bureau boundaries for the Town of Harvard.

Buildings

Total building-related GHG emissions in Harvard amount to 20,417 MT CO₂e. Within this total, the residential sector contributes about 12,000 MT CO₂e or 59% of building emissions. Commercial and industrial buildings contribute 7,200 MT CO₂e, and the municipal sector contributes about 1,100 MT CO₂e. Most of the emissions from the commercial and industrial sector (5,700 MTCO₂e) are from off-road emissions from equipment including lawn and garden equipment and light commercial and industrial equipment that remains on site.

Fuel oil makes up the largest share of building emissions (excluding off-road emissions) as shown in Figure 3. Based on the Census Bureau's ACS, 53% of homes use fuel oil as their primary heating fuel. Fuel oil and propane consumption in residential buildings is estimated based on the share of households using fuel oil or propane as their primary heating fuel and state average use statistics from the Energy Information Administration's (EIA's) Residential Energy Consumption Survey (RECS)⁹. Similarly, fuel oil use for commercial buildings is based on regional data by activity type and prevalence of using

⁸ Solarize Mass, <https://www.masscec.com/program/solarize-mass>.

⁹ U.S. EIA 2020 RECS, <https://www.eia.gov/consumption/residential/>.

fuel oil as an energy source from EIA's Commercial Building Energy Consumption Survey (CBECS)¹⁰.

Percentage of Building Energy Emissions by Source Energy

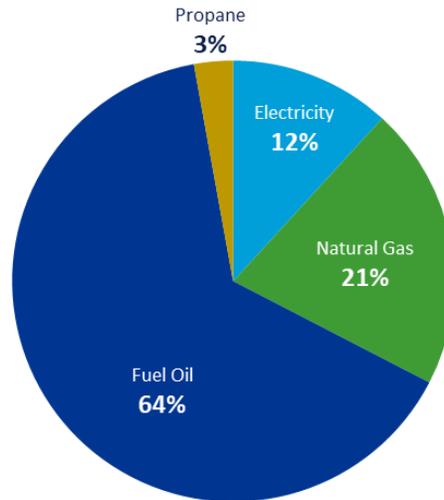


Figure 3: Share of building emissions by fuel, excluding off-road emissions.

Fuel oil is the most emissions intensive heating fuel per unit of energy while electricity has a significantly lower emissions due to high shares of electricity coming from renewable sources. About 78% of residential electricity and 25% of commercial electricity is purchased through the Harvard Community Choice Power Supply Program¹¹. Between 15 and 20% of households have participated in the Mass Save program each year between 2018 and 2023 and a high share of those households have participated previously. From 2013-2023, about 81% of locations in town participated in the program at least once.

Of Harvard's 2,110 housing units in 2023, 262 (12.4%) had installed heat pumps based on data from the Mass Save program¹². Of those, 240 installations are for HVAC and 108 of HVAC systems are partial displacement systems where some other fuel may be used at times. Of the 262, 256 of the systems in Harvard are air source heat pumps (ASHP) meaning that only 6 systems include ground source heat pumps (GSHP).

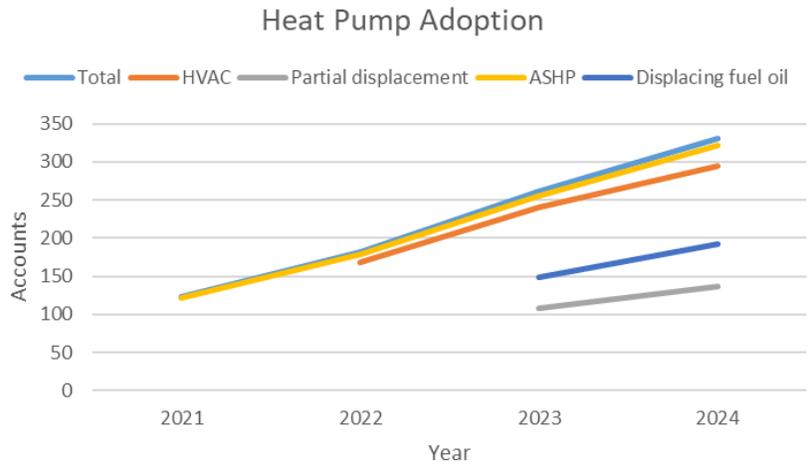
2024 data indicate 330 accounts with heat pumps, meaning an additional 68 new installations that year. Assuming that each household has their own utility account, then about 15% of housing units have at least one heat pump installed. Most of the systems,

¹⁰ U.S. EIA 2018 CBECS, <https://www.eia.gov/consumption/commercial/>.

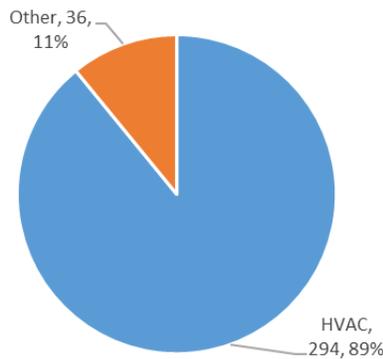
¹¹ MA Department of Public Utilities File Room, <https://www.mass.gov/dpu-file-room-administrative-services>.

¹² Mass Save Data, <https://masssavedata.com/Public/Home>.

97.5%, have ASHPs and 89% are used for HVAC (as opposed to hot water heating or other end uses). Nearly half, 46%, of the HVAC systems are partial displacement and may be used in combination with other heating fuels. More than half of the total number of systems, about 58%, are at least partially replacing fuel oil use.



Heat Pumps by End Use, 2024



Heat Pumps by Type, 2024

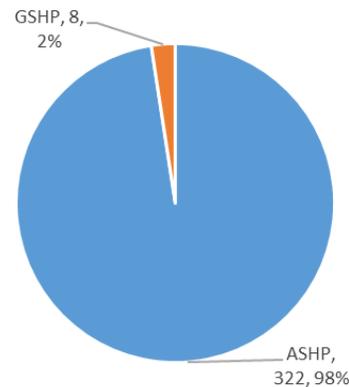


Figure 4: Heat pump adoption in Harvard with subcategories where data is available. Partial displacement data is only for HVAC systems.

Annual utility energy purchases have remained relatively stable over the last six years for which data are available¹³, see Figure 5. Residential buildings use more than twice as much electricity as natural gas. Commercial use makes up a relatively small share of town-wide utility energy purchases and roughly equal amounts of electricity and natural gas are used in this sector. In the monthly data, we see that residential use is highest in winter and summer for heating and air conditioning, respectively (see Figure 6). In the last three years for which we have data, electricity use was greatest in the winter months, suggesting the

¹³ Mass Save Data, <https://masssavedata.com/Public/GeographicSavings?view=C>.

use of electricity for heating. Commercial electricity use is more stable throughout the year with little seasonality as seen in Figure 7. Natural gas consumption for both residential and commercial buildings is greatest in the winter months (Figures 8 & 9).

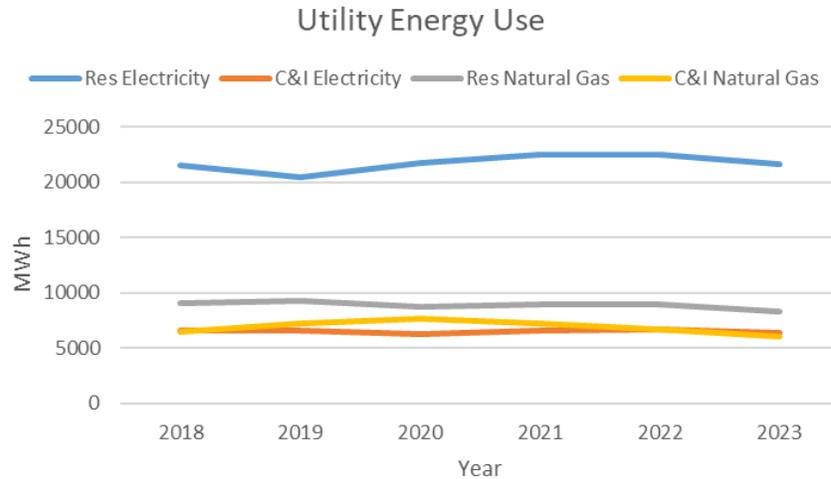


Figure 5: Utility electricity and natural gas use in the Town of Harvard.

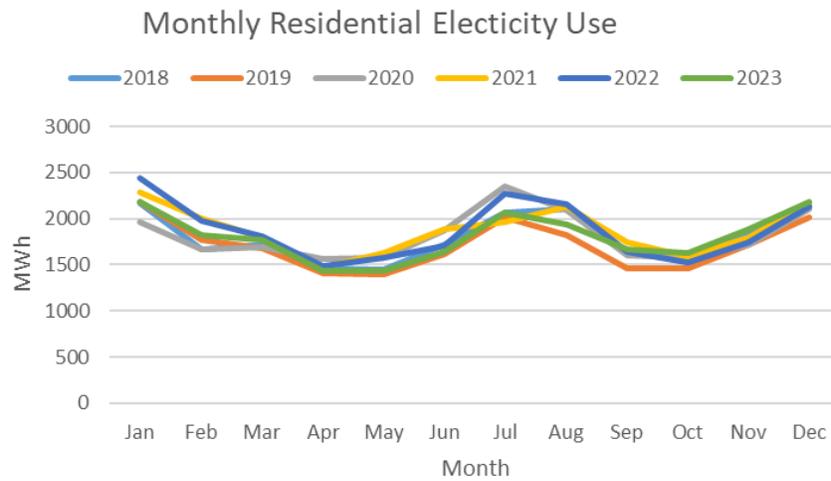


Figure 6: Monthly residential electricity consumption in the Town of Harvard.

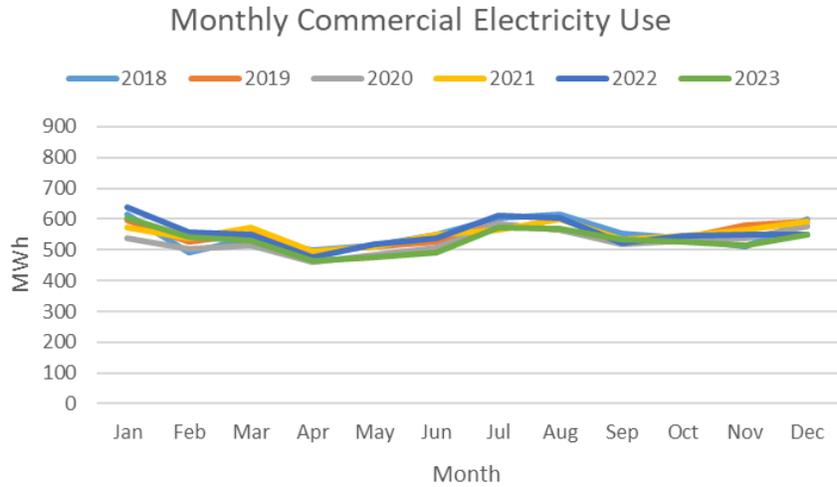


Figure 7: Monthly commercial electricity consumption in the Town of Harvard.

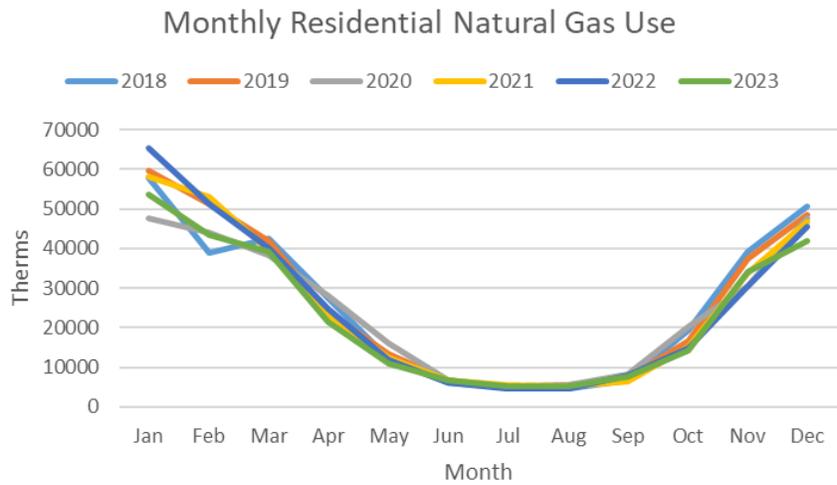


Figure 8: Monthly residential natural gas consumption in the Town of Harvard.

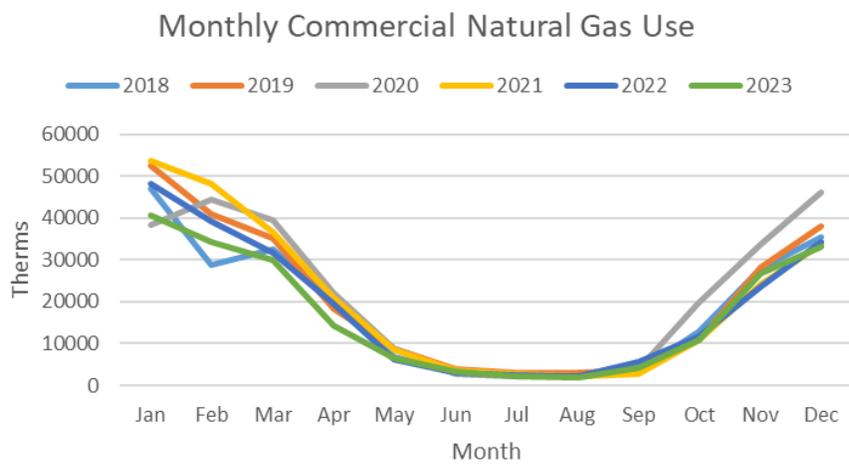


Figure 9: Commercial natural gas consumption in the Town of Harvard.

Employment patterns shape commercial and industrial energy use. Professional and technical services employers represent the largest sector by employment followed by wholesalers¹⁴ (see Figure 10). The presence of the national security sector suggests that at least part of the operations at Devens are included in the data. Overall, the largest sources of employment include office-based work as well as trades and manufacturing. Agricultural employment is listed as small (19 employees on average per month), but some farms may also be part of the food services or other industries depending on the details of their operations.

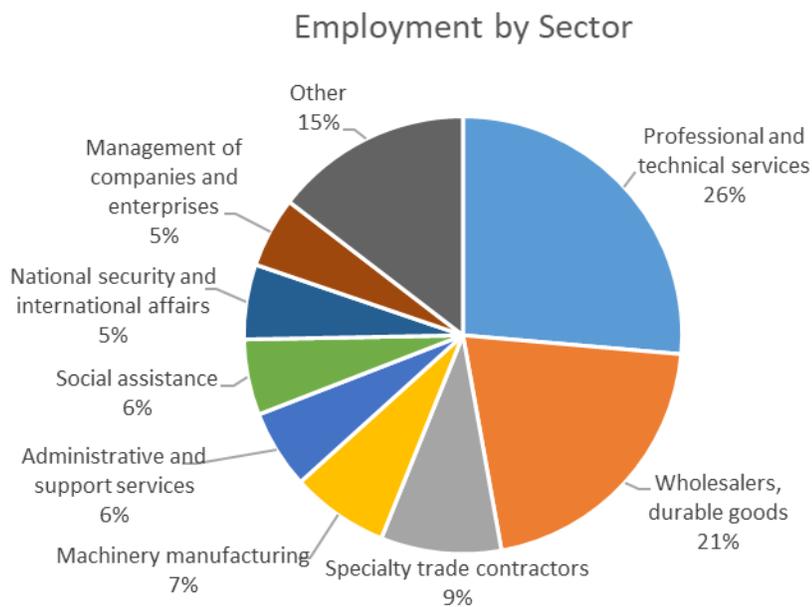


Figure 10: The largest commercial sectors in Harvard in 2023.

Municipal buildings in Harvard consumed 27% of all electricity and half of the natural gas used in commercial and industrial buildings in 2022. Municipal buildings use primarily natural gas and electricity with small amounts of fuel oil and propane (see Figure 11). Energy use spiked in 2020, possibly due to increased ventilation requirements during the pandemic, but have declined since to levels below the pre-pandemic numbers. In 2022, natural gas served 60% of municipal building energy use and electricity another 30%.

¹⁴ Department of Economic Research, Executive Office of Labor and Workforce Development, <https://lmi.dua.eol.mass.gov/lmi/EmploymentAndWages>.

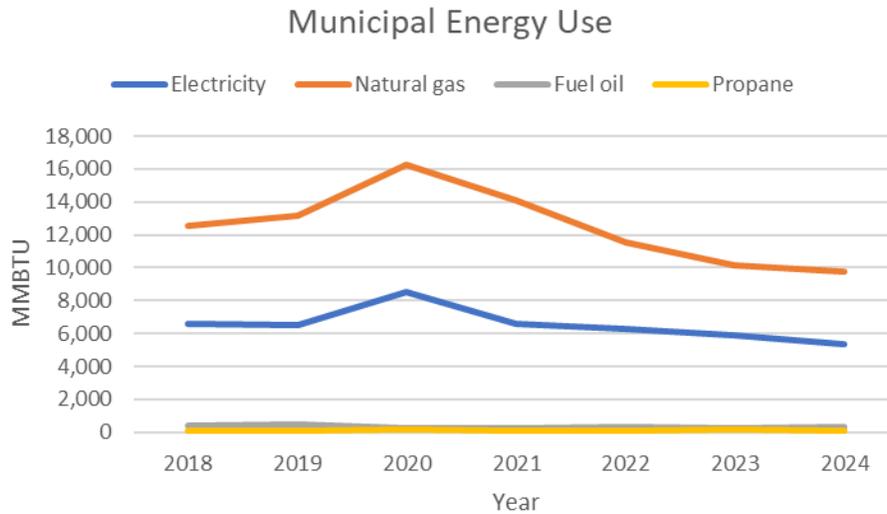


Figure 11: Municipal building energy use.

In summary, Harvard’s building emissions profile is dominated by residential energy use, driven by detached housing reliant on delivered fuels. Seasonal electricity and natural gas patterns reflect heating and cooling demand, with notable heat pump adoption beginning to influence winter peaks in electricity consumption.

Solar

Harvard hosts about 3.3 MW of solar capacity across 250 installations. Data on solar installations was collected from MassCEC’s Production Tracking System (PTS)¹⁵ and DOER’s lists of qualified generation units¹⁶. The latest data available at the time of writing includes part of 2024, but not all. A few projects were installed earlier, but solar adoption began to increase significantly following the town’s Solarize program in 2011¹⁷. Most projects and most of the installed capacity in Harvard are residential including 238 installations and 2.1 MW of capacity. Assuming the state average capacity factor of 13%, all the solar installed in the Town of Harvard could produce 3,753 MWh each year, or about 13% of all electricity consumed in 2023.

¹⁵ MassCEC PTS, <https://www.masscec.com/production-tracking-system-pts>.

¹⁶ DOER Lists of Qualified Generation Units, <https://www.mass.gov/info-details/lists-of-qualified-generation-units>.

¹⁷ Solarize Mass, <https://www.masscec.com/program/solarize-mass>.

Residential

Harvard hosts 2.1 MW of residential solar installed across 231 households as of the end of 2023 (see Figure 12). This is equivalent to approximately 11% of households having installed solar. A sharp increase in solar installations occurred in 2012, likely the result of the Solarize campaign begun in 2011. Since 2015, the average project size has been 12.2 kW and an average of 15 new projects per year installed.

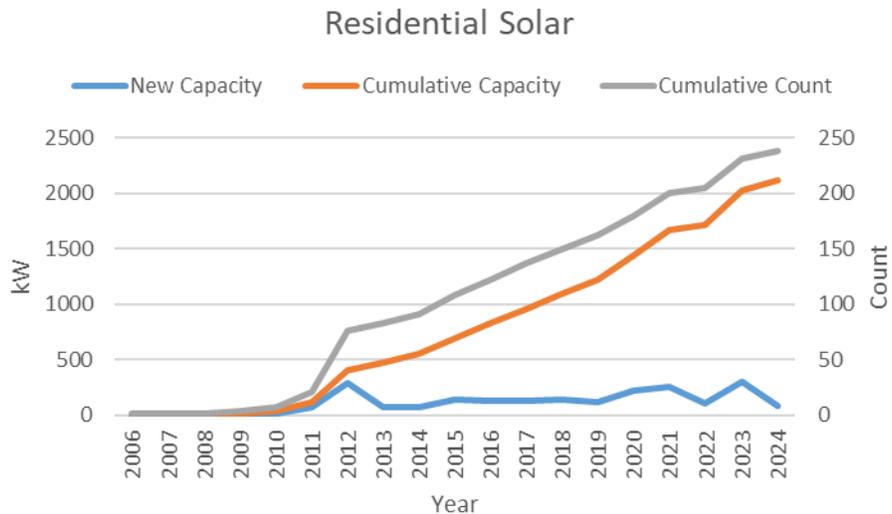


Figure 12: New capacity and cumulative total capacity and number of residential solar projects in Harvard.

Of the 205 projects for which ownership data is available, 10.7% of them are third party owned. In a third-party ownership agreement, the home owner leases their roof to a solar developer and purchases the electricity from the installed panels, but does not own the panels. This arrangement eliminates the initial capital cost of installing solar panels.

Over time, the cost of installing solar has declined significantly as shown in Figure 13. In 2006, solar cost \$7.85 per Watt but by 2018 had dropped by more than half to \$3.52 per Watt. Since then, the costs have increased to \$4.58 per Watt due to supply chain issues and inflation, but remain well below the costs from the early 2000s.

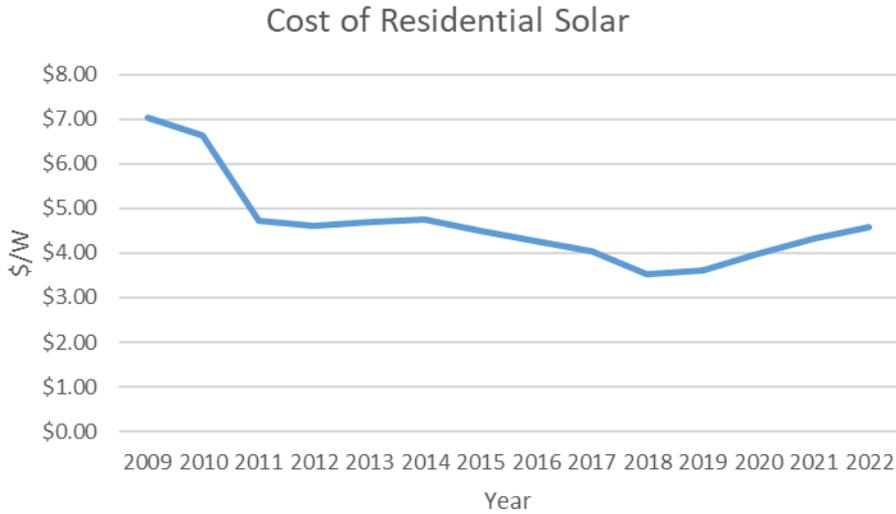


Figure 13: Cost per Watt of residential solar in Harvard over time.

Commercial

The Town of Harvard has 11 non-residential solar projects totaling 936 kW of solar capacity, not including municipal solar installations. These projects include two commercial installations, two agricultural installations, three community solar projects, and four projects listed as other. Figure 14 shows the progressive development of these projects over time.

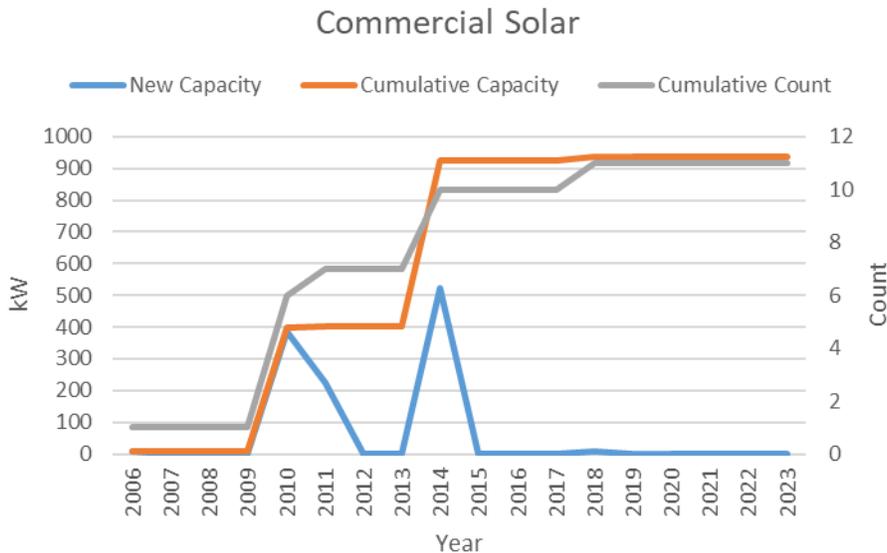


Figure 14: Commercial solar installations in Harvard (all except residential and municipal).

The largest project in Harvard is a combination of three listed in the data, which combined make up the Harvard Solar Garden Project with a total of 524kW of capacity installed in 2014. This community solar project truly lives up to the term and was an initiative of residents of Harvard who invested in the project and receive the electricity^{18 19 20}.

Another large solar installation in town is located at Carlson Orchard with a capacity of 220kW installed in 2010.

Municipal

The Town of Harvard also has three solar installations serving municipal properties. One very small 5.88kW project was installed in 2012. A second much larger 245kW project was installed in 2022 on the Hildreth Elementary School. A third project installed just this year of 44.6kW(AC) was installed on Senior Center.

Transportation

The total transportation related GHG emissions of Harvard amount to about 22,000 MTCO₂e or 51% of the town's total GHG emissions. The vast majority of those, 92.12%, come from passenger vehicles and the remainder from commercial and municipal vehicles. The Town of Harvard had a total of 5,840 vehicles in 2022. Most of those (5,567) were passenger vehicles, 221 were commercial vehicles, and 52 were municipal vehicles. There were 141 battery electric vehicles (BEVs) and 109 plug-in hybrid electric vehicles (PHEVs). All but one of these were passenger vehicles and the other was a commercial vehicle, meaning the share of electric passenger vehicles was 4.5%. Another 313 vehicles were gas hybrid vehicles. From 2020 to 2022, the number of passenger electric vehicles (BEVs and PHEVs) grew 58% based on data from MAPC²¹. Based on data from MassDOT, this rate growth has continued through 2024²² (see Figure 15).

¹⁸ Harvard Solar Garden, <http://www.harvardsolar.org/>.

¹⁹ Harvesting the Sun: The Connelly Family and the Harvard Solar Garden, MassSolar is Working, Inc., 04/23/2015, <https://solarisworking.org/stories/harvesting-the-sun-the-connelly-family-and-the-harvard-solar-garden-0>.

²⁰ B. Mohl, A solar garden grows: Harvard residents develop communal solar project, CommonWealth Beacon, 06/26/2014, <https://commonwealthbeacon.org/environment/012-a-solar-garden-grows/>.

²¹ MAPC, Massachusetts Vehicle Census Summary Statistics 2020 (Municipal), <https://datacommon.mapc.org/browser/datasets/483>.

²² MassDOT, Massachusetts Vehicle Census, <https://geodot-massdot.hub.arcgis.com/pages/vehicle-census>.

Fuel Efficient Vehicle Adoption

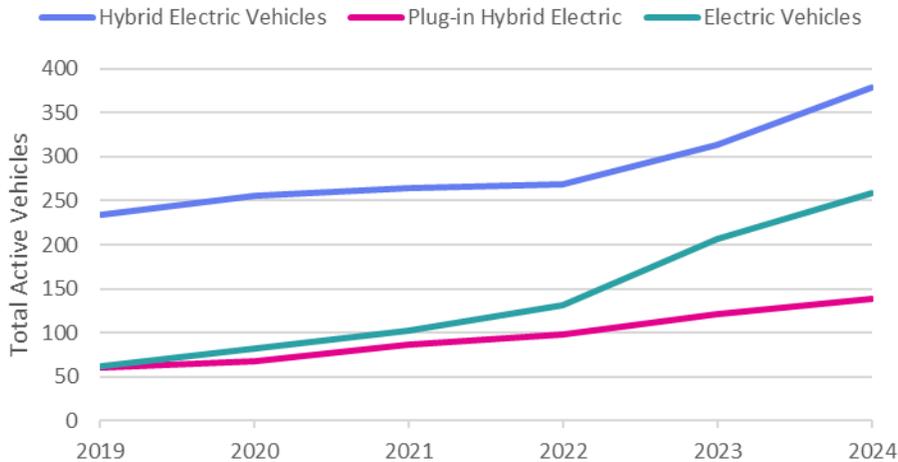


Figure 15: Trends in adoption of gas hybrids (i.e. hybrid electric vehicles), PHEVs, and BEVs from the MassDOT vehicle census.

Additionally, BEVs and PHEVs are driven more miles on average per day. According to the MassDOT data, fossil fuel vehicles drive an average of 30 miles per day while gas hybrids drive about 35 miles per day and PHEVs and BEVs drive 37 and 38 miles per day, respectively. Commercial vehicles are driven the most, an average of 40 miles per day, while passenger vehicles average 30 miles per day. Municipal vehicles are driven the least with a daily average of 14 miles per day in 2022.

The primary modes of commuting in Harvard are driving alone and working from home. More than half of workers (57%) drove alone to work and 34% worked from home in 2022 based on data from the Census Bureau (see Figure 16). Harvard is part of the Montachusett Regional Transit Authority (MART), which used to run a weekday shuttle service from Harvard to the Littleton commuter rail station²³; this shuttle services was discontinued recently. Use of public transit has declined since the pandemic, but even at its peak the Census Bureau estimates about 8% of workers living in Harvard commuted using public transit. In contrast, working from home has increased significantly in recent years rising from about 14% of workers in 2018 to 36% in 2023. For those who do commute to work, the time their commute takes has remained relatively stable.

²³ MART, Harvard Commuter Shuttle Schedule, <https://www.mrta.us/schedule-map/harvard-commuter-shuttle/>.

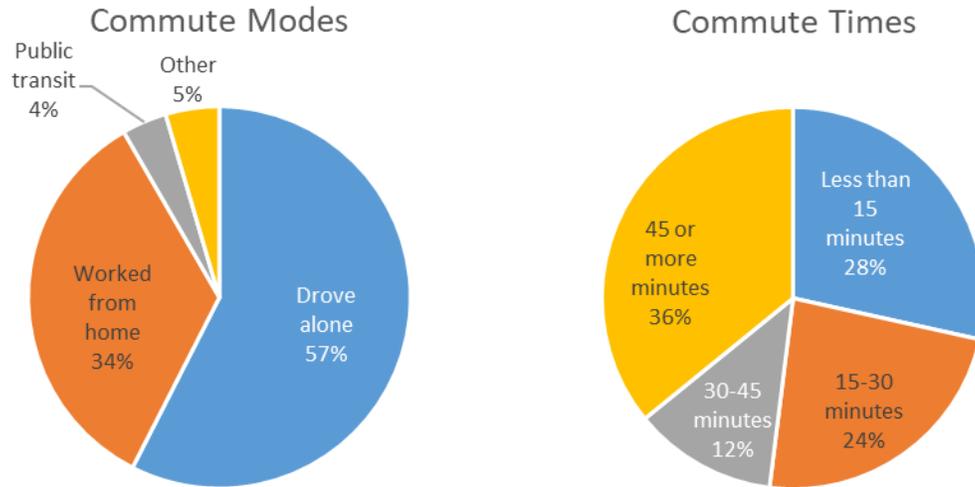


Figure 16: Commute statistics for Harvard in 2022 from the Census Bureau's ACS.

Harvard is home to two level 2 EV charging ports at the only public charging station in town located at the Hildreth School²⁴.

Waste

In Harvard, total waste emissions in 2022 were 1,280 MTCO_{2e}, or nearly 3% of all emissions. Of that total, wastewater treatment was the source of most of those emission, 1,234 MTCO_{2e}. The remaining 46 MTCO_{2e} were from solid waste disposal in a combination of landfills (10%) and incinerators (90%).

Emissions from wastewater are estimated based on statewide wastewater emissions for septic systems and central treatment plants and the town population. Emissions are assigned on a per capita basis. This estimate assumes that about 4% of households are connected to the central treatment plant and the remaining 96% have septic systems.

Solid waste data were collected from MassDEP. The Town of Harvard has a transfer station for collecting trash and recycling. About 65% of households used the town waste services in 2022. In 2022, 636 tons of trash were collected by the town program and we estimate that non-participating households generate waste at the same rate as participating households in order to estimate all household solid waste generated in the Town of Harvard. In recent years, the amount of trash collected by the program has decreased by

²⁴ U.S. Department of Energy Alternative Fuels Data Center, Alternative Fueling Station Locator, <https://afdc.energy.gov/stations#/find/nearest>.

almost 30% (see Figure 17). The diversion rate, the share of waste diverted from the landfill or incinerator, has hovered around 40% in recent years. The town encourages backyard composting, but does not offer food waste drop off or curbside collection.

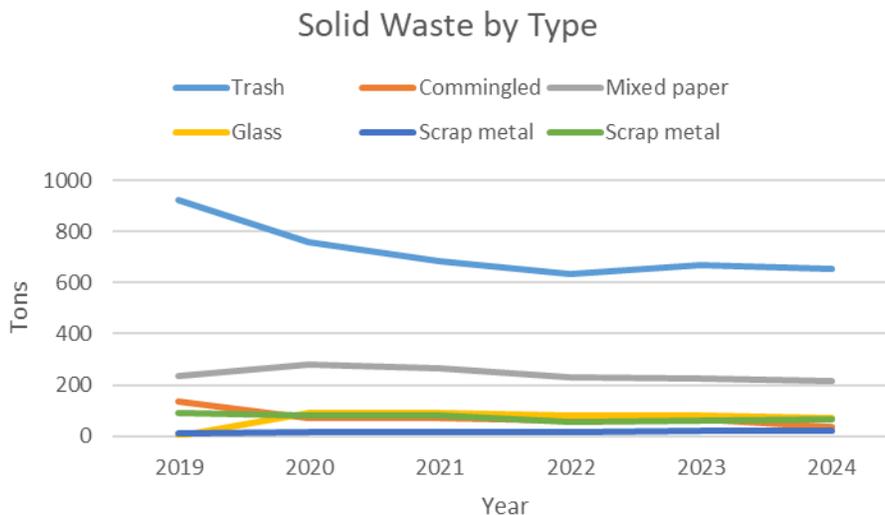


Figure 17: Solid waste collection by type over time in Harvard.

Tree Cover

Harvard is a heavily forested town and based on a survey of 1000 points, about 70% of the town is covered by tree canopy. Another 13% of land area is covered with grass, about 9% are impervious surfaces (roads, buildings, etc.), 5% water bodies, and 3% bare soil. Figure 18 shows the points surveyed throughout town as well as the distribution of land cover types.

The trees in Harvard provide many important benefits to the town including access to nature, air quality, and water management. The trees also capture and store carbon. Using the iTree Canopy tool from the US Forest Service²⁵, we estimate that about 1,385 kilotons of CO₂e is currently stored in the trees and forests in Harvard. Each year, an additional 48 kilotons of CO₂e is captured and added to the store of carbon. This figure is larger than the total estimated annual emissions of 42 kilotons of CO₂e.

²⁵ iTree Canopy tool, <https://canopy.itreetools.org/>.

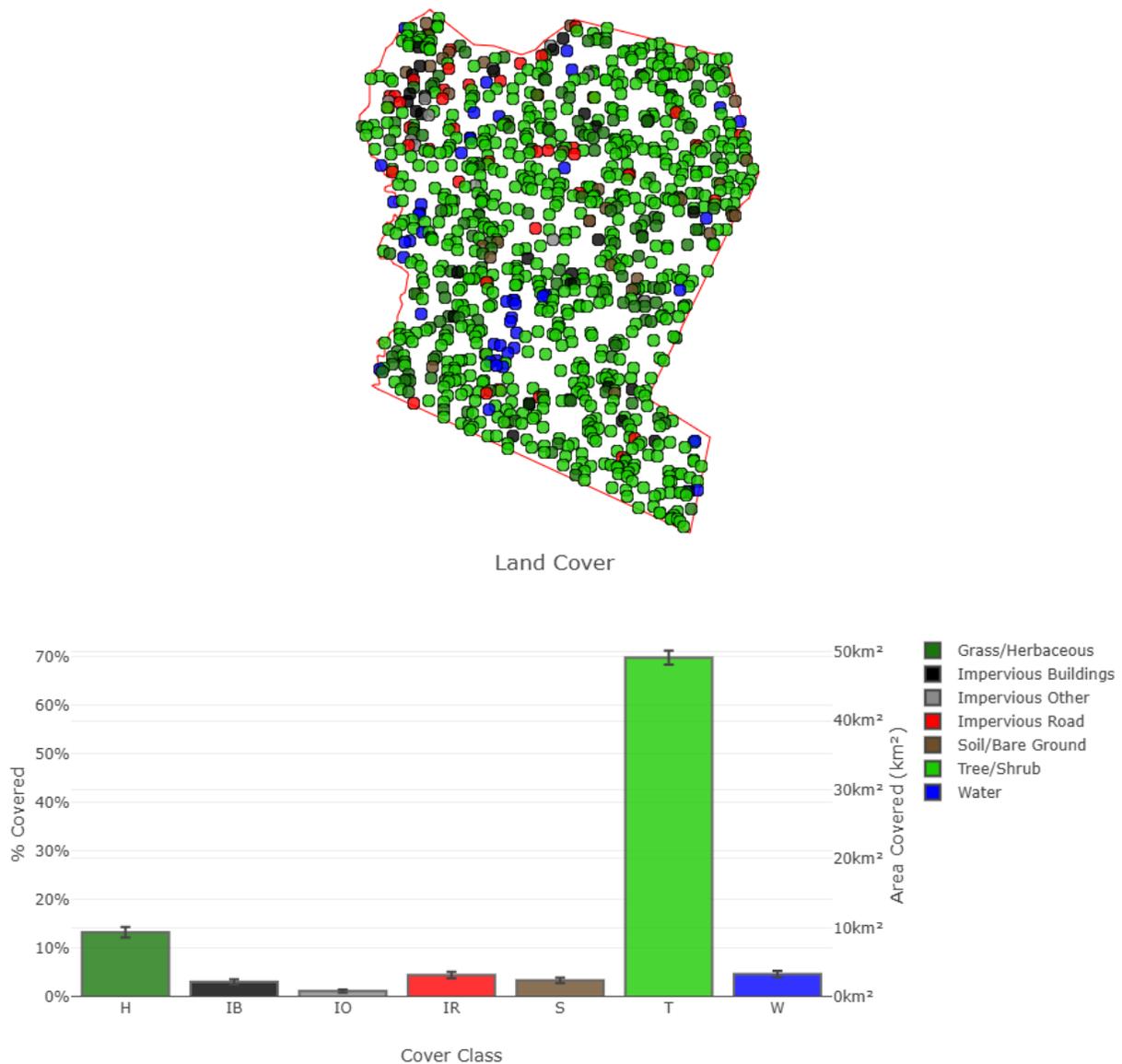


Figure 18: Surveyed points in Harvard (top) and breakdown of land cover types (bottom).

Summary

In 2022, Harvard emitted more than 43,000 MTCO₂e, about 6.3 MTCO₂e emitted per person. Transportation, particularly on-road vehicles, which make up slightly more than half of all emissions (about 50%), is the biggest source of emissions. Passenger cars account for the majority of these emissions (46.4%). Residential buildings (27.8%) and commercial and industrial buildings and manufacturing (19.2%) are the next biggest producers, with waste-related emissions remaining minor. Since transportation emissions

make up the largest source, this could be a key area to focus on in the coming years. Electric vehicle adoption in combination with the town's electricity aggregation program could reduce passenger vehicle emissions. Alternatively, encouraging increased use of the commuter rail or other alternate commute modes could achieve similar results. Harvard is leader in heat pump adoption with one of the highest known rates of adoption based on data from the Mass Save program. Continuing to encourage adoption of heat pumps, particularly for households reliant on fuel oil for heating, in combination with the town's electricity aggregation program has the potential to reduce emissions from the residential sector. Adoption was about 15% of housing units in 2024. Harvard also has significant adoption of solar with about 11% of households having solar installed. There are also notable community solar, agriculture, and municipal projects in town. The town's tree cover more than offsets annual emissions and thus should be prioritized for protection.