

Strive toward net zero energy buildings: Existing non-municipal buildings

INCREASE ENERGY EFFICIENCY OF EXISTING NON-MUNICIPAL BUILDINGS

Description and purpose of strategy: In the U.S., commercial and residential buildings are responsible for roughly 40% of all energy consumption. Many buildings have outdated water and space heating systems, high air infiltration, and poor insulation, leading to high financial and environmental burdens. Building performance standards (BPS) are one policy measure that can increase building efficiency within a municipality. Additionally, technologies like air-source heat pumps (ASHPs) should be considered as retrofits for residential and commercial buildings.

Content of fact sheet: Energy saving strategies for non-municipal buildings (residential, commercial, and industrial) and a county-specific cost benefit analysis of switching to ASHPs.

Implementation support: This fact sheet expands upon strategies and actions from the Climate Actions Database, which can be found at: capecodcommission.org/climate.

BENEFITS

- Greenhouse gas (GHG) emissions reductions or sequestration
- Health improvement from reduced pollutants
- Increased recreation
- Lower maintenance/operational costs
- Environmental enhancement/protection
- Less damage to infrastructure
- Higher property value
- Increased resilience
- Job and economic growth

COSTS

- Higher capital costs
- Higher maintenance costs
- Higher operational costs
- Additional time for municipal staff to implement

KEY FINDINGS



Equity: Adopting heat pumps and other energy efficient retrofits can improve health outcomes and lessen the financial burden of home heating for all. In addition, installing these systems can provide economic opportunities that could benefit low-income communities.



Financial benefits: Retrofits may have high capital inputs, but many of the costs can be defrayed through rebates, and over time can lead to cost savings due to decreased operating costs.



Non-market benefits: Improvements in health from reduced pollutants are an additional benefit of non-combustion heating systems. Retrofits that address heating can also reduce the use of space heaters and window air conditioning units, which can lead to increased safety and less work for the homeowner.



GHG reductions: Energy efficient retrofits represent a significant opportunity to reduce GHG emissions. For example, ASHPs are estimated to reduce between 2.77-megatonne (MT) CO₂e and 6.89 MT CO₂e per household per year depending on the home's original heating source.



Ease of implementation: Awareness of rebate programs and the financial/environmental benefits of retrofits encourage building owners to increase their energy efficiency, but municipal programs are also necessary to develop building performance standards and spread awareness of these strategies.

BENEFIT COST ANALYSIS

BPS for Non-Municipal Buildings

BPS policies establish specific performance outcomes that commercial, industrial, and multifamily residential buildings must achieve within a certain time frame. Metrics used to determine energy efficiency fall into two broad categories: energy metrics and GHG metrics. Compliance approaches differ depending on the municipality. For example, in Washington, D.C., building owners have multiple ways to comply with the standards, such as reducing site energy usage by 20%, implementing specific cost-effective efficiency measures, or reaching a set standard for a given property type. This type of flexibility is important when designing standards for a given region and population. BPS policies are mostly outcome based as opposed to prescriptive (though in some instances they are both), and as such they may not require specific retrofits. However, the below retrofits and technologies should all be considered as potential energy savings options that could be addressed through BPS policies.

POTENTIAL RETROFIT ACTIONS FOR NON-MUNICIPAL BUILDINGS

ELECTRIFICATION	AIR SEALING AND INSULATION	LED LIGHTING
Heat pump water heaters are 2–3 times more efficient than conventional water heaters, and can reduce water heating costs, which account for 17% of household energy use in New England. ASHPs and electric appliances can reduce energy use and GHG emissions, as well as improve indoor air quality.	Air sealing and insulation have been shown to reduce leakage by 50% in multifamily buildings. Additionally, air sealing and insulation can reduce moisture in unwanted spaces, improve air quality, and improve HVAC equipment performance.	According to the Department of Energy, lighting accounts for 15% of an average home's energy use. LED lighting is cost-effective, and saves energy compared to conventional alternatives.

Air Source Heat Pumps for Residential Use

On Cape Cod, residential energy use accounts for [roughly twice as much](#) usage as commercial and industrial energy use. The majority of houses in Barnstable County are heated with natural gas, followed by fuel oil, and then electricity. These homes have a significant opportunity for financial operating savings if they switch heating systems. Census data from the [American Community Survey estimates the current fuel usage in Barnstable County](#), with "Utility Gas" representing Natural Gas.

HOUSE HEATING FUEL IN BARNSTABLE COUNTY

HEATING TYPE	PERCENT OF HOUSES
Utility Gas	61%
Fuel oil, Kerosene, etc.	19%
Electricity	12%
Other	8%
Total	100%

Capital costs for different oil boilers, natural gas boilers, and ASHPs vary, but according to Mass Clean Energy Center (MassCEC), there were 541 ASHPs installed in Barnstable County in 2019 (the last year these data were available) with a median cost of \$3,733 per heating ton. A home with 2,000+ square feet would require a 4-ton ASHP (though this number is variable depending on a building's ability to retain heat), resulting in a capital cost of \$14,900. However, costs will vary depending on the existing HVAC and envelope conditions of the house, and can also be offset with [Mass Save rebates](#).

HEATING SYSTEM ANNUAL AND LIFETIME COSTS

UNIT TYPE	CAPITAL COSTS	LIFE SPAN (YEARS)	ANNUAL FUEL COSTS	LIFETIME ANNUAL COSTS	ANNUAL GHG EMISSIONS (MT CO ₂ e)
Heating oil boiler	\$6,500	15	\$2,320	\$2,753	7.62
Natural gas boiler	\$8,150	15	\$1,010	\$1,553	3.50
ASHP	\$14,900*	12.5**	\$320	\$1,512	0.73

* Homeowners replacing their entire heating system are eligible for rebates up to \$10,000, which can significantly lower this number.

** ASHPs have variable lifespans, but most research shows likely lifespans to be between 10–15 years; 12.5 was chosen as a midpoint, but shorter or longer lifespans would change the cost effectiveness of ASHPs.

Using cost and GHG savings per household with county-specific heating data yields potential savings across Cape Cod under various adoption scenarios. Below, three adoption scenarios are presented with their associated financial savings and GHG reductions.

FINANCIAL AND ENVIRONMENTAL BENEFITS OF ASHP ADOPTION FROM NATURAL GAS AND HEATING OIL

SCENARIO	ORIGINAL HEAT SOURCE	NUMBER OF HOMES	TOTAL FINANCIAL SAVINGS (\$)	TOTAL GHG SAVINGS (MT CO ₂)	SO ₂ REDUCTION (LBS.)	NO _x REDUCTION (LBS.)	PM _{2.5} REDUCTION (LBS.)
100% adoption	Heating oil	31,127	\$38,638,640	214,401	162,404	403,895	33,495
	Natural gas	101,297	\$4,186,926	280,389	(2,935)*	284,330	49,737
75% adoption	Heating oil	23,345	\$28,978,980	160,801	121,803	302,921	25,121
	Natural gas	75,972	\$3,140,194	210,292	(2,201)*	213,247	37,303
50% adoption	Heating oil	15,563	\$19,319,320	107,200	81,202	201,947	16,748
	Natural gas	50,648	\$2,093,463	140,194	(1,468)*	142,165	24,868

Note: Annual savings per home stemming from the switch to ASHPs from heating oil are estimated to be \$1,241, with associated CO₂e reductions to be 6.89 MT per year. The same changes associated with switching from a natural gas system are \$41 per year, and a reduction of 2.77 MT of CO₂e.

* Parentheses denote an increase rather than a reduction.

Savings are dependent on a few variables, such as air-sealing and size of home, and ASHP lifespan. As heat pump technology improves it is expected that ASHP lifespan will increase, which will decrease the amortized cost of the system, and result in greater savings over oil and natural gas systems.

Along with cost savings and GHG reductions, changing energy types affects the amount and type of criteria pollutants shown to affect human health in the air.

HEALTH BENEFITS FROM CRITERIA POLLUTANT REDUCTION FOR ASHP ADOPTION SCENARIOS

ASHP ADOPTION SCENARIO	HEALTH SAVINGS FROM CRITERIA POLLUTANT REDUCTION
100% adoption	\$363,025–\$820,618
75% adoption	\$272,268–\$615,466
50% adoption	\$181,512–\$410,311

Note: Health savings are for Barnstable County, estimated using [EPA's COBRA](#) tool.

Although this fact sheet addresses ASHPs in detail, geothermal heat pumps (GHPs) should also be considered as a potential alternative heating source. GHPs can be more efficient than ASHPs, but require between [400 and 8,000 square feet](#) of clear land space. GHPs also have a higher capital cost, which can be a barrier to installation.

Another important factor for home efficiency as it relates to heating and cooling is air sealing and insulation. The U.S. Environmental Protection Agency (EPA) estimates that proper air sealing and insulation can reduce the average energy bill of houses in [climatic zone five by 16%](#). Home envelopes should be evaluated regardless of heating system to realize these potential savings. Requirements for blower door testing and thermal imaging could be helpful tools to evaluate a home's envelope as a prerequisite to HVAC retrofits in order to ensure the retrofit's benefit is maximized. Mass Save offers [no-cost home energy assessments](#) as well as [75% off insulation costs](#), and is a great resource for homeowners looking to save money and energy.

EQUITY

BPS and retrofits, in particular heat pump technologies, have the potential to make heating more affordable and reduce GHG emissions. Potential equity benefits of increased efficiency buildings are:

- **Reducing heating costs.** More efficient energy systems can lower annual heating costs, which is beneficial to all residents, but especially for those who spend a large portion of their income on utilities. Spending less on heating could allow residents to reallocate their spending and reduce financial hardship.
- **Strengthening the local green economy and increasing grant opportunities.** Increases in energy-efficient heating sources represent a positive step as more cities and towns become designated as [Green Communities](#) in Massachusetts. This designation provides communities with access to grant opportunities for green initiatives, which receiving towns could direct toward low-income communities to ensure that efficient and affordable heating practices are available to everyone.
- **Reducing GHG emissions and criteria pollutants.** Reducing emissions is a powerful tool to collectively alleviate the burden of climate change. Historically, negative impacts of poor environmental practices have disproportionately affected low-income communities and communities of color; thus, a reduction in criteria pollutants could have important implications for the health of vulnerable communities.

Optimizing Equity During Implementation

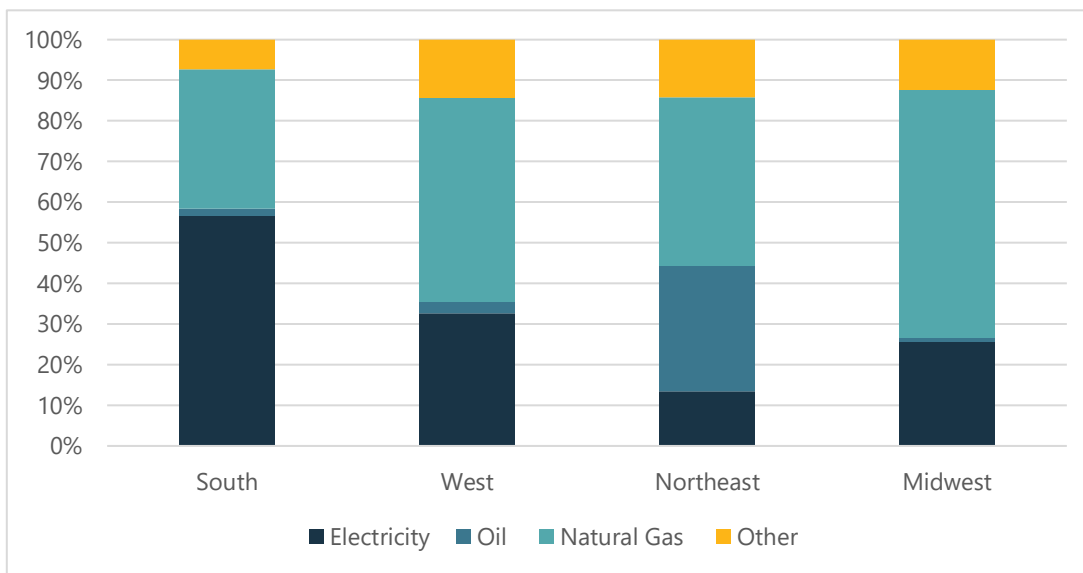
Equity considerations for tenants and building owners are important when implementing any strategy that seeks to lower GHG emissions, particularly when it's associated with higher capital costs. Some programs to lessen the burden of retrofits, such as the [Mass LEAN program](#) and the [Cape & Vineyard Electrification Offering](#), already exist; however, these efforts can be augmented with additional municipal policies to ensure that all aspects of retrofitting are accessible to everyone. For equitable implementation of building performance standards, EPA's [Benchmarking and Building Performance Standards Policy Toolkit \(Section 2\)](#) provides for considerations of compliance accommodations and exemptions for certain factors, such as financial hardship or under-resourced buildings like affordable housing.

STATE OF PRACTICE

General State of Practice

The Northeast is lagging behind the rest of the country in terms of adopting electric heating sources. According to a [2020 study](#), 47% of Northeast homeowners had never heard of heat pumps. However, they have been growing in popularity over recent years. The State of Maine currently has a goal of installing of 100,000 heat pumps by 2025, and is well on its way; [in 2021 alone, they installed 27,000 new heat pumps](#). Outcomes from this initiative have thus far been overwhelmingly positive.

U.S. HEATING SOURCES BY REGION



Cape Cod Context

In Barnstable County in 2019, the last year these data are available, MassCEC reported that 541 ASHPs were installed. Across Massachusetts, 7,100 heat pumps were installed in 2021, and that number more than doubled to nearly 18,000 in 2022. While this represents significant growth, it is well short of the state goal of [100,000 average annual installations](#) for the next 25-30 years.

CASE STUDY: CAMBRIDGE, MA

Through citywide efforts, Cambridge became one of the first Green Communities designated by MA in 2010. One effort is the Cambridge Energy Alliance (CEA), a program offered to assist homeowners in adopting energy-efficient projects. Among other programs CEA connects individuals to Mass Save and offers [no-cost heating assessments](#). One example of energy-efficient retrofitting in Cambridge is the 98-unit apartment community [Finch Cambridge](#), which received a \$147,000 grant enabling it to be 70% more efficient than the average multifamily building. Plenty of similar examples, and the city’s exemplary support of energy efficiency, make Cambridge a good case study on citywide adoption and promotion of energy-efficient retrofits.



IMPLEMENTATION

Local and state-sponsored efforts are important to support retrofits and create BPS. Different state and national programs offer financial and logistical assistance to create BPS and encourage residential retrofitting. Along with state programs, programs offered by Cape Cod's [Cape Light Compact](#) should be considered for energy efficiency. To maximize the GHG reductions and financial savings from this strategy, municipalities on Cape Cod should:

- **Engage the community.** Create townwide programs to increase awareness for heat pump technology, emphasizing cost and GHG savings.
- **Evaluate opportunities.** Create a task force to further evaluate energy saving strategies to be included in a potential BPS.
- **Provide assistance.** Support residents with applications for rebates on heating systems, air sealing and insulation quotes, and other measures to reduce GHG emissions.

REQUIRED EXPERTISE

Internal: Town committees and working groups on sustainability, policymakers, building departments

External: HVAC service providers

Resources that may assist with implementing strategies to increase energy efficiency in non-municipal buildings are provided below.

FINANCIAL AND TECHNICAL SUPPORT

Air Source Heat Pump Rebates, Mass Save	Provides information about ASHPs and rebates for qualifying homes. Rebates from Mass Save are up to \$10,000 for full-home heating, and \$1,250 per heating ton for partial-home heating.
Air Source Heat Pump Installers in Massachusetts	Repository from MassCEC with air source heat pump installers.
Mass.gov Green Community Designation and Grant Program	Information about the Massachusetts Green Community designation and resources to apply for the designation and related grants.
ENERGY STAR Air Source Heat Pumps Tax Credit	Provides additional information on tax credits for air source heat pumps.
Weatherization for Air Sealing and Insulation, MassCEC	Information on weatherization for homeowners
LEAN Multifamily Program	A program that financially assists low-income homeowners with retrofits.
Building Performance Standards Technical Assistance	A resource that provides technical assistance in designing and implementing BPS.
Cape & Vineyard Electrification Offering	Assists low- and middle-income individuals with electrification.
Cape Light Compact Income Eligible Savings	A program from the Cape Light Compact with two income tiers that are eligible for reduced energy costs.

ADDITIONAL INFORMATION

Energy.gov Air-Source Heat Pump Information	Information from Energy.gov on ASHPs, different types of equipment, how they work, and what is best for different homeowners.
Are Air Source Heat Pumps Right for You?—EnergySage	Considerations for prospective heat pump installers.
Building Performance Standards, New Buildings Institute	Background information on BPS.