Reducing Municipal Vehicle Fuel Consumption in Rural Massachusetts Communities

In support of the

Green Communities Designation & Grant Program

A program of

Massachusetts Department of Energy Resources

March 2019

Prepared by

UMass Clean Energy Extension

209 Agricultural Engineering
250 Natural Resources Way
Amherst, MA 01003-9295
413.545.8510

energyextension@umass.edu
https://ag.umass.edu/clean-energy

Table of Contents

Project Contributors

Primary Author and Researcher:

Dugan Becker – Intern and Summer Scholar at UMass Clean Energy Extension

Project Overseers and Secondary Authors:

Dwayne Breger – Director, UMass Clean Energy Extension

Zara Dowling – Research Assistant, UMass Clean Energy Extension

River Strong – Associate Director, UMass Clean Energy Extension

Special Thanks to:

Jim Barry – Green Communities Coordinator for Western Massachusetts (DOER)

Joanne Bissetta – Deputy Director, Green Communities Division (DOER)

Stephen Russell – Co-Coordinator, Massachusetts Clean Cities Coalition (DOER)

Bill Watts – Fleet Coordinator, Transportation Services at UMass Amherst

Executive Summary

Vehicle fuel usage accounts for a significant percentage of total municipal energy consumption across the Commonwealth of Massachusetts. While many communities have achieved substantial reductions in energy consumption in municipal buildings, fuel consumption by municipal fleets has proven to be a much more challenging area for improvement. Rural municipalities are especially challenged in addressing excessive vehicle fuel consumption in their communities due to a number of unique obstacles such as limited availability of resources, demanding vehicle performance requirements, low-density populations, and the high upfront costs associated with solutions.

This report marks the first step in an initiative led by UMass Clean Energy Extension (CEE) to (1) better understand municipal vehicle fuel usage levels, trends, and patterns in rural communities, (2) identify best practices for reducing vehicle fuel usage and its associated costs, and (3) provide practical resources to rural Massachusetts communities seeking to advance vehicle efficiency. This report addresses the transportation-related issues unique to rural communities by:

- Identifying the major barriers that frequently prevent rural communities from achieving optimal fuel efficiency in their fleets;
- Pinpointing some of the primary sources of fuel consumption/inefficiency within rural communities; and
- Enumerating some of the promising tools and techniques available to communities to assist in their reduction efforts

Through this report, associated fact sheets, web resources, and community-specific research initiatives, our goal is to create and distribute a collection of resources for rural communities assessing their municipal transportation goals, developing transportation efficiency strategies, and seeking practical starting points to advance efficiency efforts. In addition, our analysis is designed to aid policymakers and clean energy entities supporting communities in their transportation efficiency efforts.

We found that throughout rural Green Communities in Massachusetts, the highway department/department of public works (HWY/DPW), and the police department, tend to be the two primary sources of municipal vehicle fuel consumption. On average, these departments represent a combined total of 82% of all fuel consumption from municipal transportation, followed by the fire department with 8% of vehicle fuel consumption. This observation is consistent with our finding that HWY/DPW, police, and fire department vehicles combined represent an average of 84% of all municipal vehicles. While the vast majority of vehicles in these departments are classified as "exempt" from Green Communities' fuel efficiency requirements, the fact that these vehicles represent the primary sources of municipal fuel consumption indicates that communities must target these vehicles, regardless of exemption status, if they hope to see substantial improvements in fuel efficiency.

An in-depth literature review was conducted in order to identify promising fuel-saving techniques, which we have summarized below to aid communities in selecting the approach that best fits their unique circumstances. These summaries have been paired with recommendations on potential areas of application (e.g., "Solution 'x' may be particularly useful for police cruisers", etc.), in order to assist municipalities in the decision-making process. In addition to providing a general summary of potential solutions, various references have been included for communities seeking more information on the subject.

Lastly, it should be noted that while this report provides an introduction to the issue at hand, as well as some potential solutions to the problem, UMass CEE is currently pursuing the second phase of our initiative targeting municipal vehicle fuel consumption in rural Massachusetts. This effort will involve working closely with selected rural municipalities in their fuel consumption reduction efforts, by helping to identify areas of inefficiency through the implementation of telematics (i.e., fleet tracking) devices on municipal vehicles, and distribution of surveys to municipal employees. While these efforts will directly assist the selected communities, the data drawn from the experience should yield useful insight into rural fleet operation on a broader scale.

1. Introduction

1.1 Background

The Green Communities Act of 2008

In an attempt to promote the widespread adoption of energy efficiency and clean energy technologies, reduce long-term energy costs, and strengthen local economies across Massachusetts, the Green Communities Act (GCA) was promulgated by the Massachusetts State Legislature and signed into law by the Governor in July of 2008. By December 2017, 210 communities across Massachusetts (72% of the State's population) had opted to become designated Green Communities (GCs), enabling them to receive grants, technical assistance, and localized support from the State in their pursuit of energy use reductions and clean energy adoption. As part of the application process, all prospective GCs developed a plan to reduce their municipal energy usage by 20% over 5 years. The program has been largely successful, cutting total energy consumption by more than 12% across GCs as of 2016, equivalent to the amount of energy necessary to heat and power approximately 9,000 homes, and avoiding more than 96,000 metric tons of carbon dioxide emissions.[1] However, the largest obstacle GCs have faced in their efforts has been reducing vehicle fuel consumption. **While, on average, vehicle fuel represents roughly 20% of total energy consumption across GCs, vehicle fuel reduction represents a mere 2% of all GC energy reductions.** If these communities are unable to address vehicle fuel consumption, energy cost savings will be limited, and the ambitious greenhouse gas emission reduction commitments under the Global Warming Solutions Act (reducing statewide greenhouse gas levels 80% below 1990 levels by 2050), will be difficult to achieve. Drawing on the expertise of a wide range of state, regional, and community collaborators, CEE hopes to address the various obstacles hindering Massachusetts communities from reducing their vehicle fuel consumption, as well as highlight some promising fuel saving solutions.

The Transportation Challenge in Rural Communities

While on average vehicle fuel constitutes approximately 19% of a community's energy budget across Massachusetts GCs, this percentage can be as high as 30-35% in smaller, rural communities.[2] Rural communities (defined as having an average of 500 residents or fewer per square mile) make up about a third of all Massachusetts municipalities. In these communities in particular, addressing inefficiencies in fleet operation is an essential step in the pursuit of reduced energy use and cost. In addition to vehicle fuel frequently representing a much higher percentage of a town's energy budget in rural communities, heavy-duty vehicles typically represent a large percentage of rural fleets, which can make reducing fuel usage difficult as well. Other obstacles include high road mileage relative to population size, minimal public transportation options, rugged terrain, and a lack of funding. For these reasons, CEE has chosen to target rural communities, as areas that pose a unique challenge in reducing vehicle fuel consumption, but also have the potential to benefit tremendously from achieving said reductions.

---

[1] Synapse Energy Economics, Inc. "Massachusetts Green Communities Program 2016 Progress Report". Massachusetts Department of Energy Resources, December 2017.

[2] Green Communities Division. "Efficient Vehicles". Massachusetts Department of Energy Resources, accessed January 2019.

1.2 Study Objectives

As a multifaceted research initiative, it was critical to establish a list of objectives early in the investigative process. The goals CEE set out to accomplish through this project can be broadly categorized into four groups:

Identify Barriers to Reduced Fuel Usage in Rural Municipalities

Highlighting commonplace obstacles to reducing fuel consumption is the first step in improving fuel efficiency. By identifying patterns of municipal fuel consumption, and pinpointing fuel reduction difficulties that occur frequently across rural communities, the issue of suboptimal fuel consumption in rural areas can be understood on a large scale, as opposed to a case by case basis. Approaching the problem in this way enables the findings of this report to be applied to a wide range of rural communities, likely transcending the boundaries of Massachusetts, and giving communities a starting point for understanding and improving their own consumption habits.

Compile an Index of Fuel Saving Solutions

In addition to identifying obstacles preventing rural municipalities from reducing their vehicle fuel consumption, an equally important component of our research was compiling an index of various fuel saving techniques. Ranging from vehicle retrofits, to simply adjusting daily driving habits, educating rural communities on the wide array of fuel consumption reduction techniques is essential to ensuring that each municipality finds the solution most appropriate for their unique circumstances.

Evaluate the Current Status of Fuel Efficiency in Rural Massachusetts

The analysis of various datasets summarizing the vehicle inventories, funding, and fuel use records of Massachusetts GCs played a major role in our understanding of municipal vehicle use within the State. By performing a range of analyses using this data, one can begin to illustrate important qualities at both the state and local level, such as establishing baselines to measure future changes, identifying trends in fleet size, fuel use, and vehicle type, distinguishing outlier communities that fall outside those trends, and other valuable traits.

Identify Potential Areas for Further Research and Assistance

While much of the project up to this point has been focused around the analysis of databases and literature, the next stage of research will involve working closely with a number of rural Massachusetts communities. This "hands-on" segment of the project will provide valuable opportunities for furthered problem identification and personalized assistance in municipal fuel efficiency efforts.

2. Methodology

2.1 Scope of Research

Of the 351 municipalities in Massachusetts, 48% are considered "rural", defined as having, on average, less than 500 residents per square mile (See **Figure 1**). While many of the findings in this report are applicable to a large portion of those rural communities, the scope of our research primarily focuses on rural GCs in Massachusetts. This is due to several reasons, including (1) the availability of vehicular data for these communities, and (2) existing efforts to reduce fuel consumption demonstrated by these municipalities. As of December 2017, 60% of Massachusetts municipalities (210 communities) are designated GCs, 44% of which (92 cities or towns) also classify as rural (See **Figure 2**). The analyses found in **Sections 3.3** and **3.4** of this report have been generated based on available data reported for fiscal year 2016 (FY2016) by the 92 Massachusetts municipalities that classify as rural Green Communities.

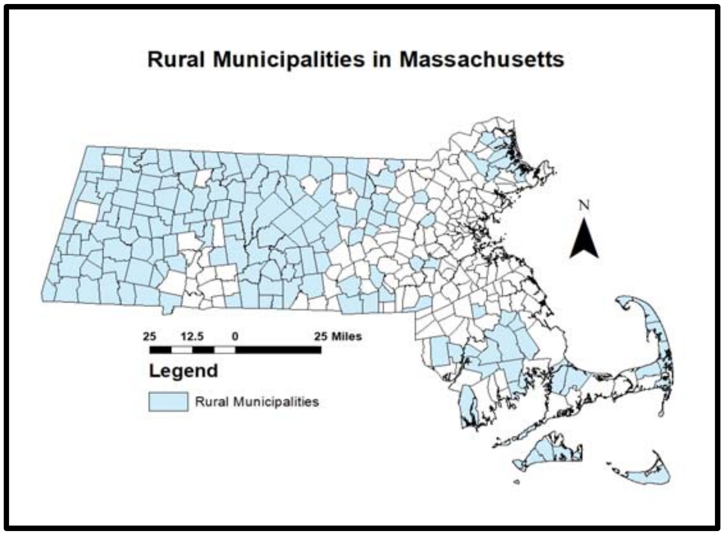


Figure 1: Rural Municipalities in Massachusetts.

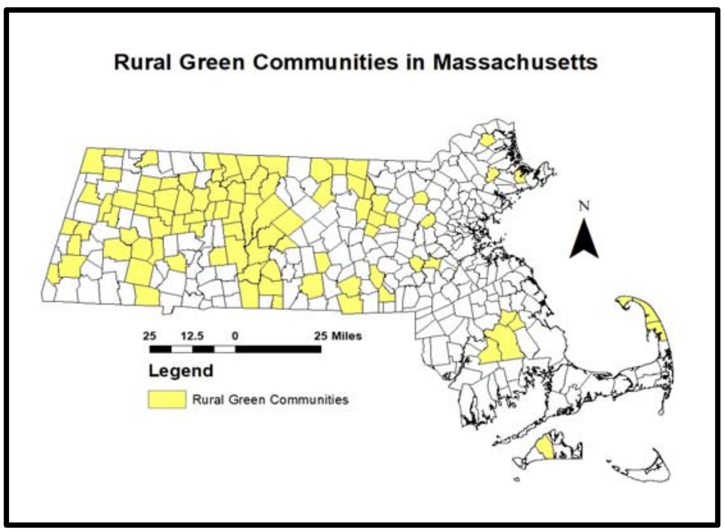


Figure 2: Rural Green Communities in Massachusetts.

2.2 Literature Review

An in-depth literature review was conducted primarily to address Objectives 1 and 2 outlined in **Section 1.2**. The literature came from a range of sources, including Department of Energy Resources (DOER) reports, handbooks, and guides, studies from the DOER Clean Cities Coalition, Federal Highway Administration reports, Environmental Protection Agency "verified technology" indexes, NPO studies, and relevant case studies in other jurisdictions. The goal of this literature review was to obtain a complete understanding of what fuel saving solutions are currently available, as well as the various challenges and successes experienced by fleets around the country in their fuel consumption reduction efforts. When possible, literature specifically addressing rural fuel consumption and/or municipal fuel consumption, particularly in reference to Massachusetts or New England, was sought out. However, some general resources related to fuel consumption were also used in circumstances where more granular data was not available.

2.3 Dataset Analysis

The findings in **Section 3** below were produced as a result of analyzing vehicle inventory and fuel consumption datasets created by the Green Communities Program and the DOER's MassEnergyInsight (MEI) tool.[3] After reviewing and organizing more than one million data points, we summarized our findings through the combination of text, maps, graphs, and tables presented in this report. While this data was most valuable in addressing Objectives 3 and 4, this information also informed Objective 1 by allowing us to identify trends and patterns of fuel consumption in municipal fleets (e.g., commonly acquired low fuel economy vehicles, departments that typically consume more, etc.).

The municipality-specific data contained in the Green Communities' vehicle inventory and fuel consumption datasets is recorded and submitted by representatives from each individual GC on an annual basis. As a result, there are occasional inconsistencies in data values and format. Conclusions drawn from these datasets and presented here have been produced from data that we have found to be accurate and self-consistent; data we found unclear or difficult to interpret were excluded from our analyses.

2.4 Vehicle Fuel Economy Data Table

Under the Green Communities Criterion 4: *Fuel Efficient Vehicle Policy*, some municipal vehicles are granted exemption from the minimum fuel economy requirements. Police cruisers, passenger vans, cargo vans, and all vehicles weighing more than 8500 pounds are exempt from the Green Communities' minimum fuel economy requirements, as outlined in **Table 1** below. Information in the column titled *Fuel Efficiency Percentile 2000-Present* was calculated using an exhaustive vehicle model list compiled by the Department of Energy's Office of Energy Efficiency and Renewable Energy, available on the *FuelEconomy.Gov* website. The raw vehicle list includes more than 40,000 vehicle models dating back to the mid-1980s. We narrowed this list to include only vehicles produced since 2000, in order to produce results more relevant to municipal vehicle acquisition. Before performing percentile calculations, we also excluded luxury brand passenger cars, as it is unlikely that municipalities are currently acquiring these vehicles. The brands excluded from these calculations were Alfa Romeo, Audi, Bentley, BMW, Cadillac, Jaguar, Lexus, Maserati, Mercedes-Benz, Porsche, and Tesla.

[3] MEI Homepage: https://www.massenergyinsight.net/home

Table 1: Green Communities' Fuel Economy Requirements for Non-Exempt Vehicles

Vehicle Type	Minimum MPG Requirement	Fuel Efficiency Percentile 2000-Present
2WD Passenger Car	29 MPG	80th
4WD Passenger Car	24 MPG	75th
2WD SUV	21 MPG	60th
4WD SUV	18 MPG	50th
2WD Minivan	20 MPG	60th
4WD Minivan	18 MPG	50th
2WD Pickup Truck	17 MPG	50th
4WD Pickup Truck	16 MPG	50th

3. Findings

3.1 Barriers to Fuel Use Reduction in Rural Municipalities

While rural communities experience a wide variety of unique obstacles that make achieving optimal vehicle fuel efficiency a challenge, this report categorizes some of the more common barriers into 4 groups:

Cost

A. Lack of Funding

The issue of cost is at the forefront of addressing vehicle fuel consumption in rural communities, both in the sense that many communities hope to reduce fuel consumption in an effort to save money, as well as the fact that a lack of funding in these communities often prevents them from achieving their desired fuel consumption reductions. Rural communities tend to have small populations, with fewer residents and businesses to provide a reliable tax base. With minimal funding at their disposal, many rural communities likely find it impractical to dedicate scarce tax dollars to energy efficiency measures such as upgrading functional vehicles in their fleet. Though it is crucial to acknowledge the monetary savings associated with reducing fuel consumption, and that investments in fuel efficiency often have a short payback period, it is understandable that many rural communities have other matters they find more pressing than fuel efficiency.

Recommended Strategies:

- *Develop tools for municipalities to estimate actual savings and payback periods for energy efficiency measures, to evaluate long-term savings.*

B. High Cost of Fuel-Efficient Vehicles (FEVs) and Green Technology

Recent technological advances in the field of transportation have included development of fuel-efficient hybrid and electric vehicles, and associated electric transportation infrastructure. However, many of these innovations come with large price tags. It is common for leading fuel efficient vehicles to cost significantly more than conventionally-fueled vehicles. For example, the starting MSRP for a conventionally fueled 2018 Kia Optima is $22,600, while the starting MSRP for the 2018 Kia Optima Plug-in Hybrid is $35,210 (55% more than the conventional option).[4] This higher initial purchasing cost is enough to deter many potential buyers, though a closer investigation reveals that the improved fuel economy could reduce fuel costs by more than $860 a year, and the Massachusetts Electric Vehicle Incentive Program (MassEVIP) offers up to $10,000 in rebates to municipalities that adopt electric vehicles, likely making the plug-in hybrid the cheaper option over the course of the vehicle's life.[5] [6] Nevertheless, the high initial purchasing cost of fuel efficient vehicles is an obstacle preventing many communities from achieving optimal fuel efficiency in their fleet. In an analysis of Green Communities' Criterion 4 published by Tufts University, a survey was distributed to numerous GCs, asking municipal representatives to identify some of the successes and obstacles they have experienced in their attempt to satisfy the Fuel Efficient Vehicle criterion. Cost was one of the primary barriers acknowledged by the surveyed communities, a number of which stated that "funding would be necessary for future acquisitions of hybrid or electric vehicles."[7]

The high cost of fuel efficient vehicles is not the only financial barrier preventing communities from optimizing their fuel efficiency; the various tools and training required for many departments to adopt new technology is also a major barrier. In the GCs survey described above, an equipment maintenance supervisor from one Massachusetts municipality commented on the unforeseen expenses the town experienced after purchasing a number of electric vehicles, including electric vehicle maintenance training courses and the purchase of new equipment required to safely work with the new vehicles. While this transition may be inevitable as electric vehicles become more common, these additional expenses may come as a surprise to some communities. Training and tool acquisition may prove to be a larger obstacle in rural communities than urban ones, as necessary resources and specialists are likely concentrated near more populated areas.

Recommended Strategies:

- *Estimate actual savings and payback periods for energy efficiency measures, to evaluate long-term savings.*
- *Identify and promote grant opportunities for fuel efficient vehicle purchases by municipalities.*
- *Fund incremental costs for purchases of hybrid and electric vehicles by municipalities.*
- *Provide state-sponsored free trainings in multiple regions of the state, regarding operation, safety, and regular maintenance of plug-in hybrid and electric vehicles.*

---

[4] Prices sourced from Kia.com

[5] Fuel savings calculated assuming average Massachusetts gas price during the creation of this report ($2.90), and 12,000 miles traveled annually.

[6] Good, Albert, et al. "Clean Green Driving Machines: Reducing Municipal Fuel Consumption". Tufts University - Graduate School of Arts and Sciences, 2018.

[7] Good, Albert, et al. "Clean Green Driving Machines: Reducing Municipal Fuel Consumption". Tufts University - Graduate School of Arts and Sciences, 2018.

Available Resources

A. Lack of Alternative Fueling Infrastructure

While alternative fuels, ranging from electricity to compressed natural gas (CNG), have the potential to significantly reduce the consumption of traditional vehicle fuels in rural Massachusetts, the current availability of alternative fueling stations in the state is a major barrier to the adoption of alternatively fueled vehicles in rural communities. While Massachusetts ranks among the top 10 states with the most alternative fueling stations (having more than 1,500 alternative fueling resources statewide), these fueling stations tend to be concentrated around urban centers such as Boston, and Worcester, therefore failing to adequately serve isolated rural communities.[8]

It is also important to note that more than 96% of those alternative fueling resources in the state are electric vehicle charging stations. While still largely concentrated around urban centers, electric charging stations are becoming more and more abundant throughout the Commonwealth, including in rural communities. Between 2011 and 2016 alone, the number of public EV charging stations in Massachusetts grew by more than fifteen-fold, a crucial step towards reducing vehicle fuel consumption in the state.[9] However, with all other forms of alternative fuel making up less than 4% of alternative fueling stations across the state, these opportunities to reduce fuel consumption remain impractical for many communities, due to lack of fueling infrastructure. In fact, as depicted in **Figure 3**, apart from electric vehicle charging stations and a single propane fueling station in Springfield, there are no alternative fueling resources in Western Massachusetts, where the majority of the state's rural communities are located.

Alternative fuels such as biodiesel, CNG, ethanol, hydrogen, and liquefied natural gas (LNG) have the potential to be valuable alternatives to standard vehicle fuels, as they currently have the ability to power many of the larger vehicles that frequently make up large percentages of rural vehicle inventories, and often cannot be substituted with electric vehicles. For this reason, a lack of alternative fueling infrastructure in Massachusetts is a major barrier to reducing vehicle fuel consumption, especially for rural communities.

Recommended Strategies:

- *Evaluate costs and potential utilization of alternative fuel dispensaries for rural communities.*
- *Focus on hybrid and electric vehicles for rural communities when applicable.*

---

[8] "Alternative Fueling Station Counts by State". U.S. Department of Energy - Alternative Fuels Data Center, 2018.
[9] Wagner, Fred, et al. "Massachusetts Plug-in Electric Vehicle and Charging Infrastructure Case Study". Idaho National Laboratory, 2016.

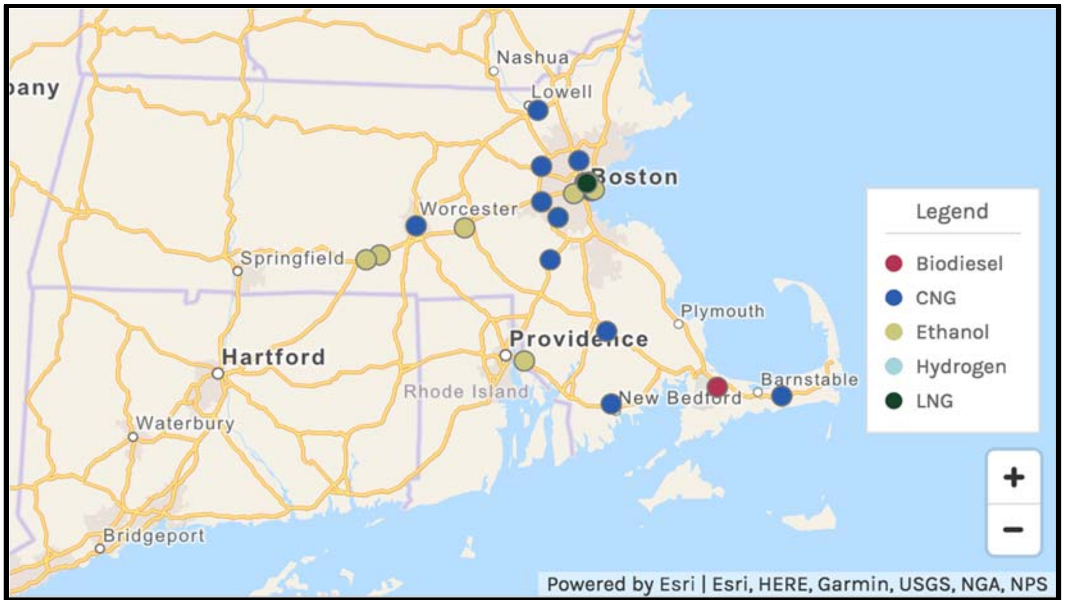


Image sourced from the Department of Energy's Alternative Fuels Data Center

Figure 3: Non-electric alternative fueling stations in Massachusetts

B. EV Charging Capability

One important consideration for municipalities hoping to adopt electric vehicles into their fleet is the existing electrical infrastructure at the municipal garages in question. As charging an electric vehicle increases the electrical load that the building needs to facilitate, some older buildings with inadequate wiring may run into difficulty in charging electric vehicles. While the majority of buildings can support level 1 charging stations, the added demand associated with level 2 and DC fast charging stations may require modification of the building's existing electrical infrastructure, therefore potentially making these stronger charging stations impractical (for more information on the different types of EV charging stations, see **Section 1** of **Appendix** A). While many buildings can likely facilitate most forms of charging stations, it is important for municipalities to have a professional electrician verify the building's compatibility before installing a charging station. That being said, level 1 charging stations may be the most affordable and practical choice for many municipalities. Level 1 charging stations operate at 120v, the same voltage as a standard household outlet, allowing municipal vehicles to be charged slowly over night (therefore putting minimal strain on the electrical infrastructure of the building), so that the vehicles are fully charged and ready for use at the start of each day.

Recommended Strategies:

- *Consult an electrician about implementing an EV charging station prior to installation.*
- *Consider utilizing level 1 charging stations for electric municipal vehicles.*

Vehicle Performance Requirements

A. Inclement Weather and Rough Terrain

Massachusetts is known for its unpredictable weather, and notably cold and snowy winters. Climate change is expected to exacerbate treacherous winter conditions: Boston had 4 of its 5 snowiest winters in the past 25 years alone, including a record breaking 110+ inches of snow in the winter of 2014-2015.[10]

According to the National Climatic Data Center[11], it snows an average of 22.4 days a year in Massachusetts, meaning that snow plows around the Commonwealth stay busy clearing the more than 36,000 miles of road in the state.[12] Plowing accounts for a large proportion of municipal fuel consumption during the winter months, even more so if plowing routes and clearing techniques are not optimized. Rural communities are often affected more drastically by plow-related fuel consumption, as long stretches of rural roads frequently have to be serviced by just a handful of plows.

Plowing is not the only barrier to reducing municipal fuel consumption brought about by winter in Massachusetts. Dangerous road conditions create a necessity for all wheel drive (AWD) and four wheel drive (4WD) vehicles in many communities. This is an obstacle for a number of reasons, including: a) AWD/4WD vehicles typically consume more gas than their front wheel drive (FWD) and rear wheel drive (RWD) counterparts, b) AWD/4WD vehicles are typically more expensive than their FWD and RWD counterparts, and c) many fuel efficient vehicle types, such as fully electric vehicles and plug-in hybrids, are rarely offered in AWD/4WD.

Massachusetts winters also can pose a barrier to adoption of alternative-fuel vehicles. Researchers at the Idaho National Laboratory found that the range of a plug-in electric vehicle can be reduced by more that 25% in cold weather conditions.[13] Though it is worth noting that this study was performed 5+ years ago, and new advancements in electric vehicle technology may help to reduce winter range reductions. Vehicles fueled by high blend levels of biodiesel also experience issues in cold climates. Biodiesel can solidify in below freezing temperatures, forcing these vehicles to reduce the concentration of biofuel in their diesel mixes to as low as 5% (B5) during winter months.[14]

Recommended Strategies:

- *Optimize snowplow routes to the most efficient/shortest path (e.g., avoid plow overlap or "doubling back" when possible, plan out routes ahead of time, etc.).*
- *Be on the lookout for emerging fuel efficient vehicles rated for winter conditions.*

B. Availability of Retrofits

While retrofitting vehicles with green aftermarket parts, such as idle reduction technology or hybrid conversion systems (further explained in **Section 3.2**), can present fleets with a valuable opportunity to

---

[10] Erdman, Jon. "New England Record Snow Tracker: Boston Breaks All Time Seasonal Snow Record in 2014-2015". The Weather Channel, 23 March 2015.

[11] Arguez, Anthony, et al. "1981-2010 U.S. Climate Normals." *National Centers for Environmental Information*, National Oceanic and Atmospheric Administration, 2010.

[12] "2016 Massachusetts Road Inventory Year End Report." Federal Highway Administration - Massachusetts Department of Transportation, 2016.

[13] "Maximizing Electric Cars' Range in Extreme Temperatures". U.S. Department of Energy - Office of Energy Efficiency and Renewable Energy, accessed August 2018.

[14] "Greening the Corporate Fleet Transition Strategy". The City of Burlington, Ontario. May 2008.

improve fuel efficiency without sacrificing vehicle performance and functionality, the practicality of these retrofits is limited by the compatibility of the vehicle in question. Though these various forms of retrofits can be applied to a wide range of vehicle types, it can be difficult to find worthwhile retrofits for certain vehicle models. For example, the Ford F350 is a common pickup truck among municipal fleets in Massachusetts, due to its large truck bed and high towing capacity, however, while hybrid conversion systems can be implemented in smaller F150 and F250 models, there appear to be no readily available hybrid conversion options for the F350. There are other possible retrofit solutions compatible with the F350 (e.g., non-electric alternative fuel conversions, idle reduction technology, low resistance tires, etc.), but the range of potential solutions is narrower, making identifying practical solutions more difficult for municipalities.

Recommended Strategies:

- *Right-size fleets through diagnosing the specific tasks necessary for each vehicle to perform, and then utilizing the most efficient vehicle available that meets said requirements.*
- *Seek out fuel reduction technologies that apply to heavy-duty vehicles.*

C. Large Number of Utility Vehicles

One important characteristic of municipal fleets in rural communities is that large utility vehicles frequently make up a significant percentage of the total fleet. This poses a challenge for two reasons: 1) these utility vehicles are frequently either over 8,500 pounds, or emergency vehicles, meaning that they are exempt from the Green Communities' fuel efficiency policy (described further in **Section 4**), and 2) large utility vehicles are often are used to perform tasks that most other vehicles cannot (e.g., towing, plowing, demolition, etc.). As vehicles with high power demands, they also typically have poor fuel economy, and can therefore account for a large proportion of vehicle fuel consumption in a given community. While there are a number of approaches that fleets can take to improve the fuel economy of these low fuel economy vehicles (see **Section 3.2**), the abundance of these large utility vehicles makes achieving a significant reduction in vehicle fuel consumption a challenge. Where a small passenger vehicle can relatively easily be substituted with a fuel efficient alternative without sacrificing functionality, this transition is not as easily achieved with large utility vehicles. Importantly, improving the fuel economy of vehicles with low initial MPG even incrementally makes a significantly larger marginal difference in fuel savings than a slight improvement in an average or high fuel economy vehicle (see **Figure 7**). Communities have a lot to gain from targeting these inefficient vehicles for replacement or modification.

Recommended Strategies:

- *Identify heavy-duty vehicles which are most efficient for their class and capabilities (e.g., plowing ability, towing capacity, etc.).*
- *Aim to utilize smaller, more fuel efficient vehicles when possible (e.g., avoid using large utility vehicles on lightweight tasks).*

D. Unfamiliarity with "Green" Technology

One notable deterrent preventing communities from achieving optimal fuel efficiency is a hesitation to adopt new technology among drivers and fleet managers. In Massachusetts communities, the vehicle selection process for municipal fleets is largely up to fleet managers, select boards, and other local leaders, meaning that there are minimal federal or state level restrictions as to which vehicles communities are allowed to acquire. While this approach enables communities to select the vehicles that they view as the best fit for their unique situation, the success of this policy is based around the assumption that decision-making parties are well aware of all potential options. That may not always be the case. In addition, veteran fleet managers may be reluctant to adopt unfamiliar or "unproven" technologies, and may opt to purchase conventionally-fueled vehicles, which have performed adequately in the past.

Recommended Approaches: Educate community decision-makers regarding the wide variety of fuel efficient vehicles and technologies available. Make sure that the vehicle selection process is not rushed. Provide municipal decision makers with a personalized education regarding new technologies. For example, the opportunity to test drive unfamiliar vehicles, or connecting hesitant parties with nearby municipalities that have adopted new technologies, may alleviate concerns.

Policy Challenges and Opportunities

A. High Vehicle Exemption Rates

Under the Green Communities' Criterion 4: *Fuel Efficient Vehicle Policy*, a significant percentage of vehicles are granted exemption from the minimum fuel economy requirements. Police cruisers, passenger vans, cargo vans, and all vehicles weighing more than 8500 pounds are exempt from Green Communities' minimum fuel economy requirements, as outlined in **Table 1** above. While in 2016, the Green Communities Program reported that "roughly 75%" of municipal vehicles were classified as exempt, across 48 rural GCs studied for this report, the average exemption rate was 93%, meaning that out of 1600+ municipal vehicles, less than 150 were subject to minimum MPG requirements.[15] With such a small fraction of municipal fleets bound to fuel efficiency standards, it is easy to see why reducing vehicle fuel consumption has been such a challenge for many GCs.

While fuel economy requirements are one policy approach to cutting fuel consumption across the non-exempt vehicles, the Green Communities Program has also established an "alternative compliance" pathway for communities with high vehicle exemption rates. To achieve alternative compliance, a community must submit a plan outlining how they will reduce their vehicle fuel consumption, using methods other than replacing their vehicles (e.g., creating a bike-share program, installing electric vehicle charging stations, etc.). Alternative compliance is a promising method of reducing vehicle fuel consumption in communities with high exemption rates, however, only communities with 100% exempt fleets (a mere 13 communities as of 2016) are required to participate in the alternative compliance pathway. This means, even if a community's fleet includes only one non-exempt vehicle, the community is not required to take any further action to reduce vehicle fuel consumption. Under the existing policy, municipalities with high exemption rates may have little motivation to expand their fuel efficiency efforts.

Recommended Strategies:

- *Expand the alternative compliance planning requirements to all new GCs.*
- *Update Green Communities' exemption protocol to include only vehicles deemed absolutely necessary, perhaps determined on a case by case basis.*

[15] "Green Communities Program 2016 Progress Report". *Massachusetts Department of Energy Resources,* Synapse Energy Economics, Inc., December 2017.

B. Lenient Fuel Economy Requirements

Non-exempt vehicles in GCs, while representing a small portion of total municipal vehicles, are subject to minimum MPG requirements, as outlined in **Table 1** above. Communities with non-exempt vehicles that fail to meet these minimums are required to submit "corrective action plans", detailing why they failed to meet the standards and how they plan to avoid similar issues in the future. However, the minimum MPG requirements established by the Green Communities Program are relatively lenient. Passenger cars are required to fall in the 75th and 80th percentiles of efficiency, but the fuel economy requirements for all other vehicle types fall around the 50th/60th percentile, meaning that 40-50% of all SUVs, minivans, and pick-up trucks produced in the last 18 years have superior fuel economy than that required by Green Communities Program standards. It is also worth noting that these mandatory minimums have not been adjusted since 2012, despite the fact that the average fuel economy of new vehicles has been increasing by roughly .5 MPG every year since 2004.[16] . The number of fuel efficient vehicle models available on the market has also been rapidly increasing: Since 2012, the number of SUV models with 25 MPG or better fuel economy has more than doubled, and so has the number of passenger car models capable of at least 40 MPG, but nevertheless, the mileage requirements of the Green Communities Program have not changed in over half a decade.

Recommended Strategy:

- *Increase fuel economy standards for non-exempt vehicles.*

3.2 Fuel Saving Solutions

Fuel Efficient Vehicle (FEV) Purchase

Fully Electric Vehicles

Applies to: Administrative vehicles, or other non-utility passenger vehicles.

Fully electric vehicles, as the name implies, are powered entirely by electricity, as opposed to conventional fuels such as gasoline or diesel. Fully electric vehicles are classified by the EPA as "zero-emissions vehicles" (ZEVs), proving to be a promising technique for municipalities to reduce the GHG emissions associated with transportation. They can be charged using the standard 120V outlets found in most homes and businesses (known as level 1 charging stations), through specialized 240V electric charging stations (known as level 2 charging stations), or at DC fast charging stations which have a capacity of up to 600V. Collectively, Massachusetts has more than 1,450 non-residential EV charging outlets, making EVs the most practical alternatively fueled vehicles for many Massachusetts communities.[17] For departments hoping to install EV charging stations in the workplace, outlets can be implemented in most buildings with relative ease (see **Section 2B**).

While it is not uncommon for fully electric vehicles to have higher initial purchase costs relative to conventionally fueled vehicles, electric vehicles and EV charging stations are frequently incentivized by both state and federal entities, often alleviating any difference in initial cost (For more information on EV incentives and rebates, see **Section 2** of **Appendix A**). Fully electric vehicles also have a considerably lower cost of operation. The Department of Energy (DOE) has created a metric known as the "eGallon", as a tool to help consumers compare the operation costs of electric and conventional vehicles. Calculated using the average fuel economy of current passenger vehicles, the average kWh price, and the average fuel economy of top selling electric vehicles, the price of one eGallon can be compared side by side with the price of gasoline or diesel. At the time of the creation of this report,

[16] "Light-Duty Vehicle CO2 and Fuel Economy Trends". U.S. Environmental Protection Agency, May 2018.
[17] "Alternative Fueling Station Counts by State". U.S. Department of Energy - Alternative Fuels Data Center, 2018.

the DOE reported that the national average price of one eGallon is $1.17, less than half the national average price of gasoline at $2.87.[18] Annual maintenance costs of fully electric vehicles also tend to be lower than conventional vehicles. A 2017 study conducted by AAA, comparing the maintenance costs of EVs and conventionally fueled vehicles, found that electric vehicles typically save drivers around 17%, or a little more than $200, in maintenance costs annually.[19]

The operational cost of electric vehicles is also typically more stable than conventional fuels. The price of gasoline and diesel can fluctuate dramatically with changes in international market conditions. As gas prices go up, the average citizen will drive less as a result.[20] However, as municipal fleets are obligated to serve the public and continue business as usual regardless of gas price, these fluctuations in cost can take a toll on municipal budgets. Because the majority of electricity in the United States is produced domestically, the price of a kWh is more stable than the price of petroleum, and electric vehicles can be charged at more reliable and consistent rates.

While limited range can be a downside to fully electric vehicles, the average range of electric vehicles has been steadily increasing over the last several years, and electric vehicle models such as the 2018 Chevy Bolt EV have ranges of over 235 miles on a full charge. While reduced range may deter some potential buyers, fully electric vehicles may be a promising option for municipal departments. For municipal vehicles which rarely travel far outside the boundaries of a given community, a slight reduction in potential range may be a worthwhile price to pay in exchange for significant savings in fuel expenses. Fully electric vehicles can be charged overnight, and be ready for use first thing in the morning, without the need to travel to a fueling station.

Hybrid Electric Vehicles

Applies to: Hybrid electric vehicles come in many forms (e.g., sedans, minivans, pickup trucks, buses, etc.), and as such are a promising option for a wide variety of municipal uses.

Hybrid electric vehicles (not to be confused with plug-in hybrid electric vehicles) are internal combustion engine vehicles (ICEVs) that feature an additional small electric motor and battery. The battery is charged through regenerative braking, meaning that every time the driver applies the brakes, some of the momentum that the car has gained during its acceleration is captured and stored in the battery to be utilized later by the electric motor. The electric motor allows for better fuel economy and reduced emissions, providing the driver with the range and power confidence of a conventional vehicle, while also providing cost savings and environmental benefits. While hybrid electric vehicles have more parts than conventional vehicles, generally no additional maintenance is required to maintain the hybrid components, and many manufacturers offer 8-10 year warranties on hybrid batteries.[21] Though hybrid electric vehicles, as with most electric vehicles, tend to have higher initial purchasing costs than conventional ICEVs, the cost savings accrued from the improved fuel economy quickly account for the price difference. The availability of state and federal incentives should also be taken into account when comparing the price of a hybrid electric vehicle to a conventional vehicle (For more information on EV incentives and rebates, see **Section 2** of **Appendix A**). It is also worth noting that current trends in battery pricing indicate that many electric vehicles could have lower initial purchasing costs than conventionally fueled vehicles by as early as 2025.[22]

---

[18] Leistikow, Dan. "The eGallon: How Much Cheaper Is It to Drive on Electricity?". U.S. Department of Energy, June 2013 (Updated July 2018).

[19] "Your Driving Costs: How Much Are You Really Paying to Drive?". American Automobile Association, 2017.

[20] "Fact #906: VMT and the Price of Gasoline Typically Move in Opposition". U.S. Department of Energy - Office of Energy Efficiency and Renewable Energy, January 2016.

[21] "The Real Costs of Owning an Electric Vehicle". Edmunds, September 9th 2013.

[22] "Electric Vehicles to Accelerate to 54% of New Car Sales by 2040". Bloomberg NEF, July 2017.

Plug-in Hybrid Electric Vehicles

Applies to: All municipal vehicles deemed appropriate by fleet managers. Currently, most PHEVs are best fit for light-duty uses, though more diverse and powerful PHEVs are rapidly emerging.

Plug-in hybrid electric vehicles (PHEVs) combine favorable aspects of both fully electric vehicles and hybrid electric vehicles. Plug-in hybrids utilize both gasoline and electricity to power the vehicle, meaning that both an internal combustion engine and an electric motor are contained within the vehicle. As with fully electric vehicles, PHEVs can be charged using level 1, level 2, or DC fast charging stations, though many PHEVs also utilize regenerative braking to charge their batteries. As described above, there are more than 1,450 non-residential EV charging outlets in Massachusetts, and this number is growing rapidly, making EVs the most practical alternatively fueled vehicles for many Massachusetts communities.

The ratio of electricity-based versus gasoline-based power supply varies among PHEV makes and models, largely depending on the "all-electric range," and the power configuration of the vehicle. PHEVs are typically classified as either having "parallel" or "series" power configurations: *Parallel* configuration means that both the electric motor and the internal combustion engine (ICE) have the ability to directly propel the vehicle, alternating between power sources when appropriate, while a PHEV with a *series* configuration is entirely propelled by the electric motor, utilizing the ICE to supply additional power to the battery, essentially acting as a gas-powered generator. While both forms of PHEV configurations offer superior fuel economy to most conventional vehicles, it is important for municipalities to identify which configuration is optimal for their situation prior to purchase.

PHEVs typically have larger batteries than non-plug-in hybrids, meaning that their fuel economy tends to be superior, by having a larger electricity reservoir to draw from rather than relying heavily on gasoline. Plug-in hybrids are a great compromise for those hoping to reduce vehicle fuel consumption, but hesitant to adopt a fully electric vehicle due to range limitations. Newer PHEVs can have all-electric ranges of more than 50 miles, meaning that on a full charge, upwards of 50 miles can be traveled without using any gas. Without charging the battery prior to use, many PHEVs will simply perform as if they are non-plug-in hybrids, using gasoline as the primary energy source, and utilizing regenerative braking to recharge the electric motor's battery.

As with fully electric vehicles and hybrid electric vehicles, PHEVs tend to have higher initial costs than conventionally fueled vehicles, though it is important to also take into account the fuel cost savings associated with these fuel efficient vehicles, as well as the numerous state and federal incentives available for EVs and EV charging station purchase. PHEVs have great potential to reduce vehicle fuel consumption and the associated costs within a municipal fleet. As with fully electric vehicles, the relatively small radius of travel necessary for many municipal vehicles is the ideal setting for PHEVs, as a large portion of miles driven each day have the potential to be powered entirely by electricity, for just pennies per mile.

Non-Electric Alternative Fuel Vehicles

Applies to: Large utility vehicles, where adopting electric vehicles is impractical.

Apart from electric vehicles, there are a number of additional alternative fuels that also have the potential to reduce vehicle fuel consumption in rural municipalities, most notably: propane, biodiesel, natural gas, ethanol, and hydrogen. These alternative fuels have been separated from electricity in this report, due to the practicality of adoption at the present time: As discussed in **Section 3.1**, there is a lack of supporting infrastructure in Massachusetts for many of these fuel types. However, as these alternative fuels still offer a number of benefits over conventional gasoline and diesel, they have been included in the eventuality that the necessary infrastructure becomes available, or in the case that supporting infrastructure is cost-effective enough to install at the municipal level. For brief descriptions and comparisons of these five fuel types, please see **Section 3** of **Appendix A**).

Fuel Efficiency in Internal Combustion Engine Vehicles (ICEVs)

Applies to: All departments, particularly those where alternatively fueled vehicles are impractical.

Where adopting alternatively fueled vehicles is impractical, substantial fuel consumption reductions can also be achieved by acquiring conventionally-fueled vehicles with high fuel economy. As demonstrated in **Table 2** and **Figure 7**, an improvement of even 1 MPG can save communities upwards of a thousand dollars over the lifespan of a vehicle, making it extremely important for municipalities to research and identify the most fuel efficient vehicle available for the task at hand, prior to purchase. Whether or not the vehicle in question is exempt from the minimum fuel economy requirements established by the Green Communities Program, maximizing fuel economy without sacrificing performance should help inform the purchase of all municipal vehicles. As discussed in **Section 3.1**, the MPG minimums for non-exempt vehicles outlined by the Green Communities Program are fairly lenient. We recommend that communities should aim to exceed rather than to meet GC requirements, taking the time to consider the savings associated with superior fuel economy. Municipalities should also consider utilizing the Massachusetts state contract VEH98 to identify fuel efficient vehicles available at a discounted rate.

Table 2: Cost savings associated with improved gas mileage.

Vehicle Type	GC Non-Exempt MPG Minimum	Avg. Price of Gas in MA (July 2018)	Annual Gas Expenditure*	Annual Cost Savings Associated with +1 MPG	Annual Cost Savings Associated with +3 MPG	Annual Cost Savings Associated with +5 MPG	Annual Cost Savings Associated with +10 MPG
2WD Passenger Car	29	$2.90	$1,198	$39	$112	$176	$307
4WD Passenger Car	24	$2.90	$1,448	$57	$160	$249	$425
2WD SUV	21	$2.90	$1,654	$75	$206	$318	$533
4WD SUV	18	$2.90	$1,930	$101	$27	$419	$689
2WD Minivan	20	$2.90	$1,737	$82	$226	$347	$579
4WD Minivan	18	$2.90	$1,930	$101	$275	$419	$689
2WD Pickup Truck	17	$2.90	$2,044	$113	$306	$464	$757
4WD Pickup Truck	16	$2.90	$2,172	$127	$342	$517	$835

*Assuming 12,000 miles per year

Vehicle Retrofits

Vehicle Telematics Systems

Applies to: All departments / All vehicle types.

Retrofitting a vehicle with a telematics system is a simple and efficient method of analyzing numerous vehicle characteristics at one time, in an easy to digest manner. Telematics systems are small after-market computers that can be installed in most vehicle makes and models to measure aspects of performance and operation, by monitoring a wide range of variables such as speed, rate of acceleration/deceleration, location, and engine diagnostics. This analysis is then reported in a convenient online format, allowing fleet managers to pinpoint potential areas of inefficiency, and determine effective solutions. For example, the analysis may reveal that drivers are taking suboptimal routes, driving dangerously or inefficiently, spending long periods of time idling, that the vehicle is overdue for maintenance, or other valuable diagnostics. For a more in-depth look at the potential benefits of vehicle telematics systems, see **Section 4** of **Appendix A**).

Hybrid Conversions

Applies to: All departments, particularly those with larger vehicles that are not available as stock hybrids (e.g., DPW, HWY Dept., Transit, Waste Management).

Hybrid conversions are one option to reduce vehicle fuel consumption without sacrificing vehicle performance. While stock electric vehicles are commonly smaller passenger vehicles, and therefore impractical as replacements for heavy duty vehicles, hybrid conversions enable fleets to convert vehicles that are unavailable as stock EVs into hybrid vehicles. Among others, large pickup trucks, cargo vans, delivery trucks, buses, ambulances, and garbage trucks, can all be modified using hybrid retrofits to improve fuel economy by up to 50%.[23] As these large utility vehicles tend to have poor fuel economy and few practical alternatives, hybrid conversions offer an opportunity to cut fuel costs while maintaining functionality.

Hybrid conversions come in a number of styles, largely depending on vehicle type. Vehicles can be converted to conventional hybrids, meaning that a secondary electric motor and battery are installed, utilizing regenerative braking to charge the battery. Vehicles can also be converted to plug-in hybrids, meaning that in addition to a secondary electric motor and battery, a charging port is also installed, allowing the vehicle operator to charge the vehicle at a level 1, level 2, or DC charging stations, as they would with a stock PHEV or fully electric vehicle. Lastly, large vehicles such as garbage trucks, construction equipment, and buses can utilize hydraulic hybrid retrofits, meaning that regenerative braking is utilized, not to recharge a battery, but instead to build pressure in a compressed nitrogen tank called an accumulator. Hydraulic hybrids use the pressure stored in the accumulator to propel the vehicle after stops, providing significant fuel saving for vehicles that make frequent stops such as buses or garbage trucks. The city of Cambridge recently installed a hydraulic retrofit on one of their municipal garbage trucks, saving more than 800 gallons of fuel annually, and reducing the truck's GHG emissions by 50-90%.[24]

Idle Reduction Technology (IRT)

Applies to: Departments with vehicles that make frequent stops, or require auxiliary equipment while parked (e.g., Emergency vehicles, buses, delivery vehicles, construction vehicles).

The U.S. Department of Energy reports that idling for 1 hour can burn up to one gallon of fuel, and over the course of weeks, months, or years, idling can prove to be a major source of fuel consumption, especially for municipal fleets.[25] For example, a recent Argonne National Laboratory report studying police cruiser fuel use found that a single police cruiser can spend up to 60% of a normal operation period idling, wasting 21% of the total fuel reserve while parked.[26] Police vehicles frequently require the use of on-board appliances such as computers and lights while parked. These appliances typically only require around 2hp of energy to operate, however, police vehicles are typically capable of generating up to 250hp during operation, and as such, frequently produce more energy than necessary while idling. With the help of idle reduction technology (IRT), idling can become an avoidable source of pollution and fuel consumption.

Idle reduction technology is the most commonly adopted alternative compliance method in Massachusetts, and while IRTs come in many different forms, all share a common goal of reducing or eliminating long periods of unnecessary idling in vehicles or heavy duty machinery. Once installed, IRTs reduce idling in one of two ways: 1) Supplying an alternative source of energy to the vehicle/machine so that on-board equipment can be used without

---

[23] "Revolutionary Simplicity for Hybrid Electric and Plug-in Hybrid Systems". XL Hybrids Inc., accessed August 2018.
[24] Good, Albert, et al. "Clean Green Driving Machines: Reducing Municipal Fuel Consumption". Tufts University - Graduate School of Arts and Sciences, 2018.
[25] "Fact #861: Idle Fuel Consumption for Selected Gasoline and Diesel Vehicles". U.S. Department of Energy - Office of Energy Efficiency and Renewable Energy, February 2015.
[26] Rask, Eric, et al. "Final Report: Police Cruiser Fuel Consumption Characterization, for the Illinois State Toll Highway Authority". Argonne National Laboratory, February 2013.

the need to keep the main engine running, or 2) Detecting when an engine has been idling for longer than a predetermined period of time and then automatically powering down the engine. These two differing approaches to idle reduction correlate with the two most common reasons for idling: 1) the need for vehicle appliances/function when in a stationary setting (e.g., hazard lights on construction vehicles, or temperature control and on-board computers in parked emergency vehicles), and 2) forgetfulness/habit (e.g. a driver on break).

Idle reduction technology has great potential to generate fuel cost savings in a wide range of applications. For example, a case study of Canyon County, Idaho reported that after adopting IRT in 60 police vehicles, the fuel economy of each cruiser increased by 4-6 MPG, equivalent to 36 additional miles of range per day. Across the 60 vehicles, these savings add up to approximately $129,000 and 1.4 million pounds of CO2 emissions per year.[27] Since IRTs come in many different forms, the majority of vehicles can be retrofitted with at least one form of the technology. UMass CEE has produced an Idle Reduction Technology Fact Sheet, outlining the different types and applications of common IRTs to help municipalities identify the best option for their particular circumstance, available in **Section 5** of **Appendix A**).

Non-Electric Alternative Fuel Conversions

Applies to: Departments with large vehicles that are commonly unavailable in electric/hybrid form (e.g., DPW, HWY Dept., Fire, Transit).

Similarly to hybrid conversions, non-electric alternative fuel conversions are one approach that fleets can take to reduce vehicle fuel consumption without sacrificing vehicle performance and functionality. For municipalities hoping to adopt alternatively fueled vehicles in their fleet, without necessarily purchasing a new vehicle, converting an existing municipal vehicle to run on alternative fuel may be a more affordable approach. Many vehicles can be converted to run on LNG, CNG, propane, ethanol, or other alternative fuels, allowing fleets to reduce pollution and avoid consumption of costly conventional fuels.

Vehicles can also be converted to run as *bi-fuel vehicles*. Bi-fuel vehicles utilize multi-fuel engines, capable of running on both the selected alternative fuel (typically natural gas or propane), as well as a conventional fuel such as gasoline or diesel. This flexibility in fueling allows the driver to alternate between fuels as needed, reducing gasoline or diesel consumption without becoming entirely reliant on an alternative fuel. However, the current lack of non-electric alternative fueling stations in rural Massachusetts may limit the practicality of adoption for many communities unless the necessary infrastructure is established first.

Behavior & Management Adjustments

Proactive Vehicle Maintenance

Applies to: All departments / All vehicle types.

Regular vehicle maintenance is an easy, inexpensive, and effective way to improve fuel economy and extend the life of any vehicle. Taking measures such as keeping an engine properly tuned, making sure tires are properly inflated, performing regular oil changes, and using the recommended grade of motor oil can improve a vehicle's fuel economy by up to 9%, as well as prevent costly repairs down the road.[28] Typically, following the manufacturer's maintenance recommendations will result in optimal performance for any given vehicle. By

[27] Good, Albert, et al. "Clean Green Driving Machines: Reducing Municipal Fuel Consumption". Tufts University - Graduate School of Arts and Sciences, 2018.

[28] "Gas Saving Tips". U.S. Department of Energy - Office of Energy Efficiency and Renewable Energy, July 2012.

establishing a maintenance schedule for each vehicle in a fleet, municipalities can enhance fuel economy at little cost.

<u>"Green" Driving Techniques</u>

Applies to: All departments / All vehicle types.

Adopting good driving habits is another easy, inexpensive, and effective way to reduce fuel consumption. Aggressive driving habits, such as speeding, rapid acceleration, and abrupt braking, can reduce fuel economy by up to 33%.[29] Excess weight on a vehicle can also reduce fuel economy by 1-2% per 100 lbs, and a loaded roof rack can reduce fuel economy by around 5% due to aerodynamic drag. Removing unnecessary equipment or loads as soon as practical can provide significant energy savings. Avoiding wasteful driving habits is a guaranteed way to improve fuel economy at little cost. Municipal fleets can encourage green driving by educating all drivers on efficient driving practices through department workshops or distributing informational documents. The University of Vermont offers an online "Eco-Driving 101" course to aid in this process, available here:
http://www.erating.org/transportation-company-education/courses

<u>Route Optimization</u>

Applies to: All departments / All vehicle types, particularly those with fixed routes (e.g., Buses, delivery trucks, snow plows).

Selecting the shortest possible route between two points can minimize the amount of fuel consumed on a trip, saving both time and money. Route optimization is especially important in fleets with fixed routes, such as delivery trucks, snow plows, and school/transit buses. While professional route optimization services are available, many telematics and GPS systems can also effectively map out the shortest route to a destination. For example, a study based out of The University of Vermont found that after adopting GPS-based route optimization, snow plows across 9 states were able to reduce their route length by 5-10% on average, providing their communities with safe road conditions in a timely and cost-effective manner.[30] Whether or not a community chooses to take the professional approach to route optimization by hiring a consultant, or implementing route optimization technology, taking the time to effectively plan a vehicle's route is a great way to reduce fuel consumption for any fleet.

<u>Fleet Rightsizing</u>

Applies to: All departments / All vehicle types.

Vehicle rightsizing is simply ensuring that the size of a vehicle (or vehicle fleet) corresponds appropriately with the tasks that it performs. By using small, fuel efficient vehicles whenever possible, and only using larger, less efficient vehicles when absolutely necessary, excessive fuel consumption can be avoided. Fleet rightsizing can be applied in day-to-day tasks (e.g., choosing to use a small sedan to run errands around town, rather than a large truck or van) or in assessing fleet composition as a whole (e.g., replacing larger vehicles with adequately-sized alternatives). For example, the City of Burlington, Ontario replaced an unnecessarily large van, with a slightly smaller and more efficient model, improving fuel efficiency for that vehicle by 40%.[31] Vehicle rightsizing should

[29] "Gas Saving Tips". U.S. Department of Energy - Office of Energy Efficiency and Renewable Energy, July 2012.
[30] Dowds, Jonathan, et al. "Identifying Best Practices for Snowplow Route Optimization". Saint Paul, MN: Transportation Research Center, University of Vermont, 2016.
[31] "Greening the Corporate Fleet Transition Strategy". The City of Burlington, Ontario. May 2008.

always be considered when choosing a vehicle for daily tasks, as well as in the research phase prior to purchasing a new vehicle.

Fleet Coordination

Applies to: Departments with particular vehicles or equipment that is used infrequently (e.g., DPW, HWY Dept.).

While not the most practical solution for every fleet, many small communities have had success in maximizing fleet efficiency by sharing certain vehicles with neighboring municipalities. By sharing graders, bulldozers, backhoes, or other vehicles deemed applicable among multiple communities, smaller municipalities that may struggle to afford additional vehicles, or do not need to possess a specific vehicle year-round, may benefit by having these vehicle resources available to them at a cost lower than sole ownership. For example, in Sweetwater County, Wyoming (an area roughly the size of Vermont), 12 vehicles are shared across 20 different agencies, including a child development center, a counselling service, two senior centers, a youth home, and a nursing home. These vehicles are managed by a centralized dispatch center, utilizing an automated dispatching system, where a department can request a vehicle, and the nearest available vehicle will be presented.[32] Franklin and Hampshire counties currently have a highway collective purchasing programs where materials such as fuels and road salt are purchased in bulk and shared amongst a number of municipalities, this program could potentially adapt to facilitate vehicle sharing as well.

Anti-Idling Policies

Applies to: All departments / All vehicle types.

Unnecessary idling of a vehicle is a wasteful and costly practice that harms both the vehicle and the environment; in fact, it is against the law to idle for longer than 5 minutes in the state of Massachusetts. One approach to discouraging this habit is to adopt anti-idling policies in the workplace. Informing drivers in your fleet that idling is against department policy is one way to reduce fuel consumption and avoid receiving a $100-$500 ticket. Anti-idling policies can be incorporated into drivers' contracts; the DOER Clean Cities Coalition also offers pre-written anti-idling pledge forms along with a number of other valuable idle reduction resources on their website: *https://cleancities.energy.gov/technical-assistance/idlebox/*.

3.3 Status of Fuel Efficiency in Rural Massachusetts

Fleet Sizes

Across the 48 rural GCs that accurately reported their vehicle inventory prior to the creation of this report, fleet sizes ranged from 9 to 88 vehicles, with an average of roughly 30 vehicles per municipality. In order to put this wide range in perspective, and better understand differences fleet size, we analyzed fleet size relative to population size (in other words, the ratio depicting how many citizens per municipal vehicle in a given community). The results were surprising, with some communities having a ratio as low as 34 citizens per municipal vehicle, and others having as many as 375 citizens per vehicle, a difference more than ten-fold in magnitude.

While this one analysis alone does not illustrate why there is such a range of fleet sizes across these communities, these results could suggest that fleets serving fewer citizens per vehicle may have room to downsize, or "right-size" their fleet. Though it is true that there is a minimum number of municipal vehicles

[32] "Technology in Rural Transportation: Simple Solutions". *U.S. Department of Transportation - Federal Highway Administration,* Turner-Fairbank Highway Research Center, October 1997.

required to sustain a community of any size (e.g., at least one fire truck, at least one police cruiser, etc.), the fleets that ranked lowest in citizen to vehicle ratio ranking tended to have unusually large fleets, especially for small rural communities. As illustrated in **Figure 4** below, right-sizing a fleet is critical to reducing vehicle fuel consumption, as fleet size is very closely correlated with vehicle fuel consumption. Efficiently sized fleets also avoid unnecessary spending on vehicles, freeing up funds for other, more productive uses.

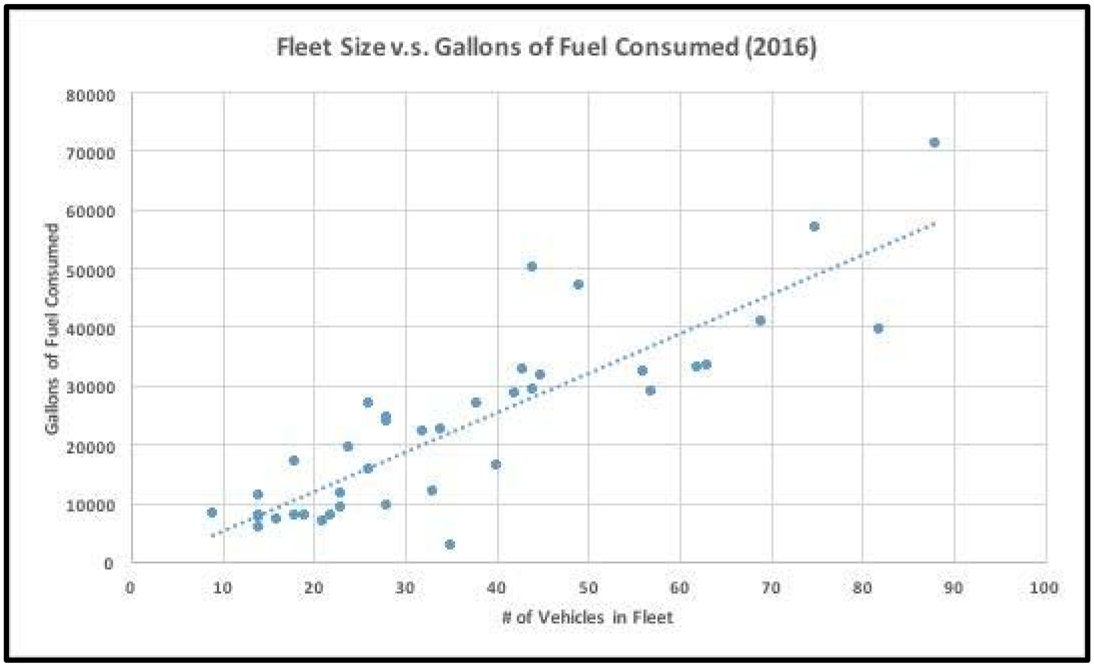


Figure 4: Comparison of vehicle fuel consumption and municipal fleet size.

Fleet Composition

Using the vehicle inventory data from 48 rural GCs, 1,480 municipal vehicles were organized according to department of use. Organizing the data in this way allowed us to identify what portion of a community's municipal fleet belonged to each department (e.g., 30% Police vehicles, 20% Fire vehicles, etc.). By averaging the make-up of these 48 municipal fleets, **Figure 5** below was produced, illustrating one of the key findings of our report: The Highway Department/Department of Public Works, the Fire Department, and the Police Department, account for approximately 84% of a rural community's vehicle inventory on average in rural Massachusetts GCs, with all other departments (e.g., Transit, Animal Control, Waste Management, Parks and Recreation, etc.) making up just 16% of the average rural fleet.

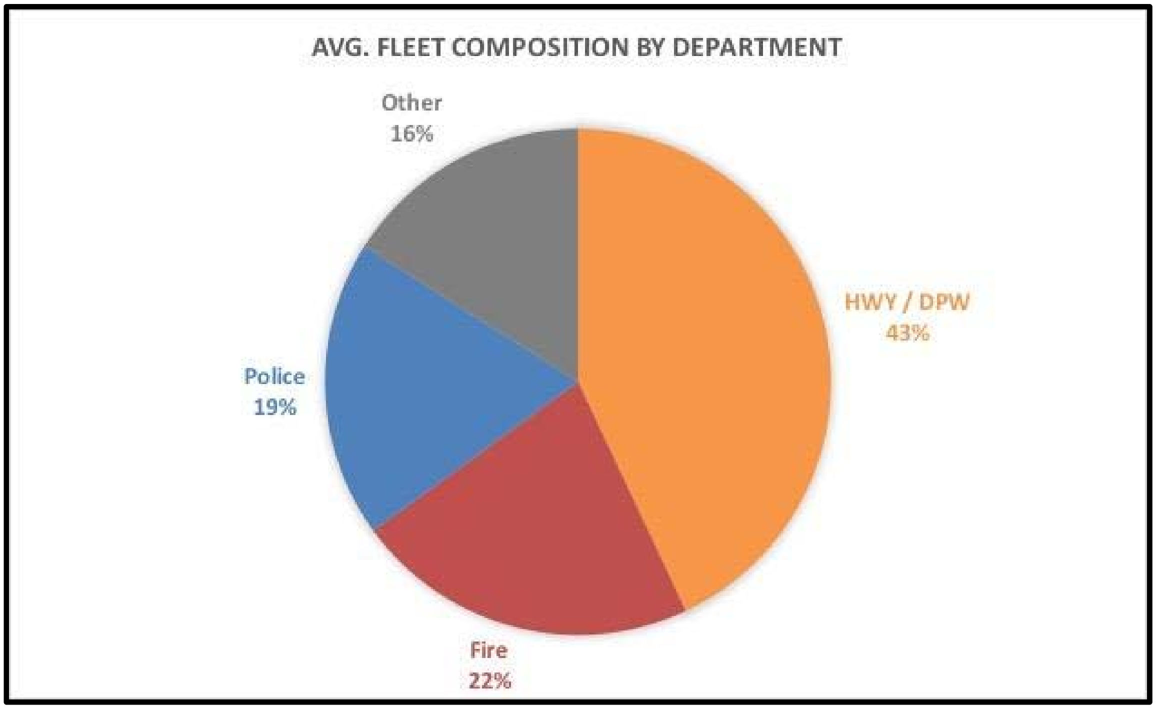


Figure 5: Average rural Massachusetts fleet composition by department.

While it may be expected that these three departments make up the majority of municipal fleets, we found the magnitude by which they were the majority to be quite surprising. Based on these findings, we choose to focus on the Highway, Police, and Fire departments in our investigations of fleet size and composition.

Department Fleet Rightsizing Opportunities

In order to identify whether or not fleet size for each of these departments correlated with the population of their given community, we generated scatter plot graphs similar to that depicted in **Figure 6**. The findings from scatter plot analyses of each of the three "vehicle heavy" departments all produced similar results: While there is a slight correlation between number of vehicles in a department's fleet and the size of the community, the data points are extremely varied, suggesting that community decision-making about fleet size may vary widely across municipalities, and there is currently no common standard governing roughly how many vehicles are necessary for a given department to adequately serve a community of a given size. As suggested in the previous subsection, the wide range of department fleet sizes within similarly sized communities suggests that some municipalities may be able to operate adequately with fewer vehicles. While differing communities are bound to have different needs depending on a number of factors (e.g., geographic characteristics, population density, seasonal tourist populations, etc.), a guide approximating the number of a particular vehicle type recommended to serve a community of a given size may prove useful to communities seeking to right-size their fleets (e.g., 1 fire truck for every 1000 residents, etc.). That being said, as community needs vary greatly regardless of population, this guide would merely act as a reference, encouraging departments to consider the number of vehicles truly necessary to serve their community.

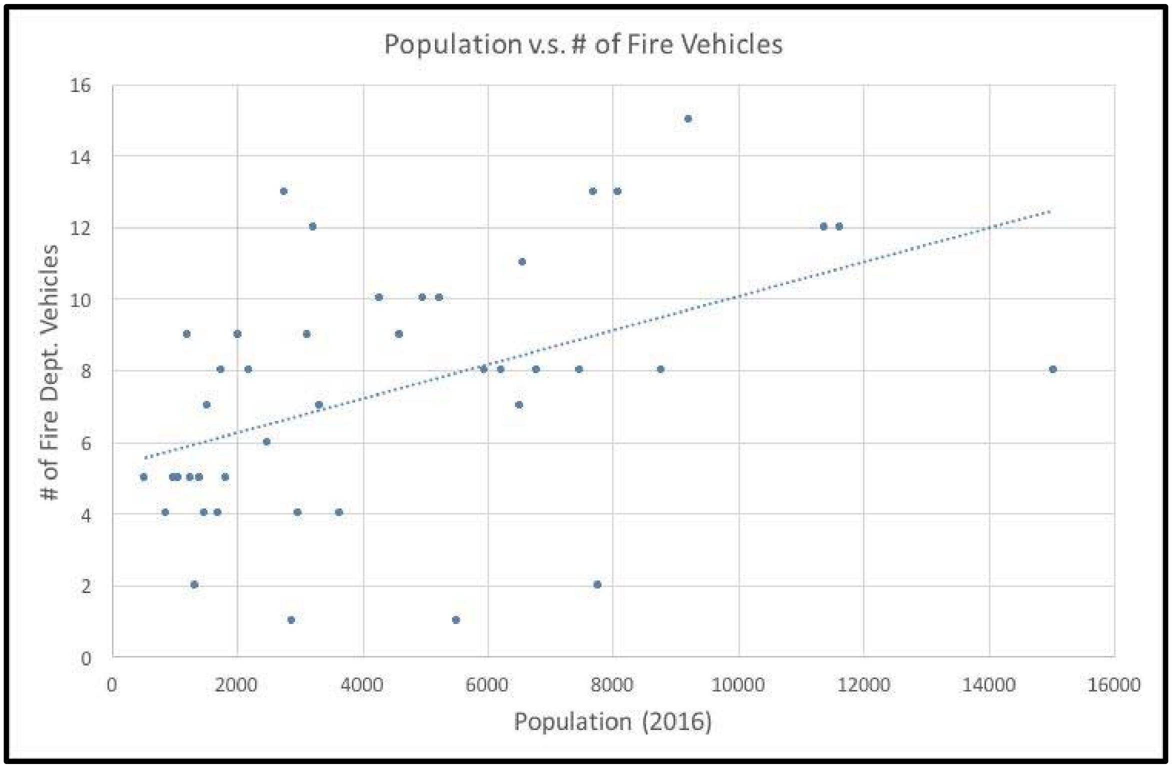


Figure 6: Comparison of fire department fleet size and municipality population.

Common Vehicle Models

To further understand municipal fleet composition, we identified the most commonly acquired vehicle models within each department and summarized this information in **Table 3** below. Our purpose was to illustrate the status quo for rural municipal fleets, and highlight potential areas for improvement (e.g., are there similar vehicles with superior fuel economy, are these commonly acquired vehicles optimized for the tasks they perform, are there solutions from **Section 3.2** particularly applicable to these vehicles, etc.). It is worth noting that the most commonly acquired vehicles highlighted in **Table 3** do not include large utility vehicles such as fire trucks and dump trucks, due to a number of reasons including: 1) there is a wide variety of models adopted across differing communities, 2) these vehicles tend to be highly specialized, meaning that characteristics such as fuel economy and horsepower vary widely, even among like models, and 3) large vehicles above 8,500lb are classified as “heavy-duty vehicles” and are not required to report fuel economy, unlike smaller passenger vehicles; While a number of the vehicles included in the table below also classify as “heavy-duty” (e.g., the Ford F350 / F550), these vehicles are commonly available to the public and therefore crowdsourced data is readily available.

Table 3: Top three most commonly acquired vehicles in rural Massachusetts municipalities by department.

Department & Acquisition Frequency Ranking	Vehicle Make/Model	Average Combined MPG Rating	Estimated Annual Fuel Cost*
HWY/DPW			
#1	Ford F350	12.14	$2,876
#2	Ford F550	8.55	$4,070
#3	Chevrolet Silverado	15.70	$2,217
Police			
#1	Ford Explorer	18.61	$1,870
#2	Ford Crown Victoria	17.81	$1,954
#3	Ford Interceptor	18.68	$1,863
Fire			
#1	Ford F350	12.14	$2,867
#2	Ford Explorer	18.61	$1,870
#3	Ford Expedition	16.05	$2,168

*Assuming 12,000 miles/year and the average price of gasoline in Massachusetts at the time of this report

A number of important conclusions can be drawn by analyzing the most commonly acquired vehicles from each of these departments. First, every vehicle on this list is considered exempt from Green Communities' FEV policy in the majority of applications, because they are all classified as either a) emergency vehicles, or b) exceeding the 8,500lb threshold for non-exempt vehicles. These 7 vehicle models alone account for more than 20% of the 1480 municipal vehicles in these rural communities, and as such likely account for a sizable percentage of total municipal vehicle fuel consumption.

The lack of fuel economy data for these commonly purchased vehicles is also quite frustrating. Take for example, the #1 most frequently acquired vehicle for both HWY/DPW as well as Fire Departments in these communities: The Ford F350. As a vehicle weighing more than 8,500lb, the Ford F350 (along with the Ford F550, and Chevy Silverado) is not required to report fuel economy to consumers, meaning that the municipalities purchasing these vehicles likely have no idea how many MPG these vehicles receive. This is a major obstacle for communities, as they are unable to compare the fuel efficiency of these large vehicles prior to purchase, and in turn have to make uninformed purchasing decisions.

While formal fuel economy ratings for these large vehicles is unavailable, we were able to approximate these values by averaging the fuel economies reported by the GCs in question during their annual vehicle inventory reports. For example, the average fuel economy of the Ford F350 was around 12.14 MPG, equivalent to more than $2,865/yr in fueling expenses, assuming current gas prices and 12,000 vehicle miles traveled (VMT). The same analysis revealed an average fuel economy rating of 8.55 MPG for the Ford F550, equivalent to more than $4,000/yr in fueling expenses under the same assumptions. Based on these calculations, if a community could improve the fuel economy of a single Ford F550 by a mere 5MPG, through the adoption of one or more of the fuel saving techniques listed in **Section 3.2**, they could save approximately $1,500 annually (see **Figure 7** below).

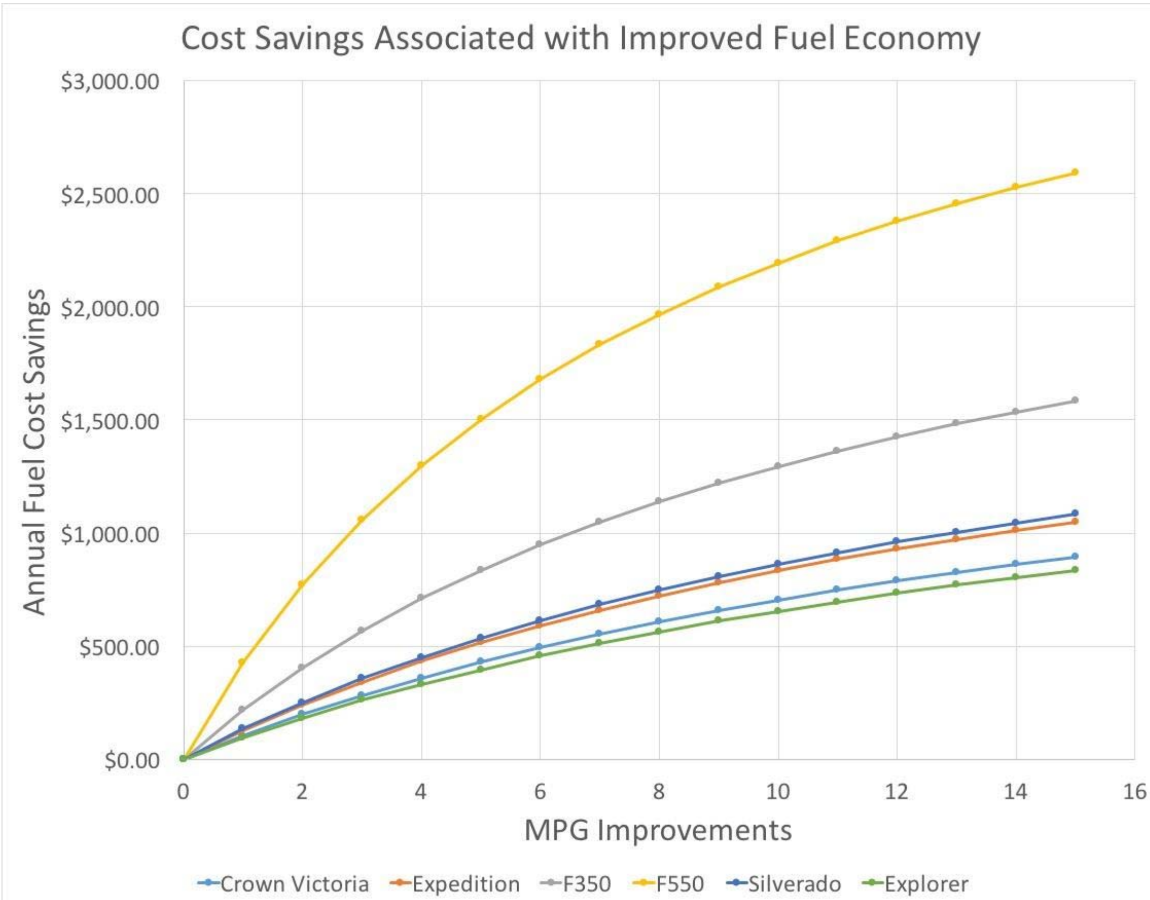


Figure 7: Line graph illustrating the potential annual savings associated with improving the fuel economy of common municipal vehicle models.

Municipal Fuel Consumption

While many of the vehicle fuel consumption records available to us through MassEnergyInsight were reported in bulk for the entire fleet, we were able to obtain department specific vehicle fuel use records from 15 rural Green Communities, which were analyzed and averaged in order to create **Figure 8** below.

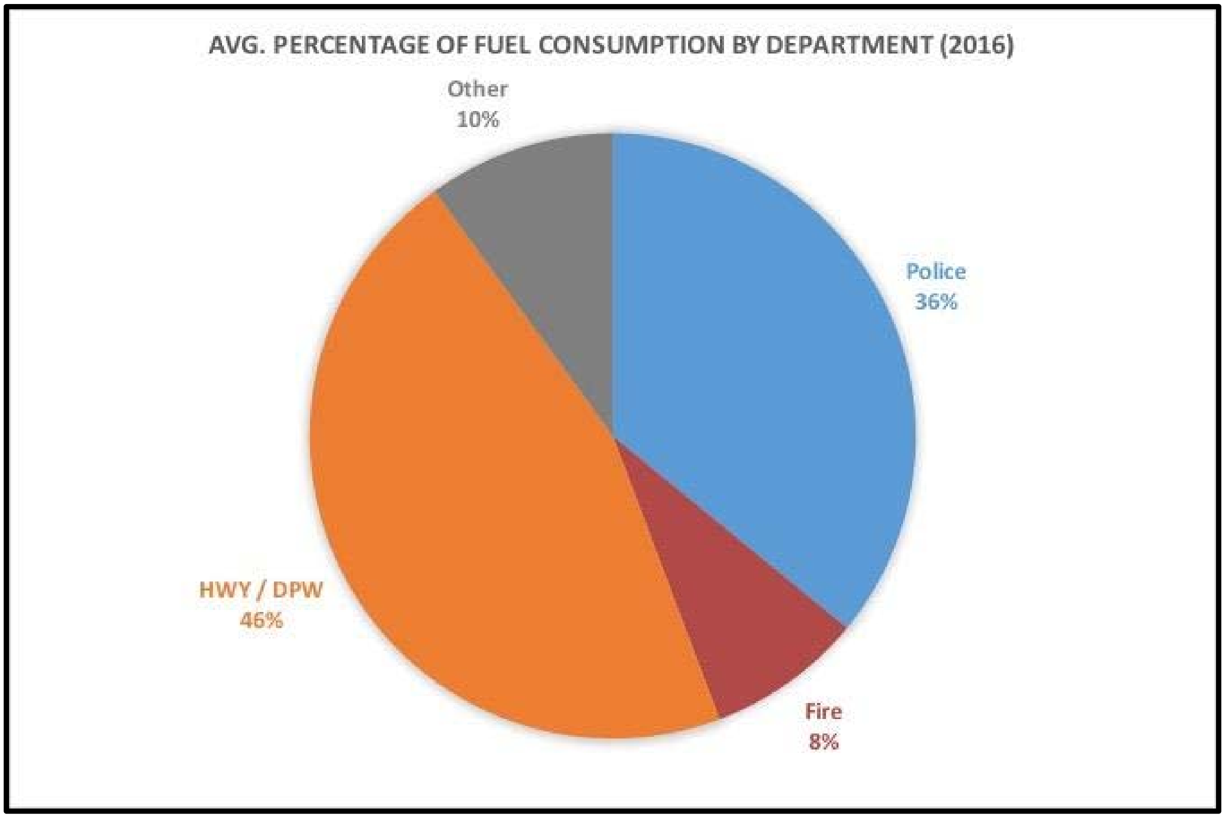


Figure 8: Average percentage of municipal vehicle fuel consumption by department.

While the HWY/DPW, Police, and Fire Departments represent the 3 highest consuming municipal departments, one key difference to note between **Figure 5** and **Figure 8** is that while, on average, the Fire Department represents the 2nd largest fleet, they consume far less vehicular fuel than the HWY/DPW and Police Departments. This further narrows the range of crucial departments to target in order to reduce vehicle fuel consumption. Though as we already established, the majority of the vehicles in these departments are exempt from Green Communities fuel efficiency policy, with HWY/DPW making up nearly half of all vehicle fuel consumption on average, and the Police Department falling closely behind, it is essential to focus on these fleets for improvement if communities hope to see a significant reduction in consumption.

3.4 Potential Areas for Further Research and Assistance

Next Steps

This report represents the first phase of UMass CEE's initiative to reduce municipal vehicle fuel consumption in rural Massachusetts. While this report contains a wide variety of valuable information to be utilized by municipalities in their vehicle fuel consumption reduction efforts, UMass CEE hopes to generate a more detailed analysis of vehicle fuel efficiency in rural Massachusetts by conducting a number of case studies over the next year. Through the use of vehicle telematics technology, detailed vehicle use and fuel consumption data will be collected from approximately 60 municipal vehicles, from three rural GCs across the state. We also plan to survey fleet managers and municipal vehicle operators on various topics surrounding municipal vehicle use.

The selected communities will be chosen based on a number of factors including population, proximity to the UMass Amherst campus, fleet size, fleet composition, prior efforts to improve fuel efficiency, and whether or not the municipality was identified as an outlier in any of the statewide analyses performed during the creation of this report. The three communities selected will represent small, medium, and large rural communities respectively (based on population). While this phase of the initiative will further illustrate the status of fuel efficiency in rural Massachusetts, as well as highlight particularly valuable fuel saving solutions, this hands on approach will also directly assist the selected communities in analyzing their current transportation habits and identifying areas of improvement.

The use of vehicle telematics and customized surveys will provide a number of useful insights into fleet operations and fuel use. While the vehicle inventory and fuel use databases utilized to generate this report lacked specificity into vehicle-level fuel consumption, making it difficult to pinpoint the largest sources of fuel consumption in a given fleet, this next phase of our initiative will help to fill that gap. The wide variety of information recorded by the telematics systems should produce a detailed analysis of municipal vehicle fuel consumption, both highlighting trends in fuel consumption, as well as informing the selected communities on the best-fit solutions for their unique situation. The hope being that this additional research, when paired with the analyses presented in this report, will produce a versatile and in-depth summary of municipal vehicle fuel consumption in rural Massachusetts, and highlight areas for improvement.

Appendix A – UMass Clean Energy Extension Resources

Section 1 – Fact sheet: Hybrid, Hybrid Plug-in, and Battery Electric Vehicles

Section 2 – Fact Sheet: Strategies to Reduce Fuel Usage by Municipal Fleets

Section 3 – Fact Sheet: Alternative Fuel Vehicles for Municipal Fleets

Section 4 – Fact Sheet: Telematics Software for Municipal Vehicles

Section 5 – Fact Sheet: Idle Reduction Technologies for Municipal Vehicles

Clean Energy Extension

FACT SHEET

Hybrid, Hybrid Plug-In, and Battery Electric Vehicles

This is one of a series of fact sheets designed to help rural municipalities reduce fuel usage in their town fleets. For more information, please visit the UMass Clean Energy Extension (CEE) website, https://ag.umass.edu/clean-energy.

Hybrid, hybrid plug-in, and battery electric vehicles are collectively known as electric vehicles. This fact sheet provides an overview of electric vehicle types, performance relative to conventional vehicles, and electric charging infrastructure. For detailed information on purchasing electric vehicles, including state purchasing contracts, funding sources and grants, vehicle models appropriate for municipal departments, and descriptions of how other towns and cities are using electric vehicles, please see our ***Fuel Efficient Vehicle Purchasing Guide for Municipalities***.

Types of Electric Vehicles

Hybrid Electric Vehicles - Hybrid electric vehicles rely primarily on internal combustion engines fueled by gasoline or diesel, but feature an additional small electric motor and battery. The battery is charged through regenerative braking, meaning that every time the driver applies the brakes, rather than wasting the momentum that the car has gained during its acceleration, some of that energy is captured and stored in the battery to be utilized later by the electric motor. The electric motor allows for better fuel economy and reduced emissions, providing the driver with the range and power of a conventional vehicle, while also providing cost savings and environmental benefits.

Battery Electric Vehicles (BEVs) - Battery electric vehicles are powered entirely by electricity, as opposed to conventional fuels such as gasoline or diesel. BEVs are classified by the EPA as “zero-emissions vehicles,” although the life-cycle emissions associated with fueling a BEV are dependent on whether the electricity is generated from renewable or fossil fuel sources. BEVs can be charged in normal household outlets (known as *Level 1 Outlets*), or by specialized higher voltage outlets, described in greater detail below. Modern BEVs can travel over 200 miles on a single charge; some luxury brands exceed 300 miles per charge. In additional to the environmental benefits associated with powering a vehicle with electricity rather than conventional fuels, the cost per mile of powering a car with electricity is significantly lower than for gasoline or diesel.

Plug-in Hybrid Electric Vehicles (PHEVs) - Plug-in hybrid electric vehicles combine favorable aspects of both BEVs and hybrid electric vehicles. Plug-in hybrids utilize both gasoline and electricity to power the vehicle, meaning that both an internal combustion engine and an electric motor are contained within the vehicle. PHEVs have a traditional gas tank, but like battery electric vehicles, PHEVs can be charged using normal household outlets or specialized fast charging stations. Many PHEVs are also designed to utilize regenerative braking to re-charge their batteries.

Comparing Electric Vehicles and Conventionally-Fueled Vehicles

Fueling Costs - The U.S. Department of Energy (DOE) has created a metric known as the "eGallon," as a tool to help consumers compare the operation costs of electric and conventional vehicles (calculated using the average fuel economy of current vehicles, and the average cost of electricity in America). As of September 2018, the average national price of one "eGallon" was $1.19, less than half the national average cost of gasoline of $2.84/gallon. Across the board, the fueling costs for electric vehicles are typically far lower than for conventional vehicles.

Maintenance Costs - Although hybrid electric vehicles typically have more complex engines than conventional vehicles, electric vehicles in general have significantly lower maintenance costs. For example, a 2017 study by the American Automobile Association (AAA) found that BEV drivers save around 17%, or just over $200 in maintenance costs annually. Many popular EV brands also offer substantial warranties on electric vehicle components; for example, the Ford Focus, Chevy Volt, and Nissan Leaf all come with a standard 8-year warranty on the EV battery. One potential downside for municipal departments that perform their own vehicle maintenance is that electric vehicles frequently require EV-specific tools, and mechanics may require additional training to work safely on these vehicles. Identifying local mechanics who have experience with electric vehicles may be worthwhile before making an EV purchase.

Initial Purchasing Costs - Currently, many electric vehicle models on the market have higher initial purchasing costs than conventional vehicles. While this fact can deter potential buyers, it is worth considering that the lifetime cost of electric vehicles is often lower than that for conventional vehicles, given the lower cost of operation. In addition, there are a number of state and federal incentives available that significantly reduce the costs of acquiring electric vehicles and EV charging equipment. A 2018 analysis by the Bloomberg New Energy Finance team suggests that current trends in battery pricing indicate many electric vehicles will have lower initial purchasing costs than conventionally fueled vehicles by as early as 2025.

Range – Hybrid and hybrid plug-in vehicles can be powered by conventional fuels for trips where the distance travelled exceeds the maximum range possible for the battery on a single charge. Range concerns may make drivers hesitant to adopt fully electric BEVs, although this may be less of an issue for municipal fleets, when vehicles are primarily used within town or city boundaries. Importantly, the average range of BEVs has been steadily increasing; many popular electric vehicle models now have ranges of over 200 miles on a single charge. In addition, Massachusetts is home to more than 1,450 public EV outlets, many of which can be used free of charge, on longer trips. Public EV charging infrastructure is continuing to expand across the state.

Performance – While a plethora of electric passenger car models are available, there is currently a lack of utility capable EVs on the market. For example, there are only a handful of readily available AWD electric vehicles, and the towing capacity of EVs tend to be significantly lower than conventionally fueled trucks or SUVs. For those hoping to achieve improved fuel economy and emissions reductions associated with EVs, while maintaining the utility capabilities of conventionally fueled trucks, numerous hybrid retrofits are available. For example, XL Hybrids has a system to convert conventional vehicles (e.g. Ford F150 or F250) into hybrids, improving the fuel economy by as much as 50%.

Greenhouse Gas Emissions - Electric vehicles produce far fewer harmful tailpipe emissions than conventionally fueled vehicles, but a more valuable comparison to consider is the relative life-cycle emissions associated with conventionally fueled vehicles versus electric vehicles, sometimes referred to as "Well-to-Wheel" emissions. Life-cycle emissions take into account all the emissions associated with resource extraction and electricity generation, and therefore are a more realistic representation of a vehicle's carbon footprint. According to a life-cycle analysis conducted by the DOE's Alternative Fuel Data Center, BEVs, PHEVs, and hybrids in Massachusetts emit 69%, 52%, and 45% less CO_2 respectively per year than gasoline-powered vehicles. It is worth noting that emissions from electric vehicles in Massachusetts are lower than the national average, due to the state sourcing a significant proportion of its electricity from clean or renewable resources.

Charging an Electric Vehicle

EV charging stations fall into three primary categories:

Level 1 - Electric vehicles can be charged directly through the standard 120V outlets found in homes, businesses, and municipal buildings. Level 1 charging is the slowest method of charging an electric vehicle, but can be a practical option for municipal fleets, as vehicles should be able to reach full charge while sitting overnight, and there is no need for investment in additional charging equipment.

Level 2 - The majority of public charging stations are Level 2 chargers, which are able to charge electric vehicles at roughly 4-6 times the rate of Level 1 chargers. This infrastructure is worth considering if the average mileage driven per day is expected to exceed the electric range of the vehicle purchased. It is important to note that these chargers typically only allow for charging of one car at a time, so adopting Level 2 infrastructure for an entire fleet would require purchase of multiple chargers.

DC Fast Chargers - DC Fast Chargers are the quickest method of charging an electric vehicle, and can fully charge most vehicle models within one hour or less. DC Charging Stations are still quite expensive, and are primarily available at commercial roadside fueling stations for a fixed price per kilowatt-hour (kWh). For municipalities considering installation of DC Fast Chargers, it is important to recognize that some older buildings may be unable to support the high electricity wattage demanded by the device. Consult with an electrician before installation.

Locating EV Charging Stations

There are a number of services available that make locating the nearest public EV charging station quick and easy. These include:

AFDC Alternative Fueling Station Locator - An extension of the U.S. Department of Energy, the Alternative Fuel Data Center (AFDC) maintains a website with a wealth of information about electric vehicles, including a fueling station locator, which drivers can use to search by location and/or charger type. https://www.afdc.energy.gov/fuels/electricity_locations.html#/find/nearest?fuel=ELEC

ChargeHub – ChargeHub's map can be searched by street address to find local stations and filter by charging station type and availability. https://chargehub.com/en/charging-stations-map.html

ChargePoint - ChargePoint's database contains over 50,000 public chargers. The Chargepoint app allows you to pay for metered charging, search by station type, and see which charging outlets are available before traveling to the station. https://www.chargepoint.com/

GoogleMaps – In 2011, Google added EV charging stations to its on-line maps, represented by a red GPS marker with a white charging station. Some stations are missing from the map, but for those listed, it can be helpful to use Street View to identify the exact station location. https://www.google.com/maps

Open Charge Map – This non-profit group has a free app where you can search by network operator, charge station type, and availability, as well as offer feedback on map reliability to improve the system. https://openchargemap.org/site

PlugShare - Plugshare.com offers searches by station type and availability, but on an international scale. Additionally, PlugShare has a "trip planning" option, where drivers can plan routes according to charging stations locations along the way. https://www.plugshare.com/

Clean Energy Extension

FACT SHEET

Strategies to Reduce Fuel Usage by Municipal Fleets

This is one of a series of fact sheets designed to help rural municipalities reduce fuel usage in their town fleets. For more information, please visit the UMass Clean Energy Extension (CEE) website, https://ag.umass.edu/clean-energy.

Reducing fuel consumption by municipal vehicles is an important way that Massachusetts cities and towns can save money while also helping the environment. However, reducing fuel usage can be challenging. Vehicle fuel consumption on average represents about 20% of total municipal energy usage for towns involved in the Massachusetts Department of Energy Resources (MA DOER) Green Communities program, but vehicle fuel usage reductions have represented just 2% of all energy reductions achieved by Green Communities to date. This issue presents particular challenges for small rural communities, where vehicle fuel usage can account for up to 35% of municipal energy usage.

This fact sheet provides a range of strategies for reducing fuel usage in municipal fleets, describes how each option can be most appropriately applied, and lists purchasing and funding resources. More details about these fuel-saving technologies can be found in other *Greening Municipal Fleets* fact sheets on our website.

Tracking Vehicle Fuel Consumption

A good first step in reducing municipal fleet fuel consumption is to understand where and when fuel consumption is occurring. This information can help municipal officials, staff, and volunteers to identify major sources of fuel consumption, and decide where to focus fuel usage reduction efforts. Options to monitor fuel use include:

- **Fuel Log** – The simplest way to track vehicle fuel use is to require municipal staff to maintain a fuel log, recording mileage and gallons pumped at each fill-up. A fuel log can be kept on a clipboard in each vehicle, with data entered quarterly or annually by municipal staff or volunteers. Fuel log templates are available on our website: https://ag.umass.edu/clean-energy/fact-sheets/strategies-to-reduce-fuel-usage-by-municipal-fleets
- **Electronic Fuel Management System –** For larger towns and cities with municipal fuel pumps, it may be simpler to purchase an electronic fuel management system, which can monitor fuel use for all vehicles using the municipal pumps. These systems typically require municipal staff to enter the odometer reading and a specific ID number identifying the vehicle at each fill-up. Some systems use cards specific to each vehicle, which eliminates the need for the employee to enter an ID number. The town of Belchertown, MA has installed an electronic system to track fuel usage by its municipal vehicles, see a case study here: https://ag.umass.edu/sites/ag.umass.edu/files/case-studies/green-communities-case-study-belchertown.pdf
- **Vehicle Telematics** – Vehicle telematics systems can be installed in individual vehicles. These systems track not only mileage and fuel consumption, but also other relevant information, like idling periods, acceleration and deceleration effects on fuel consumption, and maintenance needs. Through GPS tracking, telematics systems can also be used to optimize routes for vehicles like snow plows and garbage trucks. For more information, see our fact sheet *Telematics Software for Vehicles*: https://ag.umass.edu/clean-energy/fact-sheets/telematics-software-for-vehicles.

In the absence of data on municipal vehicle fuel consumption, it is usually safe to assume that for most rural communities, the major sources of fuel consumption are the police and highway departments. While a typical fire department also maintains a number of heavy-duty, low fuel economy vehicles, these vehicles are used relatively infrequently, and, according to our research, on average account for less than 10% of municipal fuel usage in rural communities.

Vehicle and Operation Management

There are a number of strategies for managing vehicle operation for better vehicle and fleet fuel efficiency. While simple, these strategies can lead to significant reductions in overall fuel consumption. One challenge with using these strategies is that their success relies on individuals to adopt behavioral changes and maintain good habits. Signage, written and verbal reminders, and encouragement are all important components of any program designed to promote behavioral changes.

- **Proactive Vehicle Maintenance** - Establishing and closely following a maintenance schedule for each vehicle in a fleet is one way to enhance fuel economy at little cost. Measures such as keeping engines tuned, ensuring tires are properly inflated, performing regular oil changes, and using the recommended grade of motor oil, can improve a vehicle's fuel economy by up to 9%, according to the U.S. Department of Energy. Typically, following the manufacturer's maintenance recommendations will result in optimal performance for a given vehicle. A variety of vehicle maintenance log templates are available for download from the web; smart phone apps are also available.
- **Anti-Idling Policies -** Unnecessary idling of vehicles is a wasteful and costly practice that harms both the vehicle and the environment; in fact, it is against the law to idle for longer than 5 minutes in the state of Massachusetts. Adopt and advertise anti-idling policies in your municipality, and incorporate anti-idling policies into staff contracts. Remind drivers in municipal fleets that idling is against department policy, and subject to a $100-$500 ticket. The DOER Clean Cities Coalition offers standard anti-idling pledge forms along with a number of other valuable idle reduction resources on their website: https://cleancities.energy.gov/technical-assistance/idlebox. The Massachusetts Department of Environmental Protection (MassDEP) also offers free anti-idling signage and materials to schools participating in their Green Team program: https://thegreenteam.org.
- **Green Driving Education -** Adopting good driving habits is another inexpensive and effective way to reduce fuel consumption. Excess weight on a vehicle can reduce fuel economy by 1-2% per 100 lbs, according to the U.S. Department of Energy. A loaded roof rack can reduce fuel economy by around 5% due to aerodynamic drag. Removing unnecessary equipment or loads as soon as it is practicable can provide significant energy savings. Aggressive driving habits, such as speeding, rapid acceleration, and abrupt braking, can also reduce fuel economy by up to 33%. Municipal fleets can encourage green driving by educating all drivers on efficient driving practices through workshops or informational materials. The University of Vermont offers an online "Eco-Driving 101" course to aid in this process, available here: http://www.erating.org/transportation-company-education/courses.
- **Route Optimization -** Selecting the shortest route between two points can minimize the amount of fuel consumed on a trip, saving both time and money. Route optimization can be effective for municipal vehicles with fixed (or somewhat fixed) routes, such as snow plows and school buses. While professional route optimization services are available, many telematics and GPS systems can also effectively map out the most efficient routes for a vehicle or set of vehicles. A study conducted by the University of Vermont Transportation Research Center found that after adopting GPS-based route optimization, snow plows across nine states were able to reduce their route length and associated fuel usage by an average of 5-10%.
- **Vehicle Rightsizing -** Vehicle rightsizing is simply ensuring that the size of a vehicle corresponds appropriately with the tasks that it performs. Most municipal departments require heavy-duty vehicles to accomplish certain tasks, but may also carry out administrative duties, errands, or light-duty tasks that can be accomplished with a small pickup truck or passenger vehicle. Using a smaller, fuel efficient vehicle whenever possible is a simple way to reduce overall fuel consumption, but requires municipal staff to be thoughtful about scheduling and vehicle needs for a given trip or workday.
- **Interdepartmental Coordination –** For small municipalities, light-duty tasks may not comprise enough of a single department's time to justify the cost of maintaining and insuring a fuel-efficient passenger car for departmental use. However, there may be opportunities to share fuel-efficient vehicles across departments. For example, a light-duty vehicle used by the police department for detective work could be loaned to fire department staff and volunteers to attend training in another part of the state. In addition to reducing municipal fuel consumption, such arrangements can reduce the need for municipal staff or volunteers to use personal vehicles, and reduce associated mileage reimbursement costs.

Purchasing a New Vehicle

The purchase of a new vehicle presents an excellent opportunity to increase the fuel economy of a municipal fleet and reduce overall fuel consumption. Unfortunately, fuel economy is often not considered during vehicle procurement. There are a number of reasons for this tendency: First, municipal vehicle purchase or replacement policies, if they exist in written form, often do not include consideration of fuel economy as part of the vehicle purchase process. Second, municipalities are not required to follow the fuel economy standards applied to state vehicle purchases. Even for municipalities with Green Communities status, the *Fuel Efficient Vehicle Policy* (FEV) currently in place has not been updated since 2012, despite increases in average fuel economy of approximately 5 MPG per year over the past decade. Many municipal vehicles are granted exemption from FEV requirements, including police cruisers, passenger vans, cargo vans, and all vehicles weighing more than 8500 lbs; for rural municipalities, these vehicles represent most if not all vehicles owned by the town. Third, municipal officials, staff, and residents involved in selecting or approving the appropriate vehicle for purchase may be unaware of available vehicle makes and models, and the specifications associated with these vehicles. Decision-makers may also be hesitant to adopt new technologies due to concerns about reliability or unfamiliarity with operations or repair.

New Vehicle Purchasing Policies

- **Vehicle Purchase and Replacement Policies** – Consider updating municipal vehicle purchase or replacement policies to include language that explicitly calls for consideration of vehicle fuel economy and evaluation of fuel-efficient, hybrid, or electric options during vehicle purchasing.
- **Fuel Economy Standards –** Consider adopting state fuel efficiency standards for all municipal vehicle purchases. The Massachusetts Operational Services Division (OSD) sets minimum fuel economy standards that all vehicles acquired by state agencies must meet. While stricter than Green Communities standards, these standards are still relatively moderate and achievable, and are updated regularly. Using these fuel economy targets as guidelines for municipal vehicle purchase can provide fuel savings, improve air quality, and lead to a greener fleet. OSD regularly releases a list of suggested vehicles consistent with their fuel economy guidelines. This list of recommendations can be cross-referenced with the VEH98 state contract (see *Using State Contracts* below), allowing fleet managers to determine which models are within their budget and available at a discount through the state contract.
  OSD Fuel Economy Standards Website: https://www.mass.gov/doc/fuel-efficiency-standard-for-state-fleet
  A recent list of recommended vehicles is available on our website: https://ag.umass.edu/clean-energy/fact-sheets/strategies-to-reduce-fuel-usage-by-municipal-fleets

Choosing a Fuel Efficient Vehicle

When identifying fuel efficient vehicle options for purchase, we recommend following the steps outlined below. Each section summarizes which types of vehicles a particular option is appropriate for.

- ☐ **Right-size vehicle specifications to meet fleet needs.** When determining what tasks the vehicle will be performing, consider whether other vehicles are available to complete rarely-needed tasks, and determine vehicle specifications accordingly. For example, if a heavy-duty pickup is only needed occasionally, maintain only one heavy-duty pickup in the fleet. Additional pickups can be lighter-duty, more fuel-efficient models.
- ☐ **Consider availability of electric vehicle models.** Practical options are available for light-duty/administrative uses, in which transportation is the main task for which the vehicle is required. Options are also available for other types of passenger vehicles, including school and shuttle buses.
- ☐ **Consider availability of plug-in hybrid vehicle models.** Practical options are available for light-duty/administrative uses, as well as for police cruisers and light-duty pickup trucks. Options are also available for other types of passenger vehicles, including school and shuttle buses.
- ☐ **Consider availability of hybrid vehicle models.** A variety of hybrid models are available, including compact cars, sedans, SUVs, minivans, full-size vans, and buses. Pursuit-rated police sedans and SUVs are now becoming available.
- ☐ **Consider availability of alternative fuel vehicle models and fueling infrastructure.** Alternative or flex-fuel models of many heavy-duty vehicles are readily available. In some parts of the state, however, there are no fueling stations for these types of fuels, and there are few state incentives for purchase of these vehicles or associated infrastructure.
- ☐ **Identify the most fuel-efficient conventionally fueled vehicle.** For medium and heavy-duty vehicles, especially specialized equipment such as loaders, fire trucks, and dump trucks, an electric, hybrid, or alternative fuel model may not be available. In these situations, significant fuel savings can still be realized by identifying the most fuel efficient

vehicle in its class which meets the necessary specifications. An improvement in fuel economy of only 1-5 MPG can result in significant savings for low fuel economy vehicles.

- For details on specific vehicle models currently available, please see our ***Fuel Efficient Vehicle Purchasing Guide for Municipalities*** (coming soon).
- For general information about vehicles powered by non-conventional fuels, see our fact sheets:
  Hybrid, Hybrid Plug-In, and Battery Electric Vehicles: https://ag.umass.edu/clean-energy/fact-sheets/hybrid-hybrid-plug-in-battery-electric-vehicles-general-overview
  Alternative Fuel Vehicles for Municipal Fleets: https://ag.umass.edu/clean-energy/fact-sheets/alternative-fuel-vehicles-for-municipal-fleets

Increasing Efficiency of New or Existing Vehicles

- ☐ **Consider availability of hybrid conversions and retrofits.** Hybrid and electric models of heavy-duty vehicles are often not available for direct purchase from the manufacturer, but after-market hybrid retrofits are available for medium and heavy-duty pickup trucks, cargo vans, buses, ambulances, and garbage trucks. Specific retrofit companies are approved and licensed by the vehicle manufacturer.
- ☐ **Consider whether idle-limiting technology or auxiliary power units could be added to the vehicle.** Idle reduction technologies are appropriate for vehicles that make frequent stops or require auxiliary equipment while parked, such as police vehicles, emergency vehicles, construction vehicles, and buses. These technologies can power down the engine during periods when it is not needed, and supply an alternative source of power to keep on-board equipment running when the main engine is off**.**

- For information about idle reduction technology and hybrid retrofits, see our fact sheet ***Idle Reduction Technology***: https://ag.umass.edu/clean-energy/fact-sheets/idle-reduction-technology
- For details on specific vehicle equipment available, please see our ***Fuel Efficient Vehicle Purchasing Guide for Municipalities*** (coming soon).

Using State Contracts to Purchase Vehicles and Equipment

The Massachusetts OSD offers a wide variety of statewide contracts to municipalities, providing benefits including product discounts, extended warranties, and assistance in identifying environmentally-friendly products.

VEH98: Purchase of Vehicles
As of May 2018, the VEH98 contract offers over 500 different vehicle models to Massachusetts municipalities, at an average savings of 23% below MSRP, alongside vehicle accessories discounted up to 10%. The contract includes 21 different electric vehicle models.
Website: https://www.mass.gov/files/documents/2018/11/21/VEH98.pdf
Questions? Contact the contract manager: David Sargeant, david.sargeant@mass.gov, 617-720-3118

VEH102: Advanced Vehicle Equipment, Supplies, and Services
This contract offers municipalities a wide range of discounts on electric vehicle charging stations, as well as other fuel-saving and environmentally-friendly vehicle accessories, including idle reduction technology.
Website: https://www.mass.gov/files/documents/2018/11/09/VEH102.pdf
Questions? Contact the contract manager: Ted Dobbin, Edward.Dobbin@mass.gov, 617-626-7383

Massachusetts-Based Funding Programs

Massachusetts Green Community Designation and Grant Program

More than half of the municipalities across the state of Massachusetts have opted to join the Green Community Program since its launch in 2010. As a designated "Green Communities," municipalities are able to receive both funding and guidance from the state in pursuit of improved energy efficiency and clean energy. Once designated, municipalities receive an initial grant of up to $125,000 to fund energy efficiency projects in both municipal buildings and municipal fleets. Subsequently, municipalities are eligible for additional funds through competitive grant competitions, which can include financing of electric vehicles, electric vehicle infrastructure, and energy conservation measures in vehicles, including idle reduction, vehicle telematics, and hybrid retrofits.

Website: https://www.mass.gov/guides/becoming-a-designated-green-community

Massachusetts Electric Vehicle Incentive Program (MassEVIP)

MassEVIP is an open-enrollment grant program administered by the Massachusetts Department of Environmental Protection (MassDEP), providing incentives to eligible state and municipal entities for the acquisition of electric vehicles, zero-emission electric motorcycles, and the installation of Level 2 dual-port charging stations. To date, MassEVIP has provided 83 separate entities with nearly $2.3 million in funds to acquire 267 electric vehicles and 92 dual-port charging stations.

Website: https://www.mass.gov/how-to/apply-for-massevip-fleets-incentives

Volkswagen Diesel Settlements

Due to the 2015 emissions scandal surrounding Volkswagen vehicles, Massachusetts will receive $75 million from the VW Settlement Trust. The Massachusetts Department of Environmental Protection (MassDEP) has announced a plan for how to utilize these funds, which includes replacing older, inefficient diesel equipment and funding electric vehicles and charging infrastructure.

Website: https://www.mass.gov/guides/volkswagen-diesel-settlements-environmental-mitigation

MAPC Green Mobility Group Purchasing Program

The program supports municipalities and other public entities in the transition of their fleets to clean fuels. In collaboration with MA DOER and MA OSD, the Metropolitan Area Planning Commission (MAPC) formed a partnership with XL Hybrids, to offer state and municipal entities bulk and accelerated time-frame discounts for after-market hybrid electric conversions. This program utilizes hybrid conversion options available through state contract VEH102, compatible with 14 Ford vehicle models, common among Massachusetts municipal fleets. Hybrid electric conversions can allow fleets to improve fuel efficiency without sacrificing vehicle performance and functionality.

Website: http://www.mapc.org/wp-content/uploads/2017/12/XL-Group-Purchase-FAQ-Flyer_09-28-17.pdf

Clean Energy Extension

FACT SHEET

Alternative Fuel Vehicles for Municipal Fleets

This is one of a series of fact sheets designed to help rural municipalities reduce fuel usage in their town fleets. For more information, please visit the UMass Clean Energy Extension (CEE) website, https://ag.umass.edu/clean-energy.

What are Alternative Fuels?

Alternative fuel is a label applied to all vehicular fuels other than gasoline or diesel. This fact sheet focuses on biodiesel, ethanol, propane, natural gas, and hydrogen, due to their potential to power vehicles of all size classes, including heavy-duty machinery.

Alternative fuel station infrastructure is not well-established in many rural parts of Massachusetts, and few state incentives exist for liquid alternative fuel vehicles, retrofits or fueling infrastructure. *For municipalities located away from existing infrastructure, and not committed to installing their own alternative fueling stations, hybrid and electric vehicles may be a more attainable alternative to conventionally-fueled vehicles. For information on hybrid and electric vehicles, please see our fact sheet* Hybrid, Hybrid Plug-in, and Battery Electric Vehicles: A General Overview.

Types of Alternative Fuels

Biodiesel - Biodiesel is a biodegradable and renewable fuel, frequently produced domestically from vegetable oil. Biodiesel in its pure form is known as B100, but it is often blended with standard petroleum diesel in varying ratios (e.g. 20% biodiesel = B20). Studies have found that B100 produces approximately 74% fewer greenhouse gas emissions than standard diesel over its life-cycle. Most diesel engines (produced after 1993) can run biodiesel without the need for any modification, making biodiesel an attainable alternative for many drivers. Biodiesel also has superior lubrication abilities compared to standard petroleum diesel. One important consideration regarding use of this fuel is that biodiesel typically has a higher cloud point than diesel derived from petroleum, meaning that at blends above B20, users may run into performance issues in cold weather if proper precautions are not taken. Traditional cold weather solutions for diesel, including additives, kerosene, block or filter heaters, and indoor garaging, all work well for biodiesel.

Ethanol - Ethanol is a renewable fuel, commonly produced domestically from plant matter and feedstock, especially corn products. Ethanol is blended with traditional gasoline in mixtures of up to 85% ethanol (E85). Most internal combustion engines can run on ethanol blended gasoline mixtures of up to 15% ethanol (E15) or less without any modifications, and roughly 98% of the gasoline in America already contains at least a small portion of ethanol. Modified *flex-fuel vehicles* can run ethanol mixes from E15-E85. While ethanol produces slightly less energy per gallon than gasoline, ethanol-blended gasoline is generally less expensive than pure gasoline, and ethanol has a much higher octane rating than conventional gasoline. Ethanol-based fuels emit fewer pollutants than conventional gasoline and diesel. A life-cycle analysis of ethanol fuels suggests that ethanol produces approximately 34% fewer greenhouse gas emissions than standard vehicle fuels.

Propane - After gasoline and diesel, propane is the third most commonly-used vehicle fuel globally. Also known as *liquefied petroleum gas* (LPG), propane is a high octane fuel derived from non-renewable sources. Because a large percentage of propane available in the U.S. is produced domestically, its price is not as subject to fluctuation as the price of gasoline or diesel. Propane is non-toxic, meaning that gas leaks pose little threat to soil, surface water, or groundwater. However, propane is extremely flammable, and careful handling and storage are necessary. Propane emits approximately 13% fewer greenhouse gas emissions over its life-cycle than standard fuels. While the fuel economy of propane is slightly lower than that of standard fuels, propane is usually significantly cheaper than gasoline or diesel, so that propane is typically as cost-efficient as gasoline or diesel on a dollars-per-mile basis. Using propane as a fuel is also reported to reduce maintenance costs, as propane leaves significantly less residue when combusted.

Natural Gas (CNG/LNG) – Approximately 80-90% of the natural gas used in the United States is produced domestically, and natural gas accounts for roughly 30% of all energy use in the country. While only a fraction of natural gas-based energy consumption comes from vehicular use, the natural gas fueling infrastructure is relatively well established in the U.S., in comparison to other alternative fuels. Natural gas as a vehicular fuel comes in two forms: *Compressed Natural Gas* (CNG) and *Liquefied Natural Gas* (LNG) are both stored in pressurized tanks on the vehicle. The large majority of natural gas available is a fossil fuel-derived product extracted from gas and oil wells, but renewable natural gas (also known as *bio-methane*) can also be produced from decaying organic materials. Both forms of natural gas emit fewer greenhouse gases than standard fuel: a light-duty vehicle running on conventional natural gas produces approximately 15% fewer greenhouse gas emissions during its life-cycle, while a light-duty vehicle running on renewable natural gas produces ~84% fewer greenhouse gas emissions. Both CNG and LNG-powered vehicles offer similar power and acceleration compared to conventionally-fueled vehicles. As with propane, vehicle range is slightly lower in natural gas vehicles than conventionally-fueled vehicles, assuming the same sized fuel tank, but larger tanks are often installed on CNG and LNG vehicles to accommodate this difference. Major vehicle manufacturers in the U.S. produce a wide variety of natural gas-powered vehicles, many of which are *bi-fuel*, meaning that they can run on both conventional fuels and natural gas.

Hydrogen Fuel Cells – Hydrogen-powered vehicles, also known as *fuel cell electric vehicles* (FCEVs), are a relatively new alternative to conventionally-fueled vehicles. California has 35 hydrogen fueling stations currently open to the public, and at least 22 additional stations in the planning stages. When used as a fuel, hydrogen is stored at a pressure of 5,000-10,000 PSI in a tank on the vehicle. The tank feeds into a fuel cell where the hydrogen is broken into protons and electrons, creating an electrical current which powers the vehicle. After the electrons are utilized to provide power to the vehicle, they are rejoined with protons and oxygen in a separate chamber, forming water molecules. The only emissions created by these vehicles at the tailpipe are water vapor and hot air, earning them the title of *zero emissions vehicles*. Of course, total life-cycle greenhouse gas emissions for these vehicles is dependent on the source of the hydrogen fuel, which requires energy input to be produced. Hydrogen is frequently produced domestically, using either a natural gas based process (~50% fewer greenhouse gas emissions than gasoline) or by separating hydrogen from water in a procedure known as *electrolysis*, commonly utilizing solar or wind energy to power the process (~90% fewer GHG emissions compared to gasoline). Hydrogen-powered vehicles typically take less than 5 minutes to refuel, and have a range of 300 miles or more. Hydrogen fuel cells can be used in vehicles of all size classes, making this technology of interest in areas where the necessary infrastructure is available.

Fuel Type	**Renewable?**	**Approximate Reduced Greenhouse Gas Emissions** (%)[1]	**Retrofits Available?**	**Energy Comparison** (Gasoline Gallon Equivalents)[2]
Gasoline	No	N/A	N/A	1
Diesel	No	N/A	N/A	1.14
Biodiesel	Yes	74%	None Necessary	1.047 (B100)
		15%		1.122 (B20)
Ethanol	Yes	34%	Yes	0.731 (E85)
Propane	No	13%	Yes	0.744
Natural Gas (derived from fossil fuels)	No	15%	Yes	0.832 (CNG)
				0.636 (LNG)
Natural Gas (derived from anaerobic digestion)	Yes	84%	Yes	0.832 (CNG)
				0.636 (LNG)

[1] Values drawn from Argonne National Laboratory "GREET" model: https://greet.es.anl.gov/

[2] California Energy Commission. *Gasoline Gallon Equivalents for Alternative Fuels.* Retrieved from: http://www.energy.ca.gov/almanac/transportation_data/gge.html

After-Market Conversions and New Vehicle Purchases

After-market conversions and retrofits are available for propane, compressed natural gas (CNG), liquefied natural gas (LNG), and ethanol (for E15-E85 use) fuels; these can be used to convert existing conventionally-fueled vehicles into flex-fuel, bi-fuel or alternatively-fueled vehicles. When considering a retrofit, it is important to research and identify a *qualified system retrofitter* (QSR) and certified clean alternative fuel conversion systems. Taking the proper precautions to assure that both the retrofit system, as well as the party performing the installation, are up to code is essential to guarantee that the alternative fuel system performs well and meets vehicle emissions requirements. The Department of Energy maintains an Alternative Fuels Data Center (AFDC) with a variety of helpful resources, and the Environmental Protection Agency (EPA) has compiled a list of approved alternative fuel systems. Companies such as Ford offer lists of *qualified vehicle modifiers* (QVMs) to assist their customers in the conversion process. If you are having difficulty locating a QSR, or have questions about warranty coverage for conversions on an existing vehicle, contact your local dealer or the manufacturer.

- **Alternative Fuel Retrofit/Conversion Resources:** https://www.afdc.energy.gov/vehicles/conversions.html
- **Conversion Regulations**: https://www.afdc.energy.gov/vehicles/conversions_regulations.html
- **Certified Clean Alternative Fuel Conversion Systems Master List**: https://www.epa.gov/vehicle-and-engine-certification/lists-epa-compliant-alternative-fuel-conversion-systems
- **Vehicle and Engine Alternative Fuel Conversions:** https://www.epa.gov/vehicle-and-engine-certification/vehicle-and-engine-alternative-fuel-conversions

Ready-made alternative fuel vehicles are also available directly from vehicle manufacturers. The AFDC *Alternative Fuel and Advanced Vehicle Search Tool* can be used to find alternatively fueled vehicles by vehicle type and fuel type, as well as locate nearby dealers.

- **Alternative Fuel and Advanced Vehicle Search Tool**: https://www.afdc.energy.gov/vehicles/search/
- **Clean Cities 2016 Alternative Fuel Vehicle Buyer's Guide:** https://www.afdc.energy.gov/uploads/publication/vehicle_buyers_guide.pdf
- **Clean Cities Guide to Alternative Fuel and Advanced Medium- and Heavy-Duty Vehicles:** https://www.afdc.energy.gov/uploads/publication/medium_heavy_duty_guide.pdf

Alternative Fuel Station Infrastructure

Existing alternative fueling infrastructure can be identified using the Alternative Fuel Data Center station locator: https://www.afdc.energy.gov/stations/#/find/nearest

It should be noted that relatively few propane, natural gas, ethanol and biodiesel fueling stations are available in Massachusetts, particularly in rural parts of the state.

If alternative fuel stations are not available near your municipality, it may be worthwhile to consider installation of an alternative fueling station, depending on municipal fleet size. For more information on alternative fuel station installation, see these AFDC resources:

- Biodiesel: https://www.afdc.energy.gov/fuels/biodiesel_infrastructure.html
- Ethanol: https://www.afdc.energy.gov/fuels/ethanol_infrastructure.html
- Hydrogen: https://www.afdc.energy.gov/fuels/hydrogen_infrastructure.html
- Natural Gas: https://www.afdc.energy.gov/fuels/natural_gas_infrastructure.html
- Propane: https://www.afdc.energy.gov/fuels/propane_infrastructure.html

If a municipal installation of one of these systems cannot be justified, hybrid or electric vehicle technology may be a more feasible alternative. More information is available in our fact sheet *Hybrid, Hybrid Plug-in, and Battery Electric Vehicles: A General Overview*.

Financial Resources

- Compare prices of conventional and alternative fuel vehicles using the **AFDC Vehicle Cost Calculator:** https://www.afdc.energy.gov/calc/
- Compare prices of conventional and alternative fuels from recent **AFDC Fuel Price Reports**: https://www.afdc.energy.gov/fuels/prices.html
- **Biodiesel (B20) Massachusetts State Contract**: https://www.mass.gov/service-details/biodiesel-for-alternative-fuel-vehicles

Clean Energy Extension

FACT SHEET

Telematics Software for Municipal Vehicles

This is one of a series of fact sheets designed to help rural municipalities reduce fuel usage in their town fleets. For more information, please visit the UMass Clean Energy Extension (CEE) website, https://ag.umass.edu/clean-energy.

What is Vehicle Telematics?

Vehicular telematics systems utilize a combination of GPS technology and on-board diagnostics to monitor the location and performance of an individual vehicle or a municipal fleet. This process of sending, receiving, and analyzing vehicular data can highlight potential areas of improvement within a fleet, as well as further ensure the secure use and safe operation of municipal vehicles.

What Information Can a Telematics System Record?

Vehicular telematics systems can measure a number of vehicle characteristics in real-time, including:

- Location (longitude/latitude and street address)
- Speed (via the speedometer)
- Distance travelled (via the odometer)
- Rates of acceleration and deceleration (via the accelerometer)
- Periods of operation, including when the engine is on, and when the engine is idling
- On-board diagnostic codes

This data is recorded by the telematics system and uploaded to an online database. The data can then be accessed and analyzed by fleet managers and authorized municipal personnel. These systems can also provide real-time alerts regarding vehicle operation, maintenance, and location to a mobile device or computer.

How Can Telematics Help a Fleet?

The benefits provided by telematics systems fall into three general categories:

Cost Savings

- By highlighting and avoiding wasteful driving habits such as excessive idling, hard braking, and quick acceleration, fuel usage can be reduced by up to 33%
- Many telematics systems provide maintenance reminders which can ensure that each vehicle is performing optimally, increasing fuel efficiency by up to 9% and avoiding costly repairs later on
- Utilizing the GPS capabilities of a telematics system, route optimization can be used to identify the quickest route between various locations, saving drivers valuable time
- Many insurance companies offer premium discounts to organizations utilizing telematics in their fleet, viewing it as a serious commitment to reducing risk

Convenience

- Automated record keeping eliminates the need for time-consuming paperwork, such as Driver-Vehicle Inspection Reports (DVIRs) and trip histories
- For larger fleets, real-time GPS monitoring can allow fleet dispatchers to identify which vehicle is closest to a given destination, potentially reducing response time, especially in the case of an emergency
- More accurate estimated time of arrival is another benefit of real-time GPS tracking, allowing for better time budgeting and increased customer satisfaction

Safety

- Some telematics systems reduce the risk of theft or unauthorized use by notifying a fleet manager if a vehicle is used outside a designated area or pre-approved timeframe
- Lawful driving is encouraged by most telematics systems, by either notifying the driver or fleet manager when a vehicle exceeds a marked speed limit by a given amount

Purchasing Telematics Software

Telematics systems vary in which operational characteristics they measure, and how these metrics are analyzed and reported. As a first step in the purchasing process, identify which data you need your system to collect. Also consider what other features may be important for your municipality, including whether you require integration with fuel cards, mobile device integration, real-time alerts, individual driver safety tracking, dashboard displays, or communication or navigation options. Consider whether you will need on-going customer support for analysis, or can interpret data in-house.

When contacting telematics system vendors, be ready with a list of these requirements, as well as the number and types of vehicles in your fleet. Ask about upfront and monthly costs. Most vendors will be able to provide an in-person or virtual demonstration of the software. Be sure the user interface is easy to use and interpret.

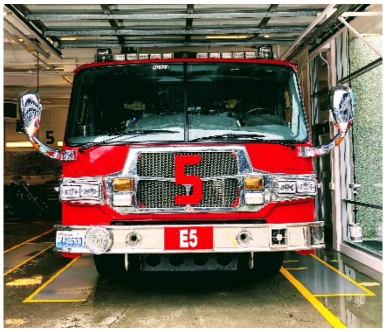
Resources

- Telematics systems are often eligible for funding through the MA Department of Energy Green Communities program: www.mass.gov/green-communities-designation-grant-program.
- Massachusetts has negotiated a statewide contract for purchase of telematics equipment: www.mass.gov/files/documents/2018/03/19/VEH106.pdf
- Telematics software can also be purchased directly from a variety of private vendors. A list of over 50 vehicle telematics software companies is available from Business News Daily, at the bottom of their reviews page: www.businessnewsdaily.com/8291-best-gps-fleet-tracking-systems.html

Clean Energy Extension

FACT SHEET

Idle Reduction Technologies for Municipal Vehicles



This is one of a series of fact sheets designed to help rural municipalities reduce fuel usage in their town fleets. For more information, please visit the UMass Clean Energy Extension (CEE) website, https://ag.umass.edu/clean-energy.

What is Idle Reduction Technology?

Idle Reduction Technology (IRT) is equipment that can be installed in vehicles and heavy duty machinery to reduce or eliminate long periods of idling. Many IRT systems also provide an alternative source of energy so that on-board appliances, such as lights, heaters, and air conditioners, can still be used when the engine is off.

Types of Idle Reduction Technology Systems:

- **Idle Limiter** – The simplest form of IRT, this mechanism turns a vehicle's engine off after it has been idling for a predetermined period of time.
- **Electronic Stop/Start System** – An electronic device that monitors vehicle battery levels while the engine is off, but appliances are in use. Once battery levels drop below a certain point, the device turns the engine on for a set amount of time to recharge the battery, and then turns the engine off again.
- **Auxiliary Power Unit (APU)** – A small secondary power source that allows a vehicle's electronic appliances to be used when the primary engine is not running. APUs can be powered using the vehicle's main fuel supply, a small separate fuel tank, alternative fuel, rechargeable batteries, or rooftop solar panels.
- **Fuel Operated Heater (FOH) and Battery Air Conditioning System (BAC)** – Small independent heating and cooling systems. FOHs can operate on a range of fuels, including gas, diesel, and alternative fuels. BACs are powered with rechargeable batteries, which can be charged by the engine while it is running, or by rooftop solar panels. These two systems are frequently utilized together.
- **Plug-in Hybrid Systems** – Rechargeable battery systems can be installed to run power take-offs, bucket truck lifts, dump truck hydraulics and other truck equipment, even when the engine is off.

How Can Idle Reduction Technology Help a Fleet?

Due to the versatility of IRT systems, nearly any vehicle can be equipped with some form of anti-idle technology. According to the U.S. Department of Energy, idling a vehicle for 1 hour can burn up to one full gallon of fuel. Over the course of weeks, months, or years, unnecessary idling can have a damaging and costly impact on vehicles. While the exact savings for an IRT system can vary, IRT systems provide 3 main benefits:

- Reduced fuel consumption
- Reduced engine wear - extended vehicle life & reduced maintenance costs
- Reduced vehicle emissions

Choosing an IRT System for Your Fleet

Argonne National Laboratory maintains a list of available Idling Reduction Equipment on its website: http://www.anl.gov/energy-systems/downloads/compendium-idling-reduction-equipment-class-1-8-vehicles Download the spreadsheet at the bottom of the page, and then filter by the following search terms to find the particular types of IRT you are considering. Where available, the spreadsheet includes estimated fuel use reduction, estimated cost ranges, and links to manufacturers' websites.

Type of Technology	***Argonne National Laboratory Spreadsheet Search Terms***	
	Technology	**Function**
Idle Limiter	Idle management systems	Automated idle shutdown timer
Electronic Stop/Start	Idle management systems	Idle management system to cycle engine as needed to maintain battery state of charge and coolant heat
	Idle management systems	Idle management to circulate coolant for heat and allow low power accessories to run from battery
Auxiliary Power Unit	APU (Battery)	Battery APU to provide electric power
	APU (Battery)	Battery APU to provide electric power, heating, and cooling
	APU (Diesel)	Diesel auxiliary power unit for electricity generation
	APU (Diesel)	Diesel auxiliary power unit with HVAC and electricity generation
Fuel-Operated Heater	Fuel-operated heater	Fuel fired air heater
	Fuel-operated heater	Fuel fired heater for cabin air
	Fuel-operated heater	Fuel fired coolant heater
	Fuel-operated heater	Fuel fired heater for coolant
Battery Air Conditioning System	Battery HVAC	Electrically driven air conditioning
	Air Conditioner	Water-based evaporative air conditioning system
	Battery HVAC	Solar panel and controls to provide electrical power for heating/air conditioning/hotel loads for vehicles
Plug-in Hybrid Systems for Power Take-off and Truck Equipment	Idle management systems	Plug-in electro-hydraulic hybrid (battery) system for Boom, Bucket and Material Handling truck equipment
	Idle management systems	Plug-in hybrid (battery) system for vocational truck equipment
	Idle management systems	Plug-in hybrid system for vocational trucks to power truck equipment with electric power (batteries)
	Idle management systems	Plug-in hybrid system for vocational trucks to power truck equipment with electric power (batteries) and optional cab comfort system