The Village of Ardsley, NY: Creating an Actionable Plan to Lower Municipal Emissions

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May 2023

ACKNOWLEDGEMENTS

We would like to thank Professor Erin Connell for her guidance and advice throughout this project. We would also like to thank Hon. Asha Bencosme, Trustee, Village Manager Joseph Cerretani, and Charles Hessler for their invaluable contributions to our work. We also would like to make the following acknowledgements:

Village of Ardsley

- Hon. Nancy Kaboolian, *Mayor*
- Leslie Tillotson, *Village Treasurer*
- David DiGregorio, *General Foreman*
- Anthony Piccolino, *Police Chief*

Village of Hastings-on-Hudson

- Mary Beth Murphy, *Village Manager*
- David Dosin, *Chief of Police*

City of White Plains

- Hon. Tom Roach, *Mayor*

Village of Irvington

- Larry Schopfer, *Village Administrator*

New York University

- Roberta Muñoz, *Adjunct Liaison Librarian*

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I. EXECUTIVE SUMMARY

There is currently a favorable political climate for environmentally-conscious policy-making, especially in the transportation sector. Within the Village of Ardsley and surrounding communities, there is an interest in reducing emissions. The Village of Ardsley seeks to reduce municipal vehicle emissions due to health and environmental concerns while maintaining the quality and reliability of its municipal services. Our team's project aims to review the most appropriate technology for Ardsley's needs, examine the feasibility of potential vehicle transitions, and advise on emission reduction technologies and other emission-reduction policies. The project's methodology primarily consisted of a literature review, external and internal interviews, information gathering from the current vehicle inventory and other documentation, and research on available policy and technology.

Our team conducted internal interviews with five employees of the Village of Ardsley. From our internal interviews, our team found that Ardsley employees had similar concerns about the transition to electric vehicles, which include: lack of electric vehicle (EV) infrastructure, the high cost of EV's, EV operability for emergency vehicles, EV operability during power outages, EV reliability in cold weather, and lack of mechanic training for EV vehicles. We also found that Ardsley has already begun some initiatives to reduce emissions, such as: membership in the NY Climate Smart Communities Program, purchasing an electric bike for the police department, having an unofficial anti-idling policy, upgrading most street lights to LEDs, and upgrading Village Hall's lighting to be LEDs. We conducted four external interviews with employees of the Village of Hastings-on-Hudson, the Village of Irvington, and White Plains, all neighboring municipalities. Through our external interviews, we learned about different Electric Vehicle purchasing policies from the three different municipalities. Our team found that all three municipalities are generally satisfied with the transitions they have made. Each municipality has a unique vehicle purchase policy: Hastings-on-Hudson's policy is that all admin and police vehicles must be EVs, Irvington's policy is that when a vehicle needs to be purchased, they evaluate EV alternatives and have a set criterion that they need to meet before purchasing the EV. Lastly, White Plains' policy is that any vehicle that is purchased needs to be electric unless there is some reason it should not be, and all Sedans must be electric. Our team also found that there is a backlog when purchasing EVs, EVs require generally less maintenance, it is essential to have department head buy-in when purchasing EVs, there has been no electric grid impacts by EVs, and Electric Vehicles can be purchased through tax credits and grants. Through our review of Ardsley's inventory and emissions report, our team found that 55% of Ardsley's fleet runs on diesel, and that DPW emits the most total emissions, at 62.5%, yet the Police Department emits the most emissions per vehicle. Through our literature review, our team found that lowering emissions decreases negative health outcomes, reduced vehicle use is the most effective way to reduce emissions, driving ranges of EV's are expected to increase in the next few years, low temperatures affect the EV batteries, the overall cost of ownership of an EV vehicle is lower than a conventional vehicle, and that the electric vehicle market is expected to be fully mature by 2025.

Our team produced a vehicle purchase checklist through a decision tree model, to be utilized by department heads when making vehicle purchasing decisions. Our team identified electric vehicle and hybrid vehicle replacements to the vehicles identified in the capital plan, and created a replacement schedule. We identified additional vehicles that have suitable EV or hybrid replacements on the market today. Our team crafted a two-phase infrastructure plan to install electric vehicle chargers in the Village of Ardsley. Lastly, our team identified policy recommendations that could further reduce emissions beyond the vehicle sector and help in implementing the vehicle transition plan: increasing biking and walking infrastructure, improving municipal buildings' energy efficiency, providing training to mechanics, and ensuring department head involvement in the vehicle purchasing decision-making process

II. INTRODUCTION

The Village of Ardsley seeks to reduce its emission by transitioning their municipal vehicle fleet into more sustainable alternatives. Environmental and health concerns are the driving forces behind Ardsley's interest in making the transition. As a member of New York State's Climate Smart Communities, Ardsley seeks to set emission reduction goals. The Village of Ardsley's 2019 Inventory of Government Operations Greenhouse Gas Emissions Report found that the Village's yearly emissions totaled 535 metric tons (MT) CO2e. The Village's fleet was found to be the main contributor of those emissions, at 49% of total emissions, followed by the Village's buildings, at 43% of emissions. Street lights and traffic signals contributed to 8% of emissions (Appendix I).

Given Ardsley's goal of reducing municipal emissions, the main objectives of our capstone project include:

- Reviewing the current low-emission vehicle technologies and emission-reduction policies
- Identifying low-emission vehicles that can be utilized in Ardsley's municipal fleet
- Crafting a fiscally responsible transition plan, including infrastructure needs

III. METHODS

Our team's research methods have consisted of regular check-ins with the Village of Ardsley and information gathering through desk research, client meetings, and interviews with employees of Ardsley and neighboring villages. This strategy has allowed us to compile our findings that inform our recommendations. Weekly team meetings have also been utilized to collaborate on deliverables.

Our team conducted the literature review research from November 7th until December 20th, 2022. The research was conducted on multiple platforms, including Google Scholar, Engineering Village, and Ebsco. We also consulted the U.S. Department of Energy (DOE) and U.S. Department of Transportation (DOT), World Health Organization (WHO), and U.S. Environmental Protection Agency (EPA). Lastly, our team reviewed relevant industry articles to review the current market offerings. The terms searched on different platforms included "electric vehicles," "medium- and heavy-duty electric vehicles," "low emission vehicles," and "electric vehicle infrastructure." Our team reviewed over 97 articles and sources, as referenced in our works cited section. In addition to our literature review, our team conducted desk research throughout the year to identify appropriate vehicle and equipment replacements, vehicle retrofitting alternatives, and low-emission policies.

Our team conducted internal interviews from January 3rd, 2023 until January 18th, 2023, with five employees of the Village of Ardsley. All interviews were conducted over Zoom. Our team attempted to interview the Village's fire chief, but was unable to do so. The questions posed to each employee were uniform, with slight variations depending on their job duties. Our team conducted external interviews from January 30th, 2023 until March 23rd, 2023. All interviews were conducted over Zoom. We conducted interviews with representatives of the Village of Hastings-on-Hudson, the Village of Irvington, and the City of White Plains- all geographical comparable municipalities to the Village of Ardsley. The questions posed were uniform for all three municipalities.

The Village of Ardsley provided the team with a March 2022 auto schedule with information for each of the vehicles owned by the municipality. This consisted of make, model, model year, vehicle identification numbers (VINs), auto class, cost when purchased new, and collision and comprehensive deductibles. We were additionally provided with fuel expenses and fuel purchased broken down by month for FY 21-22. The inventory table devised for the Village's municipal fleet contains the following vehicle information: make and model, year purchased, municipal department, style, vehicle type, fuel type, cost when purchased, and the VIN. Ardsley has 51 municipal vehicles we examined in our report. We removed 4 vehicles given their usage and classifications: 1 vehicle was an antique fire truck used for parades and 3 were trailers.

IV. FINDINGS

A. Internal Interviews

The Village of Ardsley assisted the Team in arranging interviews with five internal stakeholders who serve as department heads in the municipality. The team conducted five interviews with the Police Chief, Village Manager, Mayor, Village Treasurer, and DPW Foreman. The team attempted to schedule an interview with the Fire Chief. The interviews have provided insight into perceptions and potential impacts of a vehicle transition, along with information on the day-to-day operations of various departments. Below is a summary of the insights gleaned from the interviews.

Through our team's interviews with Village employees, we found that all our interviewees shared similar concerns about a potential transition to electric vehicles.

The top concern expressed during our internal interviews is the lack of appropriate infrastructure for the transition to EVs, with some expressing a desire for the infrastructure to be built first before purchasing any electric vehicles. Another expressed concern was the current high cost of electric vehicles, as the Village's debt is currently maxed out. Additionally, there was a concern that Village mechanics are not properly trained to fix electric vehicles. There was also hesitation regarding the fact that the majority of the Village fleet provides essential services, and the potential ability to charge electric vehicles throughout the day. Additionally, since the Village lost power during Hurricane Sandy, the Village wants to ensure that the vehicles would be able to run when power is lost. Lastly, there is a worry that electric vehicles would not perform well during the colder months.

In its commitment to caring for the environment, the Village has already begun efforts to reduce greenhouse gas emissions.

Ardsley's Police Department has purchased an electric bicycle, which is used for patrol when possible. The Police Chief has stated that the officers have been satisfied with this equipment. All departments have an anti-idling policy that applies to all vehicles except for emergency vehicles. The Police Department also has an unofficial policy of shutting off vehicles when they are not in use. The Village has also converted almost all of its street lights (449 of the 454) to LED lights. Lastly, the Village has begun LED lights upgrades in the Village Hall.

B. External Interviews

The Village of Ardsley provided the Team with contacts to four external stakeholders in the region, who have implemented vehicle transitions in their municipalities. We conducted interviews with the Police Chief and the Village Manager from Hastings-on-Hudson, the Village Manager of Irvington, and the Mayor of White Plains. The interviews yielded insights on the procurement process, challenges and opportunities associated with the transition, and attitudes towards the change. Our team found that all three municipalities are generally satisfied with the transitions they have made. Each municipality has a unique vehicle purchase policy: Hastings-on-Hudson's policy is that all admin and police vehicles must be EV, Irvington's policy is that when a vehicle needs to be purchased, they evaluate EV alternatives and have a set criterion that they need to meet before purchasing the EV. Lastly, White Plains' policy is that any vehicle that is purchased needs to be electric unless there is some reason it should not be, and all Sedans must be electric.

All municipalities are transitioning their vehicles to electric in phases, but have different policies when considering the purchase of electric vehicles.

The Village of Hastings-on-Hudson has purchased all electric vehicles for their administrative and police cars. Their policy is that all police and administrative vehicles have to be electric, and all new vehicles need to be evaluated for EV replacement. The Village of Irvington's policy is to always consider the use of alternative vehicles when making a vehicle purchase. They will only purchase an alternative vehicle if it is: commercially available, sold by a national dealer locally, contains no aftermarket modifications, has fuel readily available, and meets operational and safety standards. White Plains' electric vehicle purchase policy is that if a department chooses to buy a non-electric vehicle, they must have an explanation as to why it is not electric. In addition, all sedans need to be electric.

Electric vehicles purchased have taken a long time to arrive, as there is a national backlog for EVs.

The Village of Hastings-on-Hudson has purchased an electric Ford Mustang Mach-E, and it has taking about a year to arrive. The Village of Irvington also stated that there is a backlog, as they had not received some vehicles that were ordered over a year ago. White Plains has also stated that it is difficult to get the vehicles. Even as a member of the Climate Mayor's buying program, the Mayor believes that there is little vehicle availability, and sees supply as the main issue in making the transition to EVs.

In making the shift to electric vehicles, it is important to have Village departments' buy-in.

Our interviews highlighted the importance of involving department heads in the vehicle purchasing decision making. The police chief in Hastings-on-Hudson stated that the police department had no choice in making the shift to EVs, and that the village did not solicit input from the department. The village has a no-compromise policy, where only electric vehicles can be purchased for the police department, which can create friction with department heads. In the Village of Irvington, each department head is involved in making the purchasing decision for vehicles. White Plains' department heads are also involved in choosing the vehicles purchased.

Electric vehicles have less driving range in the winter, but it has not affected their daily operations.

The vehicles in Hastings-on-Hudson get an average of 250 miles a charge, and it goes down to 210 miles a charge in the winter, but they have not found that to be an issue. The Village of Irvington does not currently use electric vehicles when it is cold, but the Village Manager has heard no complaints from the departments.

All municipalities have installed Level 2 charging stations for the municipality's vehicles.

The Village of Hastings-on-Hudson currently has one Level 2 charger for vehicle staff, and one charger hanging from the second floor of the Village Hall. They have plans to install six additional chargers, and have hired an electrical engineer to draw up plans for this. The Village of Irvington has two charging units for village vehicles. White Plains has Level 2 chargers, and mentioned that once they purchase electric vehicles for the police department, they will need Level 3 chargers as well.

The municipalities have found that electric vehicles require less maintenance, and White Plains emphasized the importance of mechanic training and buy-in.

The municipalities have mentioned that one benefit of Electric Vehicles is that they require less maintenance. The Mayor of White Plains has also stated the importance of mechanic buy- in. He stated that their mechanics are experienced with Ford vehicles, and other American manufacturers, so they were more receptive to Electric Vehicles coming from these manufacturers.

Outfitting electric vehicles for the Police Department's use is expensive, so two municipalities chose hybrid vehicles instead.

The Village of Hastings-on-Hudson has an electric Mustang for the police department, and has noted that the custom outfitting has been expensive, costing the Village $105,000. Moving forward, they stated that they will wait until the Ford F150 comes out to avoid those high outfitting costs. Both the Village of Irvington and White Plains police vehicles are hybrid vehicles.

None of the municipalities have seen an impact on the electrical grid after their transition.

The Village of Hastings-on-Hudson states that they had not seen electrical grid impacts. They have done a lot to reduce electricity use, such as putting in place sensors, LED lights, and providing rewards for reduced electricity use. These measures have reduced electricity use in the Village. Irvington has not seen an impact on the electricity grid yet, but the village manager has stated that they are not pushing the limits yet. White Plains has seen no issues as well.

All municipalities have taken advantage of tax credits or grants for their EV vehicle purchasing, in addition to competitive bids from other municipalities.

The municipalities have taken advantage of different grants, such as the Con-Edison Power Ready Program, the Zero Emission Grant Program, and NYSERDA grants. The Village of Hastings-on-Hudson was able to receive rebates and leased-by opportunities when purchasing vehicles, in addition to tax credits. The Village of Irvington purchases its cars through competitive bids or through another government contract. In addition to this, they are expecting a reimbursement of $7,000 per electric vehicle purchased, given by the Zero Emission Grant Program. The Village of Irvington has also taken advantage of the ConEdison Power Ready Program, which gives reimbursements for electric vehicle infrastructure installation. White Plains was also able to take tax credits for their electric vehicle purchases. White Plains has utilized grant money for necessary infrastructure upgrades, and will be installing 90 Level 2 chargers. There are NYSERDA grants available based on points for municipal climate actions. White Plains additionally is part of the ConEdison program that pays a municipality if it limits its charging hours from 12am-6am.

C. Inventory

1. Full Municipal Fleet

Based on an Emissions Inventory of the Village of Ardsley, the municipal vehicle fleet accounted for 48% of the CO_2 emissions from government operations in 2019 (Appendix I). We analyzed the information on the vehicles in order to understand the current makeup of the fleet and understand current municipal trends.

Not including the antique fire truck and three trailers, there are a total of 51 regularly-used vehicles in Ardsley's municipal fleet. One vehicle belongs to the Building and Code Enforcement Department while the rest belong to the Police Department (12 vehicles), DPW (30 vehicles), and the Fire Department (8 vehicles). Our full inventory chart can be found in Appendix IV.

Ardsley's vehicles are all from American car manufacturers.

Ardsley's vehicles are all from American-based vehicle companies and manufacturers. These include Chevrolet, Dodge, Ford, John Deere, and Mack (Appendix V Fig. 1). It is unclear to us if there was a reason for this, but there is a history of U.S. government entities being required or receiving tax incentives to purchase American-made products.[1]

Many of the lightweight vehicles used by Ardsley's departments are widely-available vehicles that have been modified for municipal use, especially within the police department. This allows for more affordable and more accessible vehicle maintenance options, which the municipality noted as being a priority. Future vehicle purchases could consider similar vehicle manufacturers.

DPW vehicles primarily rely on diesel fuel.

Out of the 30 vehicles operated by DPW, 25 of them rely on diesel fuel (Appendix V Fig. 3). This is about 83% of the department's vehicles. These diesel vehicles include garbage trucks, mobile equipment such as tractors, dump trucks, and medium-weight trucks. DPW also has the greatest department variety when it comes to vehicle makes and models which is consistent with the department's myriad of responsibilities.

The other department that uses diesel fuel is the fire department (Appendix V Fig. 4). The three fire trucks they operate run on diesel fuel and account for about 37.5% of the department's vehicles: significantly lower number than the percentage of DPW's diesel vehicles.

Ardsley spent about $3.42/gallon on regular, unleaded fuel and about $4.06/gallon on diesel fuel.

The Village of Ardsley spent $116,461.31 on fuel and purchased about 31,008.29 gallons of fuel (Appendix V Fig. 5-6). For FY 21-22, DPW reported as having spent a total of $76,411.25 on fuel:

$11,591.76 on the five regular fuel vehicles and $64,819.49 on the twenty-five diesel fuel vehicles. DPW purchased a total of 3,497.30 gallons of regular fuel and 15,900.82 gallons of diesel fuel. Regular fuel for DPW cost approximately $3.31 per gallon and $4.08 per gallon.

The police department reported a total regular fuel spending of $24,857.33 for their twelve department vehicles. The police department also purchased a total of 7,234.63 gallons of regular fuel. Regular fuel for the police department cost approximately $3.44 per gallon.

The fire department reported spending $15,192.73 on fuel for the same period of time: $10,830.15 on regular fuel and $4,362.58 on diesel fuel. The fire department purchased a total of 3,120.36 gallons of regular fuel and 1,255.18 gallons of diesel fuel. Regular fuel for the fire department cost approximately $3.47 per gallon and diesel fuel cost about $3.48 per gallon.

DPW vehicles, on average, had the highest fuel costs and fuel use for both diesel and regular fuel.

Given the details on the fuel expenses of each department in addition to the department's vehicle makeup, we were able to estimate how much the Village of Ardsley spent in FY 21-22 on fuel for the average vehicle as well as how much fuel was used (Appendix V Fig. 7-8).

We estimate that each DPW regular fuel vehicle cost about $2,318.35 and used an average of 699.46 gallons of fuel. Each DPW diesel fuel vehicle cost about $2,592.78 and used an average of 636.03 gallons of diesel fuel. The police department spent about $2,071.44 on fuel for each of their vehicles and each vehicle used an average of 602.89 gallons of fuel. Fuel for each regular fuel vehicle in the fire department cost about $2,166.03 and used an average of 624.07 gallons of fuel. Each diesel fuel vehicle in the fire department cost about $1,454.19 in fuel expenses and used an average of 418.39 gallons of diesel fuel.

DPW accounted for the majority of vehicle emissions as a department; but, each police vehicle contributed more emissions on average.

The 2019 emissions study broke down the municipal fleet vehicle emissions by department and showed DPW vehicles contributed 162 CO_2e, police vehicles contributed 68 CO_2e, and fire department vehicles contributed 29 CO_2e. 63% of vehicle emissions in Ardsley came from DPW vehicles (Appendix V Fig. 9).

Given the fleet changes since the study, we analyzed the emissions by department by removing vehicles that were purchased between 2020 and the present. This changed the fleet makeup to have 39 vehicles: 1 Building and Code Enforcement Department vehicle, 9 Police Department vehicles, 23 DPW vehicles, and 6 Fire Department vehicles.

We estimated that, on average, police department vehicles emitted 7.556 CO2e, DPW vehicles emitted 7.043 CO2e, and fire department vehicles emitted 4.833 CO2e (Appendix V Fig. 10. While the department vehicles accounted for 26% of the municipal vehicle emissions, the average police vehicle emitted the most CO2e than the average DPW or fire department vehicle (Appendix V Fig. 11).

As mentioned previously, the police department vehicles see the most use when compared to the rest of the municipal fleet, which could account for the higher emission levels. Ardsley's police see more regular use and are often left idling in order to maintain operations of the police computer system. The police chief informed us that the Chevrolet Tahoes needed to be left idling due to a technical irregularity while other models were able to operate the computer system while the vehicle was off.

2. Vehicle Fuel Use and Efficiency

With the information provided, we were unable to do a more definitive analysis of the fuel efficiency of Ardsley's municipal fleet. The Village does not collect information regarding the fuel use and efficiency for each of its municipal vehicles. In our recommendation section, we provide additional insight into how Ardsley might be able to do this. Collecting this information could prove useful in identifying which vehicles are performing better and, as a result, provide insight into which vehicles should be updated for a more efficient and lower-emission model.

Given our findings, it is important to note that each departments' vehicles are used for very different purposes. For example, the fire trucks of the fire department do not see the same amount of use as the police department's patrol vehicles and, as such, will see vastly different fuel costs and consumption. DPW has many different kinds of heavy vehicles that consume a great deal of fuel and have different frequencies of use. Cross-department comparisons of vehicles should account for additional factors beyond cost of fuel and fuel consumption.

D. Literature Review

Below is an abridged version of our literature review, highlighting key points in our research. Our team's full literature review is located in Appendix II. Our research is based on several key focus areas, including health impacts, benefits of transitioning to EVs, technical limitations of EVs, fuel efficiency, infrastructure needed to make the transition, and comparable use cases. The literature review aims to cover the current state of research on low emissions vehicles, their implementation or viability in practice, examples of EV transition programs, as well as review the availability of comparable vehicles coming to market, in order to support our recommendations.

The team's research showed a variety of findings or trends concerning the transition to electric or low emission vehicles. Common themes were discovered, including health benefits, fuel efficiency, overall costs, and lower carbon footprint. Vehicle range, battery life, and reliance on the electrical power grid were also commonalities throughout our research. A detailed overview of the evaluations, articles, case studies, and vehicle comparisons have been included in this report.

Lowering emissions decrease air-pollution related health issues and death.

While many studies struggle to specifically link transportation-caused air pollution to health issues, air pollution contributes to increased rates of asthma, COPD, and respiratory issues.[2] People who live in urban and suburban areas with greater vehicle emissions are at a higher risk of these diseases, especially if they work outdoors or with heavy vehicles.[3] Lee et al. examined how municipal waste workers who drove the waste trucks were exposed to less carbon pollution than those who were collecting the waste outside the truck.[4] A series of studies proved that truck drivers, street cleaners, highway toll workers, and bus drivers, who are exposed to greater levels of vehicle exhaust, were at a higher risk for lung cancer, heart attack, and heart diseases.[5 6 7 8] Larger-scale transition to low-emissions vehicles, especially heavy-duty vehicles, could decrease emissions-related deaths globally by 3 million.[9] Additionally, 100% EV sales and 100% clean electricity is estimated to generate $1.2 trillion in health benefits, and will save 110,000 lives and 2.7 million asthma attacks in the U.S. by 2050.[10]

Reducing vehicle use is the most effective way to reduce emissions, lower temperatures affect electric vehicle battery life, the total cost of ownership for electric vehicles is lower than conventional vehicles, and driving ranges are expected to increase in the next few years.

Conlon, Waite, Wu, and Modi suggest that to achieve overall energy emissions reductions it is important to prioritize vehicle electrification ahead of complete grid decarbonization.[11] A study in Europe showed that electric SUVs did not contribute to reducing emissions. The authors suggest reducing the reliance on technology fixes, downsizing, and reducing vehicle use to reduce emissions.[12] Temperatures of 0 °C and −15 °C reduce the battery capacity of Battery Electric

Vehicles of 150 km by 53% and 40%, respectively.[13] Even without government subsidies, the Total Cost of Ownership (TCO) of EV vehicles is less than conventional vehicles.[14] Another point concerning EVs sold in the United States is that their fully charged driving range can vary from 62 to 270 miles per charge (with a median of 93 miles), depending on the brand or model.[15] EV ranges are expected to reach 500 miles per charge in the next few years, bringing them closer to the majority of fossil fuel-powered vehicles.[16]

The vehicle market is rapidly shifting towards electric vehicles and is predicted to be fully mature by 2025, and EV vehicles can save between $6,000 and $10,000 per year.

When determining the price and drive range of an electric vehicle, the size and capacity of the battery is the most important component.[17] Aryandi, Gunawana, and Monaghan found that Plug-in hybrid electric trucks operate with the lowest fuel costs of $0.16/kWh.[18] [19] It is predicted that by 2030, the battery price will be close to half of the current price.[20] In the first quarter of 2022, 2 million EVs were sold globally, a 75% increase from the first quarter of 2021.[21] New electric vehicles sales are predominantly battery electric vehicles, accounting for 75% of electric sales.[22] A 2022 U.S. Department of Energy Report maintains that there are several medium and heavy electric vehicles currently available in the U.S. Market, including transit buses, delivery trucks, forklifts, mowers, tractors, and ground support equipment.[23] Zero emission trucks and buses availability has increased by 26% from 2020 to 2023, and there are 544 models currently available.[24] These markets are projected to be fully mature by 2025.[25] There will be a variety of pickup trucks coming into the market by 2023 and beyond.[26] Currently it is estimated that small electric trucks will become cost competitive by 2030, and heavy trucks by 2035.[27] The U.S. Department of Energy's study shows that nearly half of medium- and heavy-duty trucks will be cheaper to buy, operate, and maintain as zero emissions vehicles than traditional vehicles by 2030.[28] The International Council on Clean Transportation (ICCT) estimates that 45% heavy duty vehicles sales in 2030 will be zero-emission, and 100% in 2040.[29]

The Customer Report reports that electric vehicles have higher upfront cost compared to internal combustion engine vehicles, there is much evidence available indicating the electric vehicles are cheaper to maintain. NRDC estimates the annual savings at the levels between $6,000 and $10,000.[30]

Level 2 chargers are the most suitable for Ardsley's needs.

The generally approved classification of charging stations is set on a scale 1 to 5, with Level 1 having the lowest power capacity and Level 5 the highest. Level 1 equipment is recommended for personal use of light duty vehicles at owners' houses. Level 2 equipment also uses alternative current and can draw energy from local distributional systems. It operates on upgraded, 220-volt outlets, with power ranging from 6.6 kWh to 19.2 kWh. Level 3 to Level 5 equipment uses direct current, charging the battery directly and delivering much more power, without the necessity of purchasing the inverter. Level 1 is a convenient form of charging EVs and accounts for approximately 50% of in-house charging stations for EV owners as of June 2022.[31] The U.S. Department of Energy reports that the Level 2 charging equipment can meet the needs of MD/HD vehicles with low utilization and long dwell periods.[32] There might be a need for different types of equipment for MD/HD vehicles, such as inductive or overhead equipment which allows vehicles to charge while parked. Charger tower prices range from $1,000 to $4,000 in the Lee and Clark estimates, while others use a range from $469 to $9.985 per tower.[33] The big price range is dependent on the qualities of the equipment – complexity of interface, on-site payment system, or network connection. Level 2 stations, moreover, have better durability and more features than Level 1 and are recommended for workplace stations where multiple vehicles are charged. The Department of Transportation, Forbes, and many other sources indicate that Level 2 is sufficient for needs of small- to medium- sized commercial charging stations.[34] [35] [36] Additionally, Level 2 has higher power than Level 1 stations. One hour of charging at a Level 2 station allows driving a range of 10 to 20 miles, compared to only 3 to 5 miles for vehicles charged at Level 1.[37] Costs can be optimized by controlling the following factors: location, features, and charging form. The Energy Efficiency and Renewable Office at the Department of Energy reported that the Level 2 wall mounted charging station is 37% cheaper than the average installation cost of a pedestal unit, with an average cost of $2,035 for the mounted wall unit and $3,209 for a pedestal mount. Level 2 chargers typically require an installation of 240-volt circuit, circuit needed for household clothes dryers.[38]

New York State is investing in municipalities to make the switch to electric vehicles and infrastructure, in addition to utility company incentives.

In September 2022, Governor Hochul directed the State Department of Environmental Conservation to require all new passenger cars, SUVs and pickup trucks sold in the State of New York to be zero-emission by 2035.[39] New York state is also allocating $5.75 million for the purchase of zero-emission vehicles and installation of supporting infrastructure to municipalities.[40] The National Electric Vehicle Formula Program will provide funds to states to deploy EV charging infrastructure.[41] Of this, New York State will receive $175 million over the next 5 years to create an electric vehicle charging network.[42] Utility companies, such as PSE&G, offer incentives for the installation of EV chargers.[43] The Climate Mayors Electric Vehicle Purchasing Collaborative is open to all U.S. cities and provides competitive bid contracts, resources, and support for vehicle transitions.[44] The political environment is particularly supportive of investments and expansion of alternative vehicles. First, there is the EV Make Ready program. The program supports development of infrastructure for non-residential needs. The entities might be eligible to receive up to 100% of costs associated with development of Level 2 and Level 3-5 charging stations.[45] Evolve NY is a program promising $250 million funding by 2025. The goal is to build a fast and reliable charging facility close to 5 cities in NY State, including Yonkers.[46] Lastly, there is Climate Smart Communities, a program supporting local governments to reduce their GHG emissions. There are 3 possible grants that one can apply for. The grants support purchase of vehicles and charging stations.[47]

E. Emission Reduction Technology and Policies

Since purchasing low emission vehicles will be expensive, our team conducted further research into low-cost alternative technology and policies that can reduce emissions. These include: vehicle exhaust retrofits (such as IdleRight technology), renewable diesel, policies that encourage walking and cycling, and building retrofits to reduce building emissions. The retrofitting of vehicles can be implemented on Ardsley vehicles that are not old enough to be retired and cannot be suitably replaced with electric or hybrid counterparts.

1. Vehicle Exhaust & Idle Reduction Technology (IRT) Retrofits

The Diesel Emissions Reduction Act (DERA) requires any heavy-duty vehicles owned by the state or those performing work for the state to be retrofitted with Diesel Exhaust Fluid (DEF) systems and utilize low-sulfur fuel or be phased out.[48] Most diesel vehicles produced for the United States market after 2008 have DEF systems, but it would be recommended to verify this for any older vehicles in the municipal fleet. Carbon-capture add-ons have also been in development for fossil fuel vehicles. The startup Remora has developed a method which filters exhaust emissions by converting CO2 into liquid.[49] The retrofit module costs approximately $15,000 and the captured CO2 has the potential to either be recycled or monetized.[50] This system would be best suited for heavy vehicles and those relying on diesel fuel that may present a challenge when transitioning to electric powered vehicles. The Village of Ardsley may want to focus on utilizing this option for garbage collection trucks, fire trucks, and heavy-duty construction vehicles. They may also be limited by what options are available from companies offering the technology and what vehicles can ultimately be outfitted, but there are a number of options available on the market.

A number of studies were conducted by municipalities and agencies across the country, from successfully implementing Idle Reduction Technology (IRT) on police vehicles to the use of a variety of emission reducing solutions. These range from full stop-start engine management for idling to battery or electrical systems-based idling management. [51] Though different solutions may be a better fit for some agencies and vehicles, depending on their usage, IRT offers the ability to operate through a vehicle's engine or certain electrical systems to reduce emissions. A table listing study participants, IRT types, functionality, and other information can be found in Appendix X.

The City of Burlington, Vermont also participated in a pilot program with the Vermont Clean Cities Coalition (VTCCC) to reduce emissions from police vehicles. They adopted a fuel management system in one of their vehicles branded as "IdleRight", which is part of a larger group known as idle reduction technology (IRT). These devices monitor a vehicle's auxiliary systems, such as the battery level of the emergency lights, and reduce idling and unnecessary power consumption when possible. During the pilot in Burlington, this technology was installed on one police car, resulting in significantly reduced tailpipe emissions and saving 345 gallons of fuel. It also cut down on required vehicle maintenance and operating costs by about $800 a year.[52] An unintended positive outcome of the pilot included residents decreasing their complaints towards police vehicle idling and decreased wear on the vehicle.

An alternative to IdleRight is the GRIP Idle Management System. While IdleRight is vehicle specific, GRIP provides a platform with monitoring and metrics for an entire fleet of vehicles once installed.[53] Though the two options provide very similar base services, they come at different price points, with IdleRight costing approximately $165 per vehicle installation and acting as a standalone product, while GRIP provides the benefit of a dashboard and can be used fleetwide, at a cost of $3,000 per vehicle.[54] For example, projected savings for a police cruiser are $3,500 per year on the GRIP platform, despite being a pricier option, while IdleRight cuts operating costs by approximately a third.

2. Renewable Diesel

Renewable hydrocarbon biofuels are produced from biomass using a variety of chemical processes. This fuel is suitable for diesel vehicles. Additionally, it is produced in the United States. As noted by the US Department of Energy, renewable diesel has many advantages, including compatibility with diesel engines and lower emissions levels. Renewable diesel meets the ASTM D975 standard for petroleum in the United States, a set of tests and acceptable limits for diesel fuels available on the US market.[55] Renewable diesel (RD) also reduces greenhouse gas emissions by up to 80% because it is produced from 100% feedstock.[56]

In addition to the benefits, it is also a financially feasible alternative. In 2022, a survey of 46 retailers indicated that the renewable diesel cost was approximately $6.15/gallon while the average diesel price was $6.24/gallon.[57] According to the US Energy Information Administration, the usage of renewable diesel in the US is predicted to double by 2025. The decision to use renewable diesel is dependent on appropriate investments in fuel storage. RD is widely used in both California and New York City, among others. New York City has conducted a pilot program in recent years, and many companies such as Google have committed to use renewable diesel.

Despite this progress, production capabilities of renewable diesel are significantly limited. Projections of production for the year 2025 will not be achieved due to limited availability of feedstock.[58] Additionally it is not guaranteed that renewable diesel is a zero-emission and sustainable technology. The EPA noted that the mass production of renewable diesel would limit production of biofuels as they are manufactured using the same resources. Moreover, high demand for feedstock will have unpredictable, but most likely negative, impacts on the market and the environment.[59] The demand for animal fat is expected to grow faster than production, so the availability of biofuels is expected to remain at similar levels.

Although renewable diesel technology is promising and affordable, the scarcity of the product and precarious supply chain makes it difficult and not reliable. We refrain from incorporating renewable diesel as a part of our recommendations due to low plausibility of mainstream implementation in Ardsley.

3. Encouraging Walking and Cycling

To reduce emissions, municipalities can implement policies that increase pedestrian safety and bicycle infrastructure. Municipalities can replace multilane streets with bike lanes and walkways. Appendix VIII shows how walking and biking are the most carbon efficient modes of transportation. Over half of car trips in the U.S. are under 3 miles, a 20-minute bike ride for most riders.[60] Converting more car trips into bike trips greatly reduces carbon emissions. Improving a city's walkability will not only reduce emissions, but can improve the quality of life of its residents.[61] Policy changes that reduce the amount of driving can be more efficient in reducing emissions.[62] An important aspect when encouraging increased walking and cycling rates is ensuring safety.[63]

To increase biking rates, municipalities can add more protected bike lanes. They can convert 12- to 14-foot wide driving lanes into 10-foot wide lanes, to introduce a protected bike lane. This measure has been proven to reduce car speeds, and better protect both cyclists and pedestrians from traffic.[64] To achieve maximum impact, the bike lanes should be placed to connect common destinations, not just as trails for recreational purposes.[65] This initiative was implemented in Philadelphia, and the added bike lanes led to a 70% increase in biking to work from 2010 to 2017.[66] In addition to adding bike lanes, a good way to increase cycling rates is by subsidizing or partnering with bike sharing services. Many small municipalities are successfully using bike sharing in their communities.[67]

4. Lowering Building Emissions

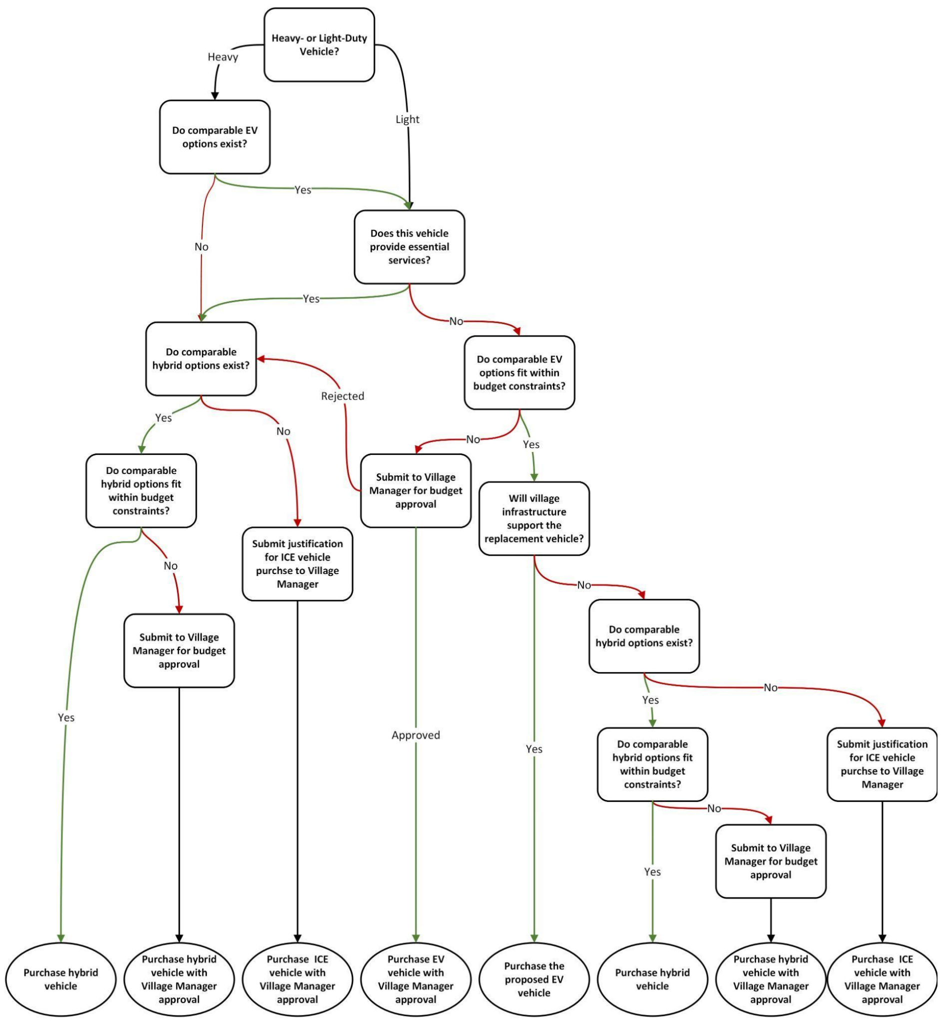
An effective way to lower emissions is to make buildings more energy efficient. Energy use in buildings is a major source of greenhouse gas emissions and air pollution. In Ardsley's 2019 emissions report, they indicate that the total building emissions are 236 MT of CO2e., accounting for 43% of Ardsley's total emissions. To reduce statewide emissions by 40% by 2030, addressing building emissions is essential.[68] An example government policy that aims to reduce emissions from buildings is NYC's Local Law 97, which puts carbon caps on buildings larger than 25,000 square feet.[69] Ardsley has identified five buildings that have the highest emissions: the firehouse, Village Hall, the highway garage, public library, and the community center. All of these large buildings could be made more energy efficient through retrofitting efforts. One energy source in buildings is the HVAC equipment, which represents 30-40% of energy use in buildings, and includes things such as boilers, fans, heat pumps, and chillers.[70] Retrofitting buildings could potentially reduce 40% of a city's natural gas usage.[71] Energy Star, a program through the EPA, helps local governments design and implement emission-reduction policies to municipal buildings.[72]

One way to significantly reduce emissions generated from municipal buildings is by exploring geothermal energy sources. Geothermal is an energy source that can be used for heating and cooling purposes in buildings. It is proven to be an energy source that is locally sourced and sustainable.[73] One study has found that using geothermal energy is cheaper than conventional energy sources when the price of electricity is low in the region, in addition to utilizing less energy to heat a building. Additionally, utilizing geothermal heat pumps can lead to a reduction in CO2 emissions.[74]

V. RECOMMENDATIONS

A. Vehicle Purchase Decision Tree

To aid department heads and village administrators in making choices when municipal vehicles need replacement, we created a decision tree to guide them on purchasing lower emission options. As shown in Appendix VII, this decision tree takes the decision-maker through several steps, determining the best choice for comparable options, while also considering the needs of the Village, such as infrastructure, essential services, budget constraints, and vehicle availability.



B. Capital Plan Vehicle Replacements

Out of the vehicles in the inventory, many have the potential for future replacement and are identified in the following sections. Many of these vehicles are already being phased out and replaced as part of Ardsley's Capital Plan. The table below shows mobile equipment and lightweight vehicles that have already been identified for replacement in the plan and are scheduled to occur between the fiscal years of 2022 and 2031. We include potential lower-emission vehicles that Ardsley may consider replacing with given their budget allocations, timeframes, and available technologies.

To replace these vehicles, the Village of Ardsley can utilize the New York State Clean Transportation program funding opportunities. Opportunities include the Drive Clean Rebate for Electric Cars, which provides rebates of $2,000 for electric vehicle purchases, that can be combined with the Federal Tax Credit of $7,500.[75] Additionally, the New York Clean Transportation Prices offer funding for projects that electrify transportation, reduce air pollution, and increase clean mobility.[76] Lastly, the New York Truck Voucher Incentive Program provides vouchers and discounts to purchase or lease electric trucks and buses.[77]

VEHICLE	REPLACEMENT PLAN	SUGGESTED REPLACEMENT
CHEVROLET Tahoe - DPW	FY 2023 - 2024 $65,000.00	Chevrolet Silverado (Hybrid) $53,000 est.
JOHN DEERE Loader 624J - DPW	FY 2023 - 2024 $325,000.00	Volvo L25 Electric $151,575 est.
CHEVROLET Tahoe - Fire	FY 2025 - 2026 $80,400.00	Chevrolet Silverado (Hybrid) $53,000 est.
JOHN DEERE Tractor 4720 - DPW	FY 2026 - 2027 $135,000.00	Kubota LXe-261 $29,339 min.
CHEVROLET Tahoe - Fire	FY 2028 - 2029 $93,073.00	Chevrolet Silverado (Hybrid) $53,000 est.
CHEVROLET Tahoe - DPW	FY 2030 - 2031 $80,000.00	Chevrolet Blazer $35,100 min. Chevrolet Equinox $34,000 est. Chevrolet Bolt EUV $28,795 min.

C. Additional Vehicle Replacements

In addition to those vehicles the municipality has plans to replace, we have identified some other lightweight vehicles that Ardsley could consider for replacement below. We have separated the suggestions into those that could be implemented in the short term and those that could be implemented later on as EV infrastructure and technologies continue to develop.

VEHICLE	SHORT TERM	LONG TERM
MERCURY Mariner **- Building**	Chevrolet Silverado (Hybrid) $53,000 est.	Chevrolet Blazer $35,100 min. Chevrolet Equinox $34,000 est. Chevrolet Bolt EUV $28,795 min.
DODGE Charger **- Police**	Chevrolet Malibu (Hybrid) Ford Fusion (Hybrid)	Chevrolet Bolt EUV $28,795 min.
CHEVROLET Tahoe **- Police, DPW, and Fire**	Chevrolet Silverado (Hybrid) $53,000 est.	Chevrolet Blazer $35,100 min. Chevrolet Equinox $34,000 est. Chevrolet Bolt EUV $28,795 min.
CHEVROLET Suburban **- Police**	Dodge Hornet PHEV $31,590 min.	Chevrolet Blazer $35,100 min. Chevrolet Equinox $34,000 est. Chevrolet Bolt EUV $28,795 min.
FORD Explorer **- Police**	Ford Explorer (Hybrid) $47,070 min.	Ford Mustang Mach-E $45,995 min.
JOHN DEERE Tractors **- DPW**	No short-term options.	Kubota LXe-261 $29,339 min.

Given that most of Ardsley's municipal vehicles are considered emergency vehicles, fully transitioning them to EVs will require changes to Ardsley's pre-existing emergency systems. We have identified plug-in hybrid vehicles for upcoming replacements rather than fully electric options despite the studies that say hybrid vehicles are not as successful in lowering emissions. We hope this plan would ensure that Ardsley's could still provide emergency services in the event of a long-term power outage and could purchase vehicles while charging infrastructure is being gradually implemented; a process described later in our recommendations. Village vehicle policy might recommend hybrid vehicle operators prioritize electric power over fuel.

D. Cost-Benefit Analysis

The high cost of EVs and lack of charging infrastructure are two of the main concerns regarding the transition. This report includes a cost-benefit analysis (CBA) of replacement suggested in the Capital Plan Vehicle Replacement of this paper. The full CBA can be found in Appendix VI. The CBA is focused on the four Chevrolet Tahoe replacement suggestions as there is not enough information available about other suggested replacements. The analysis is based on a variety of assumptions and takes place over 10 years – the average lifetime of a vehicle.

The calculations were based on following costs and benefits:

- Benefits:
  - Avoid investment in conventional diesel vehicles.
  - Save fuel diesel expenses resulting from operating all-electric vehicles.
  - Avoid maintenance costs.
  - Health benefits resulting from reduction in emissions of PM2.5.
- Costs:
  - Cost of purchasing 4 recommended electric vehicles.
  - Cost of the construction of charging stations.
  - Costs of annual maintenance.
  - Costs of charging electric vehicles.

The sum of benefits is estimated at $455,473 and includes $319,760 of avoided investment in conventional diesel vehicles, $81,442 saved diesel fuel expenses, $31,471 in avoided diesel maintenance costs, $8,772 in societal benefits from GHG reductions, and $8,067 in health benefits from reduction of PM 2.5 in the air. The sum of costs in this CBA is $318,291 and it comprises $260,000 in upfront costs, $14,400 in infrastructure costs, $31,855 in maintenance costs, and $12,036 in charging expenses.

Diesel fuel expenses are calculated using the vehicle inventory. The maintenance costs of diesel vehicles are based on the American Automotive Association's estimates, which for diesel and electric vehicles are approximately $0.09933 and $0.0794 per mile.[77] Annual maintenance costs for traditional vehicles are estimated to be $4,501, while maintenance of their alternatives would cost only $3,830. Based on our calculations, Ardsley spends an average $3.42 on a gallon of regular gas and $4.02 for a gallon of diesel. Annually, that accumulates to approximately $9,729 for four vehicles included in this CBA. After vehicle replacement, it is estimated that Ardsley could spend as little as $1,477 on charging costs of all 4 vehicles. It is estimated that the electricity cost per mile of charging is $0.03.

The estimates of reduction of emissions and associated benefits are based on two software programs: the Environmental Protection Agency's Diesel Emissions Qualifier (DEQ) and AFLEET developed by the Argonne National Laboratory. The health benefits from reduction of emissions of the PM 2.5 is valued at $970. The Social Cost of Carbon (SCC) is an approximate rate that helps estimate the economic damages associated with emitting every additional ton of greenhouse gas. The SCC is determined by the Presidential Administration – under President Biden's administration, the Social Cost of Carbon is currently $51 per ton. Transition of each of the four vehicles to electric alternatives is expected to yield a 4.3 tons reduction in carbon emissions, resulting in savings of $877 in total every year.

The net present value of the replacement of 4 suggested vehicles is 1.43. According to the standards of cost-benefit analysis for policy-making, if the ratio of benefits to costs is larger than 1, the program is a fiscally feasible option. This is an ex-ante CBA, conducted before implementation of the program. The actual costs and benefits might differ from the estimates depending on various factors. It compromises the accuracy of the analysis. Sensitivity analysis helps determine how the net benefits would change in case specific parameters fall out of estimated range. In this CBA, the varying parameters are costs of new EVs, infrastructure development, and electricity associated with charging. Under the best-case scenario, assuming the Village would receive a number of grants, the net present value of the replacements is 1.54. In comparison, if the Village would decide to not take advantage of the available incentives and discounts, the net present value of the benefits would decline to 1.25. The exact calculations are shown in Appendix VI. Based on the analysis, the benefits of transitioning to electric vehicles outweigh the costs.

E. Retrofitting Traditional Fuel Vehicles

We have identified vehicles that we believe could be retrofitted in some capacity to decrease their emissions. These vehicles are those that may not have an EV equivalent on the market, or may have an EV equivalent that is neither affordable given the village's budget, nor feasible with their infrastructure. Many of these vehicles are medium- to heavy-weight and use diesel fuel. We recommend utilizing idle reduction technologies (IRTs) as an affordable way to decrease emissions that considers the circumstances surrounding vehicle use and market-availability.

As these units can often be installed on the majority of vehicles through their computers and ignition systems, it would be the best choice for reducing emissions and fuel consumption in cases where a vehicle does not have a comparable electric version when it is time to replace it or an electric vehicle is not a viable option.[78] As mentioned before, IRTs are also a cost-effective solution, ranging in price from a few hundred dollars per unit to a few thousand, depending on the brand and features selected.[79] Though these units should be within the village's budget for vehicles that are not ready to be phased out of service, the calculated savings on fuel and maintenance would also help pay for themselves over time.

In cases where IRTs may not be compatible with certain vehicles, such as heavy equipment and older vehicles, retrofitting with carbon capture may be a more appropriate option when attempting to curb pollution. There are also a number of funding options available for diesel vehicle retrofits, including the Congestion Mitigation and Air Quality Program (CMAQ) which can help the village move closer to its goal of reducing emissions.[80]

F. Tracking Fuel Efficiency

As of the conclusion of this project, Ardsley does not track fuel efficiency by vehicle but rather, has data on department monthly totals. This information could prove valuable in determining which vehicles are performing inefficiently and could potentially be replaced with an EV or a lower-emission vehicle. Knowing this could help Ardsley decrease vehicle emissions in the long-term by identifying vehicles that are economically and environmentally inefficient and phasing them out of use.

Given the use-patterns of some of the municipal vehicles, we suggest that the municipal departments develop internal measures of determining if a vehicle is using fuel inefficiently or not. Garbage trucks, for example, have an average fuel efficiency of 2-3 miles per gallon while a highway patrol vehicle might have an average of over 20 miles per gallon.[81] A similar process already exists within DPW regarding the retirement of mobile equipment, given that age and fuel consumption for these are not a consistent indicator of use.

G. Infrastructure Plan

Successful transition to hybrid plug-in and electric vehicles is conditional on the development of charging infrastructure in Ardsley. Investment in charging infrastructure is a significant financial commitment and, therefore, is divided in two steps. Phase 1 shall be considered for immediate implementation, while Phase 2 requires a greater level of detail and long-term investment in Ardsley's decarbonized and independent fleet system. It is important to note that the infrastructure plan should be implemented before purchase of Electric Vehicles.

1. Phase 1

The goal of Phase 1 is to provide reliable charging solutions to municipal employees, effective immediately. Each new EV should be equipped with portable charging equipment. Portable 208/240-volt circuits, normally used for dryers or air conditioning, are essential to provide security and independent access to charging facilities in-house. This power of units is classified as Level 2 chargers, the most popular type of chargers across the country.[82] With approximately 25 miles range per hour of charging, this is an appropriate choice for light-duty administrative vehicles. The purchase of portable chargers for each municipal building allows employees to charge their EVs while performing their duties at work, traveling, or while parked.[83]

- The J+ BOOSTER 2 Portable EV J1772 connector is a highly rated portable charger that can be considered for use by Ardsley. This portable charger provides safety and security for individuals operating EVs, in particular during road trips outside of the Village.

Apart from purchasing portable chargers, it is of utmost importance that the Village partners with the local electricity provider to ensure the Village is well-prepared for the development of charging infrastructure.

- The EV Charge capacity within the Village streets varies from 0 MV to 3.95 MV, with the lowest capacity along Ashford Avenue.[84] ConEdison provides financial incentives to install Utility Transformer and Utility Service.[85]
- In preparation for a mass transition to EVs, the Village must contact the local utility to choose and negotiate appropriate electric plans to ensure preferential billing.[86] ConEdison's SmartCharge allows plug-in hybrid and EV owners to save and earn money on charging vehicles. The incentives include: 10 cents per kWh when charging in off-peak hours or $35 per month per vehicle when avoiding summer peak hours.[87]

It is important to start engaging in the initiatives undertaken by New York State that promote and encourage municipalities to transition their fleets away from fossil fuels. Ardsley should act as soon as possible to build relationships with other municipalities and apply for all applicable programs and grants. Ardsley can immediately apply for programs, such as the following:

- The Municipal Zero-Emission Vehicle Program (ZEV) administered by the Department of Environmental Conservation supports counties, cities, towns, and villages in acquisition of ZEVs and development of charging infrastructure. Round 7 of funding for 2023 is expected to open in the second half of the year.[88]
- Under the New York State Tax Credit for Public and Workplace Charging, employers can receive up to $5,000 income tax credit for developing charging infrastructure at a workplace.[89]
- Charge Ready NY administered by NYSERDA provides aid for the development of public or workplace charging infrastructure, offering savings of 35-80% on the installation costs.[90]

Lastly, it is important to acknowledge that charging infrastructure is supplied with power from the grid, which is currently produced through combustion of fossil fuels. If Ardsley aims to decarbonize the municipal transportation, it is essential to consider the source of electricity used along with development of the charging infrastructure. There are several models of renewable energy development that Ardsley should learn more about: microgrids, photovoltaic installations, community solar, and rooftop leasing – all allowing to significantly decarbonize energy supply.

2. Phase 2

During Phase 2, the Village can install charging stations at the new DPW Parking Building to lay the foundation for a safe and successful transition to an electric fleet. It is recommended that:

- Two Level 2 chargers can be installed at the front of the building. Notably, wall-mounted charging stations are recommended as they have considerably lower costs than floor pedals. It is estimated that the average cost of a wall mounted unit is $2,035 and $3,209 for a pedestal mount.
- As the Village's fleet transitions to electric vehicles, the Village can create a plan to install at least one Level 3, Direct Current Fast Charger (DCFC). As informed by the Village Manager, the electric capacity at the DPW is limited. The Village should consider purchasing a small transformer that would allow for the installation of additional chargers. This is an important step to ensure medium- and heavy- duty vehicles can be charged in a timely manner. DCFC are an extremely efficient and reliable source of energy, as they are able to charge anywhere from 100 miles to 200 miles within 30 minutes. Although DCFC are preferential, Extreme Fast Chargers (XFC) chargers can be also considered. These fast chargers' popularity is growing across the country, under recommendation of the U.S. Department of Energy's Vehicle Technologies Office.[91]

After careful consideration of photovoltaic options in the Phase 1, Ardsley can incorporate photovoltaics into their energy supply. An optimal solution for Ardsley would involve development of a sustainable microgrid. Microgrids are independent power systems that are operated separately from local electricity providers.[92] Although traditional microgrids have been reliant on fossil fuels, development of zero-emission energy sources created an opportunity for sustainable microgrids. The benefits of owning such a grid include resilience to extreme weather, decrease of electricity lost in transmission, reduce prices, and increase energy reliability.

The U.S. Department of Energy commissioned a study of microgrid development costs. The cost of the community grid is estimated at $2,119,908.[93] It is a very expensive investment but yields significant benefits. Additionally, there are possibilities of financing, such as: tax-exempt bonds, grants, loans, NYSERDA's Green Bank, Commercial property assessed clean energy, or resilience bonds. Following are possible solutions for decarbonization of the grid:

- Development of photovoltaic installations along with development of microgrids would provide Ardsley with a net zero charging infrastructure for the fleet, as well as resilient and reliable access to electricity in extreme weather conditions. Although this type of investment can be completed in phases spread over several years, the high investment costs hinder the feasibility of this solution.
- Alternatively, Ardsley could consider investing in photovoltaic installations without developing the microgrid. This would yield similar benefits in terms of reducing electricity prices and net zero emissions, however Ardsley would not be able to enjoy high levels of resilience and reliability.
- Subscription to community solar is another possibility – installations on offsite locations, allow subscribers to benefit from the most popular upsides of the photovoltaic installations. This is an affordable option that would help Ardsley incorporate clean energy into its charging infrastructure but does not help accomplish energy security or independence.
- Lastly, Ardsley could consider leasing rooftop space to private sector solar panel companies interested in the development of community solar projects. In such a partnership, the Village would lease its roof space to house solar panels. In exchange, Ardsley would receive consistent, monthly payments. If Ardsley were to express an interest in accumulated upfront payment for the purpose of investment, solar panel companies such as Ecogy Energy pledge to accommodate that request. This is of crucial importance as it would allow Ardsley to reinvest the money into development of charging infrastructure. Additionally, many solar panel companies offer an opportunity to subscribe to the grid and get a 10% discount on electricity prices for the client and their community.[94] There is criticism of this model. Opponents highlight the contracts are long-lasting obligations, often signed for 20 to 25 years, and they prohibit the owners of rooftop spaces from directly benefiting from solar installations. Despite the criticism, it could be a good source of funding for investments necessary to jumpstart transition to EV.

H. Policy Recommendations

Our team sought to find other ways Ardsley could reduce its municipal emissions beyond its municipal fleet, as these changes could lead to a significant reduction in emissions. Additionally, we sought to recommend policies that would aid in the implementation of the vehicle transition plan. In order to reduce emissions beyond switching the municipal fleet, we recommend that Ardsley engage in the following activities:

Establish policies that promote walking and cycling, such as expanding sidewalks and bike lanes, and developing a bike sharing program.

To further reduce greenhouse gas emissions, our team recommends that Ardsley implement policies that encourage walking and cycling in the village. The Village of Ardsley has already begun expanding its network of sidewalks, so we recommend continuing this expansion, especially to connect the most populous areas of the Village.[95] Guided by the Climate Smart Communities actions, which provide guidance and grants, our team recommends that Ardsley install more sidewalks, bike paths, and develop a bike sharing program.

In order to encourage more cycling and walking in the Village, we recommend:

- Installing more sidewalks
- Installing additional bike paths
- Developing a bike share program

There are a variety of grants and sponsorships available for expanding bike paths, expanding sidewalks, and promoting bike-sharing programs, such as the:

- Rebuilding America's Infrastructure with Sustainability and Equity[96]
- Carbon Reduction Program[97]
- Congestion Mitigation and Air Quality Program[98]
- Safe Streets for All Program[99]
- Transportation Alternatives Program.[100] [101]

Install technologies in high-emission buildings that improve energy efficiency and lower emissions.

Guided by the Climate Smart Communities recommendations, to further reduce emissions, and improve energy efficiency in municipal buildings, we recommend that Ardsley:[102]

- Continue to audit Village building and facilities to determine energy usage and efficiency
- Partner with Sustainable Westchester (a NYSERDA-selected company) to access a free assessment of heating and cooling solutions

- Upgrade HVAC systems in municipal buildings, utilizing rebates, financing, and incentives provided by:
    - NYSERDA, and
    - New York Power Authority (NYPA).
- Conduct a study on the feasibility of utilizing geothermal energy for municipal buildings.
    - According to NYSERDA's GeoPossibilities Tool, Ardsley's Village Hall could be a good fit for geothermal energy.[103]
    - There are financial rebates available in making this switch, offered by ConEd or NYSEG, in addition to a 30% federal tax credit and $5,000 NYS tax credit.[104]

Provide training to mechanics and ensure department head involvement in the vehicle purchasing decision-making process.

- Given our external interview findings, we recommend that Ardsley involve department heads in vehicle purchasing decisions and ensure their buy-in for the transition plan. To do this, we suggest that the Village of Ardsley involve all department heads in discussions on infrastructure and vehicle purchasing.
- Through our external interviews, we learned of the importance of mechanic-buy in and training for a successful transition. Because of this, we recommend that Ardsley invest in training its Village mechanics to be able to properly fix electric and hybrid vehicles. One way to ensure mechanic buy-in is to purchase electric vehicles from the manufacturers that mechanics have a lot of familiarity with, such as General Motors and Ford. There are a variety of courses available to mechanics in New York State, such as:
    - Automotive Technician Training Services.[105]
    - Training offered by General Motors, such as the all-day electrical vehicle training for NYC mechanics last year.[106]

VI. LIMITATIONS

While we were able to provide significant guidance to the Village of Ardsley in developing a plan for decreasing their emissions, there are several limitations to our findings. We have identified these limitations below:

- Our team attempted to schedule an interview with the Village of Ardsley's Fire Chief, but were unsuccessful in doing so. Because of this, our findings and recommendations do not include direct data from an interview with the head of Ardsley's fire department.
- The differences in department vehicle makeup between 2019 and this report are fairly large and, as such, we do not expect the emissions estimates to be a sufficiently accurate indicator for the current fleet's vehicle emissions.
- The Village of Ardsley tracks fuel spending by department and not by individual vehicle. Using the annual department spending, the number of vehicles in each department, and the kind of fuel each vehicle used, we were able to calculate the average fuel cost for each department vehicle. As a result, the cost benefit analysis presented in this report is based on these averages and is not tailored to performance of specific vehicles.
- The Village does not track or keep any record of the annual mileage each vehicle in the municipal fleet has. This limited any analyses that could be conducted on the fuel efficiency of the specific vehicles in the fleet and we had to rely on make and model estimates. We were also only able to obtain these estimates from commercially-available vehicles and not for the municipality's specialized vehicles.
- As noted in our Literature Review, the electric vehicle industry is fast-moving. Because of this, the vehicles recommended come from our research in 2022 and 2023. Better technologies and pricing may become available after the conclusion of our research.
- Given our research and the available data, we were unable to make an in-depth comparison of total lifecycle carbon emissions between electric vehicles, hybrids, and internal combustion engine vehicles. This included the carbon footprint generated during vehicle production, fuel generation, and associated processes.
- The Building Department vehicle was not separated in the fuel data provided to us from the municipality. This may have impacted the fuel and inventory analyses to a small degree as an additional vehicle may or may not be a part of the data.

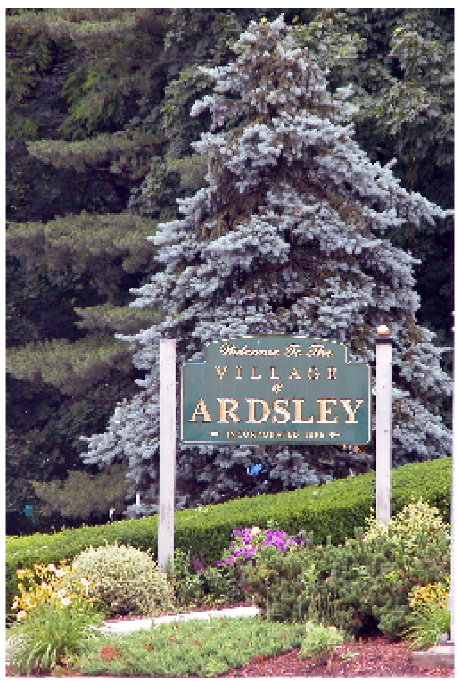
VII. APPENDICES

Appendix I. Ardsley Emissions Report

Village of Ardsley

2019 Inventory of Government Operations
Greenhouse Gas Emissions

June 2021



Produced by the Village of Ardsley's Climate Smart Communities Task Force
With Assistance from ICLEI – Local Governments for Sustainability USA

Village of Ardsley Government Operations GHG Emissions Inventory Page 1

Credits and Acknowledgements

Village of Ardsley

This report was prepared by Asha Bencosme, Ardsley's Climate Smart Communities Coordinator. The author would like to thank the Village of Ardsley Staff, specifically, Charles Hessler and Theresa Del Grosso for providing the local information necessary for the completion of this report, and would like to make the following additional acknowledgements:

Village of Ardsley

Nancy Kaboolian, Village Mayor
Steve Edelstein, Board Trustee
Meredith Robson, Village Manager

Village of Ardsley's Climate Smart Communities Task Force

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Executive Summary

The Village of Ardsley recognizes that greenhouse gas (GHG) emissions from human activity are catalyzing profound climate change, the consequences of which pose substantial risks to the future health, wellbeing, and prosperity of our community. Furthermore, the Village of Ardsley has multiple opportunities to benefit by acting quickly to reduce community GHG emissions. These benefits include reducing energy and transportation costs for residents and businesses, improving the health of residents and making our community a more attractive place to live and do business.

To demonstrate its commitment to addressing the growing threat of climate change, in February of 2010 the Village of Ardsley became a registered Climate Smart Community by formally adopting the New York State Climate Smart Communities (CSC) pledge comprised of the following ten elements:

1. Build a climate-smart community;
2. Inventory emissions, set goals, and plan for climate action;
3. Decrease energy use;
4. Shift to clean, renewable energy;
5. Use climate-smart materials management;
6. Implement climate-smart land use;
7. Enhance community resilience to climate change;
8. Support a green innovation economy;
9. Inform and inspire the public;
10. Engage in an evolving process of climate action;

The CSC program, administered by the New York State Department of Environmental Conservation (DEC), is a certification program that provides a robust framework to guide the actions local governments can take to reduce GHG emissions and adapt to the effects of climate change. The first step in this process is to perform a GHG inventory for all buildings, vehicles, and operations controlled by the local government. Using data from 2019, this GHG inventory provides a baseline from which the Village can set emissions reduction goals, determine ways in which those goals can be reached, and track progress.

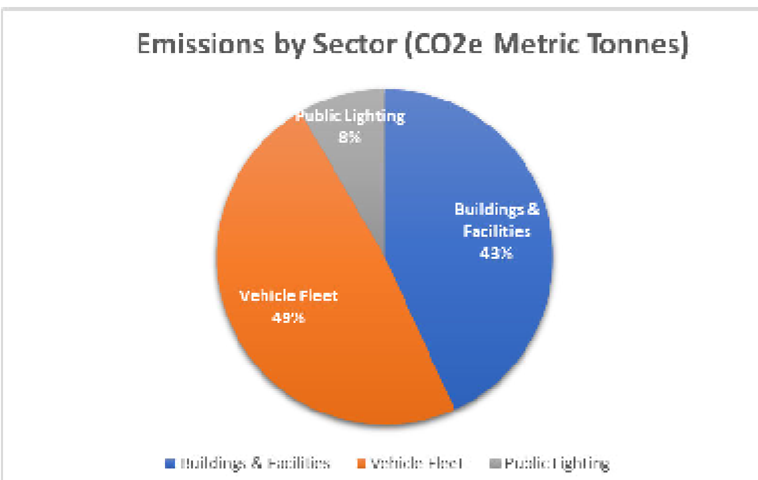
This report provides estimates of greenhouse gas emissions specifically from Ardsley's 2019 government operations. To create this inventory, data for the Village's fuel and electricity use was collected and reviewed. The data was generated from electric and natural gas bills for all Village-owned buildings and operations, as well as fuel records for the Village's vehicle fleet. The GHG emissions for all local government operations are measured in metric tons of CO2 equivalents (CO2e) and were calculated using emission factors published by the U.S. Environmental Protection Agency (EPA) and ICLEI's ClearPath software platform.

Key Findings

In 2019, GHG emissions from Ardsley's government operations totaled 535 metric tonnes (MT) CO2e. Figure 1 shows the emissions for government operations broken down by sector. The Village's vehicle fleet sector accounted for the largest percentage of GHG emissions at 49%. The second largest contributor is the Village's buildings and facilities with 43% of emissions. It is recommended that actions to reduce emissions in both of these areas should be a key part of the Village's climate action plan. Streetlights and traffic signals were responsible for the remainder of local government operation emissions at 8% of emissions.

The Inventory Results section of this report provides a detailed profile of emissions sources within the Village of Ardsley. This information will be key to guiding local reduction efforts. This data will also provide a baseline from which the Village will be able to compare future performance and demonstrate progress in reducing emissions.

Figure 1: Village of Ardsley's Government Operations Emissions by Sector (MT CO2e)



Climate Change Background

Naturally occurring gases dispersed in the atmosphere determine the Earth's climate by trapping solar radiation. This phenomenon is known as the greenhouse effect. Overwhelming evidence shows that human activities are increasing the concentration of greenhouse gases and changing the global climate. The most significant contributor is the burning of fossil fuels for transportation, electricity generation and other purposes, which introduces large amounts of carbon dioxide and other greenhouse gases into the atmosphere. Collectively, these gases intensify the natural greenhouse effect, causing global average surface and lower atmospheric temperatures to rise.

The Village of Ardsley could be impacted by increased frequency of extreme weather events including heat waves, droughts, powerful storms and flooding from the Saw Mill River in the future. Other expected impacts in New York include frequent and damaging storms accompanied by flooding and landslides, summer water shortages as a result of reduced snowpack, increased wildfires, and the disruption of ecosystems, habitats, and agricultural activities.

Reducing fossil fuel use in the community can have many benefits in addition to reducing greenhouse gas emissions. More efficient use of energy decreases utility and transportation costs for residents and businesses. Retrofitting homes and businesses to be more efficient creates local jobs. In addition, money not spent on energy is more likely to be spent at local businesses and add to the local economy. Reducing fossil fuel use improves air quality and increases opportunities for walking and bicycling improves residents' health.

Evidence of Human-Caused Climate Change

There is overwhelming scientific consensus that the global climate is changing, and that human actions, primarily the burning of fossil fuels, are the main cause of those changes. The Intergovernmental Panel on Climate Change (IPCC) is the scientific body charged with bringing together the work of thousands of climate scientists. The IPCC's Fourth Assessment Report states that "warming of the climate system is unequivocal."[1] Furthermore, the report finds that "most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations."

2020 was the hottest year on record for the continental United States. The steady uptick in average temperatures is significant and expected to continue if action is not taken to greatly reduce greenhouse gas emissions.

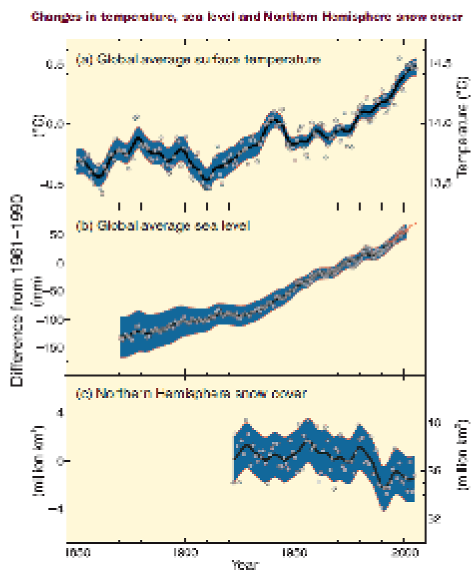


Figure 2: Observed changes in global temperature, sea level and snow cover

ICLEI Climate Mitigation Program

In response to the problem of climate change, many communities in the United States are taking responsibility for addressing emissions at the local level. Since many of the major sources of greenhouse gas emissions are directly or indirectly controlled through local policies, local governments have a strong role to play in reducing greenhouse gas emissions within their boundaries. Through proactive measures around land use patterns, transportation demand management, energy efficiency, green building, waste diversion, and more, local governments can dramatically reduce emissions in their communities. In addition, local governments are primarily responsible for the provision of emergency services and the mitigation of natural disaster impacts.

[1] IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

ICLEI provides a framework and methodology for local governments to identify and reduce greenhouse gas emissions, organized along Five Milestones:

1. Conduct an inventory and forecast of local greenhouse gas emissions;
2. Establish a greenhouse gas emissions reduction target;
3. Develop a climate action plan for achieving the emissions reduction target;
4. Implement the climate action plan; and,
5. Monitor and report on progress.

Figure 3: ICLEI Climate Mitigation Milestones

This report represents the completion of ICLEI's Climate Mitigation Milestone One for government operations and provides a foundation for future work to reduce greenhouse gas emissions in the Village of Ardsley.

Sustainability & Climate Change Mitigation Activities in the Village of Ardsley

The Village of Ardsley has already implemented programs that have or will lead to ancillary benefits in the form of energy conservation and greenhouse gas mitigation.

Local initiatives by the Village government include:

- Converted all streetlights to LED lights by November 2018
- Joined Community Choice Aggregation from 2019, with an opt-in to 100% renewable energy
- Installed solar panels with annual generation capacity of 25kW on the Ardsley Fire House
- Committed to educating residents on how to reduce emissions by 50% by 2030

Inventory Methodology

Understanding a Greenhouse Gas Emissions Inventory

The first step toward achieving tangible greenhouse gas emission reductions requires identifying baseline emissions levels and sources and activities generating emissions in the community. This report presents emissions from operations of the Village of Ardsley government. The Village of Ardsley is focusing first on government operations emissions in order to lead by example and may inventory community-wide emissions in a future report. The government operations inventory is mostly a subset of the community inventory, as shown in figure 4. For example, data on commercial energy use by the community includes energy consumed by municipal buildings, and community vehicle-miles-traveled estimates include miles driven by municipal fleet vehicles.

As local governments have continued to join the climate protection movement, the need for a standardized approach to quantify GHG emissions has proven essential. This inventory uses the approach and methods provided by the Local Government Operations Protocol (LGO Protocol), which is described below.

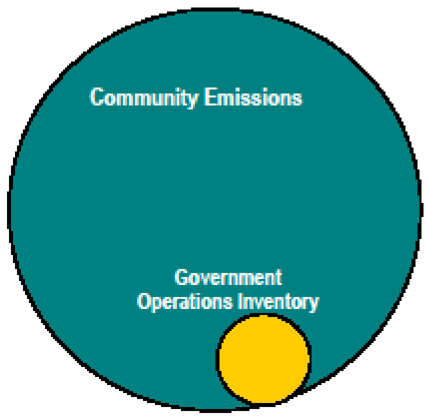


Figure 4: Relationship of Community and Government Operations Inventories

Approach

This inventory was developed using the approach and methods provided by the Local Government Operations Pro-tocol (LGO Protocol) developed by ICLEI, the California Air Resources Board (CARB), the California Climate Action Registry, and The Climate Registry. The LGO Protocol serves as the national standard for measuring and reporting GHG emissions associated with local government operations. It provides the principles, approach, methodology, and procedures necessary to develop a complete, transparent, and accurate reporting of a local government's GHG emissions.

Emissions Scopes

For the government operations inventory, emissions are categorized by scope. Using the scopes framework helps prevent double counting. There are three emissions scopes for government operations emissions:

- **Scope 1:** All direct emissions from a facility or piece of equipment operated by the local government. Examples include tailpipe emissions from local government, and emissions from a furnace in a local government building.
- **Scope 2:** Indirect emissions associated with the consumption of purchased or acquired electricity, steam, heating, and cooling.
- **Scope 3:** All other indirect or embodied emissions not covered in Scope 2. Examples include contracted services, embodied emissions in good purchased by the local government, and emissions associated with disposal of government generated waste.

Scope 1 and Scope 2 emissions are the most essential components of a government operations greenhouse gas analysis as they are the most easily affected by local policy making. Under the DEC's CSC program, tracking Scope 3 emissions is encouraged, but optional. Scope 3 emissions data was not available for this inventory, however, the Village hopes to ensure that the necessary data is available for government operations GHG inventories moving forward. Some examples of Scope 3 data that the Village could track include solid waste generated by the Village, as well as accounting for the number of miles travelled by Village employees as part of their daily commute.

Base Year

The inventory process requires the selection of a base year with which to compare current emissions. The Village of Ardsley's community greenhouse gas emissions inventory utilizes **2019** as its base year. The Village felt that this was the most recent year under which the Village was operating under more typical circumstances. During 2020, the world was affected by the coronavirus pandemic which affected all government operations, with limited staff in the office for a number of months resulting in lower electricity and gas use as well as vehicle miles traveled. This was highly unusual and using 2020 as a base year would not include emissions produced during the normal course of operations.

Quantification Methods

Greenhouse gas emissions can be quantified in two ways:

- Measurement-based methodologies refer to the direct measurement of greenhouse gas emissions (from a monitoring system) emitted from a flue of a power plant, wastewater treatment plant, landfill, or industrial facility.
- Calculation-based methodologies calculate emissions using activity data and emission factors. To calculate emissions accordingly, the basic equation below is used: *Activity Data x Emission Factor = Emissions*

All emissions sources in this inventory are quantified using calculation-based methodologies. Activity data refer to the relevant measurement of energy use or other greenhouse gas-generating processes such as fuel consumption by fuel type, metered annual electricity consumption, and annual vehicle miles traveled. To obtain this data, the Village gathered and reviewed all electricity and natural gas bills for the Village's Con Edison and Power Authority of the State of New York (PASNY) accounts, as well as fuel records for gasoline and diesel used to power the Village's vehicle fleet.

Calculations for this inventory were made using ICLEI's ClearPath software platform. Data was first measured in kWh for grid electricity, therms for natural gas, and gallons for gasoline and diesel used for vehicles. Using the ClearPath tool, this data was multiplied by emission factors published by the EPA in order to convert the energy usage, or other activity data, into quantified emissions. Different emission factors were used based on the fuel type, vehicle class, and eGRID subregion, which in this case is the NYCW (NPCC NYC/Westchester) subregion.

The GHG emissions in this inventory are measured in metric tons of CO2 equivalents (CO2e). In order to measure all greenhouse gases, especially non-CO2 gases, in a common term that indicates their relative strength of the greenhouse effect they have in the atmosphere, the ClearPath tool applies multipliers, referred to as Global Warming Potentials (GWP), to all greenhouse gases emitted. This ensures results are presented in consistent and uniform terms. The GWP values used in this inventory are those published in the IPCC's 5th Assessment Report.

Government Operations Emissions Inventory Results

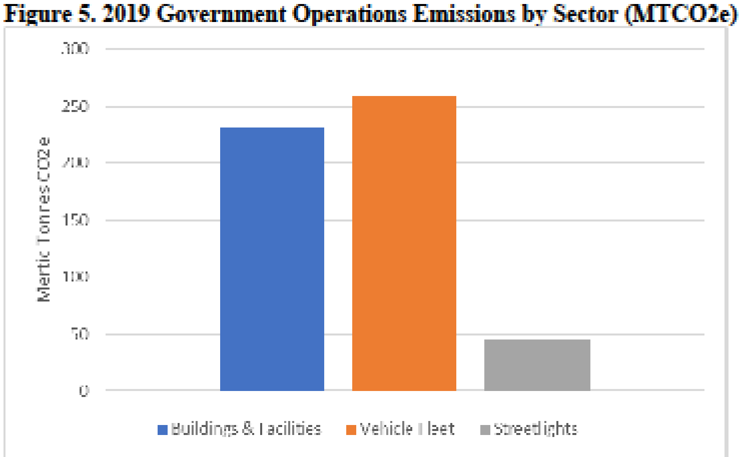
Emissions by Sector

For developing emissions reduction policies, it is often most useful to look at emissions broken down by sector, as each sector will have a particular set of strategies to reduce emissions. Table 1 and Figure 5 show the Village of Ardsley's government operations emissions broken down by sector, while the remainder of this section breaks down these emissions in further detail within each sectors.

Table 1: Government Operations Emissions by Sector

Sector	metric tons CO2e
Buildings and Facilities	231
Vehicle Fleet	259
Public Lighting	45
Totals	**535**

Figure 5. 2019 Government Operations Emissions by Sector (MTCO2e)



Vehicle Fleet

Vehicles were the largest source of government operations emissions, with a total of 259 Metric Tonnes of CO2e. In 2019, the Village of Ardsley operated a vehicle fleet with 35 vehicles. Table 2 shows vehicle emissions and fuel cost by fuel type.

The Village of Ardsley spent $92,304 on vehicle fuel in 2019. There may be opportunities to reduce costs through fuel efficiency and trip reduction measures.

Table 2: Local Government Vehicle Fleet Emissions by Fuel Type

Source	metric tons CO_2e	Consumption (gal)	Cost ($)
Gasoline	109	12,434	40,642
Diesel	150	14,663	51,662
Totals	259	27,097	$92,304

Table 3 shows vehicle emissions and fuel cost by department. This information will be helpful in engaging department directors to identify strategies to reduce vehicle fuel use.

Table 3: Vehicle Emissions and Fuel Cost by Department

Department	metric tons CO2e	Fuel Cost
Public Works	162	$25,253
Fire	29	$10,750
Police	68	$56,301
Total	259	$92,304

Buildings & Facilities

After Vehicles, Buildings and facilities were the next largest sector of government operations emissions. Table 4 shows building emissions by Village department building. Table 4 does not include an additional 5 metric tonnes of CO2e from grid transmission and distribution losses. With these emissions included, the total buildings related emissions totaled to 236 MT of CO2e.

Table 4 shows building emissions by department. This information will be helpful in engaging department leaders to identify strategies to reduce energy use. Table 4 also shows building energy cost by department. The Village of Ardsley spent $89,235 on building energy use in 2019. There may be opportunities to reduce costs through building energy conservation measures.

Table 4: Building Emissions and Energy Cost by Building

Department	metric tons CO2e	Energy Cost
Village Hall	46	$19,752
Highway Garage	40	$12,448
Firehouse	86	$30,978
Public Library	34	$15,881
Community Center	25	$10,176
Totals	231	$89,235

Table 5 shows buildings sector emissions by source. Electricity use is the largest source of buildings emissions, followed by natural gas use.

Table 5: Buildings Emissions by Source

Source	metric tons CO2e
Electricity	107
Natural Gas	124
Totals	231

Table 6 shows the five individual buildings with the highest emissions. These buildings may present particularly cost-effective energy reduction opportunities.

Table 6: Five Largest Contributors to Emissions from Buildings Sector

Facility	Metric Tons CO2e	% of Building Sector Emissions	Energy Cost
Fire house	86	37%	$30,978
Village Hall	46	20%	$19,752
Highway Garage	40	17%	$12,448
Public Library	34	15%	$15,881
Community Center	25	11%	$10,176
Totals	231	100%	$89,235

Public Lighting

Like most local governments, Ardsley operates a range of public lighting including street lighting, parking lot lighting, and holiday lighting. The Village tracks lighting owned by the Village, as opposed to those owned by the County. In order to improve accuracy and provide a better representation of CO_2 in future inventories, the Village should isolate data for each type of lighting to better account for the consumption of each specific type of use. Table 7 shows emissions from Ardsley's public lighting totaled 43 MT CO_2e. Table 7 does not include an additional 2 metric tons of CO_2e from grid transmission and distribution losses. With these emissions included, the total lighting related emissions are 45 MT CO_2e. Streetlights were the largest contributor to public lighting emissions, although, as of 2019, the Village has converted all of Ardsley's streetlights to Light Emitting Diodes or LEDs. As a result, the current GHG inventory is reflecting a significant reduction in energy use and emissions from the public lighting sector than there would have been had this conversion not taken place.

Table 7 shows public lighting emissions and energy cost by location. Street lighting was the largest contributor to lighting sector emissions. New technologies, in particular Light Emitting Diodes or LEDs were installed on all streetlights and have provided a very good payback on investment.

Table 7: 2019 Public Lighting Emissions by Location (MT CO_2e)

Street Lighting Location	Metric Tons CO2e	% of Sector Emissions	Cost ($)
2019 NYPA Streetlights Meter ***056*********	28	68%	$29,241
19 American Legion Drive	5	11%	$4,610
2019 Bridge Street Lights	3	7%	$4,476
1 Heatherdell Road	3	6%	$2,609
2019 NYPA Street Lights Meter ***156*********	2	4%	$1,761
Ashford Ave & Park	1	3%	$1,660
2019 Festive Lights	1	1%	$898
Totals	**43**	**100%**	**$45,255**

Conclusion

This inventory marks completion of Milestone One for government operations (i.e. "Conduct an inventory and forecast of local greenhouse gas emissions") of the Five Milestones for Climate Mitigation that are part of the ICLEI Framework. The next steps are to set an emissions reduction target, and to develop a climate action plan that identifies specific quantified strategies that can cumulatively meet that target. In the meantime, the Village of Ardsley will continue to track key energy use and emissions indicators on an on-going basis. ICLEI recommends conducting a new inventory at least every five years to measure emissions reduction progress.

Future, emissions reduction strategies for the Village of Ardsley to consider for its climate action plan include increasing energy efficiency and renewable energy investments and infrastructure, as well as vehicle fuel efficiency. Other key data points to collect and track might include: waste and wastewater emissions, water delivery rates, government employee vehicle trips and employee commuter miles, as well as solid waste collection rates. This will capture both direct and indirect emissions related to operations. Many local government operations generate solid waste, much of which is eventually sent to a landfill. Typical sources of waste in local government operations include paper and food waste from offices and facilities, construction waste from public works, and plant debris from parks departments.

This inventory shows that it will be particularly important to focus on energy efficiency in Village facilities and buildings and fuel use. The Village should also incorporate the suggestions mentioned throughout this report for tracking additional information into departmental protocols to ensure future GHG inventories are as complete and accurate as possible. Both ICLEI and the Ardsley Climate Smart Communities Task Force recommend conducting a new inventory at least every five years to measure emissions reduction progress. Through these efforts and others, the Village of Ardsley can achieve additional benefits beyond reducing emissions, including saving money and improving the economic vitality and quality of life in the Village.

Appendix II. Literature Review

Abstract

Our Capstone team seeks to develop policy recommendations and a plan that would allow the Village of Ardsley to effectively transition their vehicle fleet away from fossil fuels and reduce the emissions generated while performing municipal services. Our research is based on several key focus areas, including health impacts, benefits of transitioning to EVs, technical limitations of EVs, fuel efficiency, infrastructure needed to make the transition, and comparable use cases. This literature review aims to cover the current state of research on zero emissions vehicles, their implementation or viability in practice, examples of EV transition programs, as well as review the availability of comparable vehicles coming to market, to support our recommendations.

The following report highlights key findings and points of interest across studies or articles that cover the emerging field of electric and low emission vehicles. These findings focused primarily on the impacts of transitioning to EVs, market availability for different sized vehicles, infrastructure needs and considerations when transitioning to low emission vehicles.

The team's research showed a variety of findings or trends concerning the transition to electric or low emission vehicles. Common themes were discovered, including health benefits, fuel efficiency, overall costs, and lower carbon footprint. Vehicle range, battery life, and reliance on the electrical power grid were also commonalities throughout our research. A detailed overview of the evaluations, articles, case studies, and vehicle comparisons have been included in this report.

Introduction

	Overarching Goals of the Literature Review	Guiding Research Questions
1	Investigate the Impacts and Considerations for Transitioning to Electric Vehicles	*- How do vehicle emissions affect human health?* *-How do vehicle emissions affect the environment?* *- What are the benefits and limitations to electric vehicle transition?*
2	Understand the Current and Future Market for Electric Vehicles	*- How does the fuel/efficiency of fossil fuel vehicles compare to electric?* *-What does the electric vehicle market look like now and what will it look like in the future?*

3	Survey the Infrastructure Needs of Electric Vehicles	*- What is the infrastructure needed for operating electric vehicles?* *- What are the costs associated with operating electric vehicles?*
4	Examine the Political Landscape and Implementation Practices	*-What is the political landscape for electric vehicle transitions?* *-How are similar communities to Ardsley lowering vehicle emissions?*

Methodology

Our team conducted the literature review research from November 7th until December 20th, 2022. The research was conducted on multiple platforms, including Google Scholar, Engineering Village, and Ebsco. We also consulted the U.S. Department of Energy (DOE) and U.S. Department of Transportation (DOT), World Health Organization (WHO), and U.S. Environmental Protection Agency (EPA). Lastly, our team reviewed relevant industry articles to review the current market offerings. The terms searched on different platforms included "electric vehicles", "medium and heavy-duty electric vehicles", "low emission vehicles", and "electric vehicle infrastructure". Our team reviewed over 97 articles and sources included in this literature review, as referenced in our works cited section.

Definitions

Throughout the document, we refer to several concepts that are commonly used in literature on energy transition. For clarity and transparency purposes, this section defines key concepts used in this paper.

Carbon-neutrality is a ratio between the releasing carbon through various activities and absorbing carbon via carbon sinks – storing removed carbon dioxide, referred to as carbon sequestration. **Net zero emissions** is a scenario where all greenhouse gasses emissions are balanced out by an adequate amount of carbon sequestration. Carbon sinks are natural or superficial systems that absorb more carbon dioxide than they emit, including soil and forests.[1]

Decarbonization, according to Deloitte, is a more general concept that refers to reduction and/or removal of carbon dioxide, released as a byproduct of human activity, from the atmosphere. Decarbonization can be achieved by transitioning to low carbon energy sources (such as biofuels, renewable energy, or hydrogen) and the ultimate goal of decarbonization is to eliminate carbon dioxide completely.[2]

Low emissions are repeatedly referred to in this document. Emissions under consideration are: black carbon (BC), sulfur oxides (SO2), nitrogen oxides (NOX) (including nitrogen monoxide and nitrogen dioxide, NO2), ammonia (NH3), carbon monoxide (CO), methane (CH4), non-methane volatile organic compounds (NMVOCs), including benzene, and certain metals and polycyclic aromatic hydrocarbons, including benzo[a]pyrene (BaP). There is also a group of secondary emissions: PM, ozone (O3), NO2 and several oxidized volatile organic compounds (VOCs).[3] Low emission levels do not produce much pollution.[4] Lowering emissions is important because it results in air pollution and related negative health repercussions. Low emission standards serve as a baseline for new technologies and programs, such as low emission vehicles or Low Emission Zones in many European cities where only low emission vehicles can enter certain neighborhoods free of charge.[5]

Findings

Health Impacts of Decreasing Emissions

There is currently a wide array of studies conducted on the adverse health effects of transportation-associated air pollution. The emissions that pose the most serious health risks come from nitrogen dioxide (NO2), carbon monoxide (CO), metals, particulate matter, black smoke, benzene, and polycyclic aromatic hydrocarbons (PAHs).[6] Each of these pollutants has been studied for the specific exposure risks they pose for human health but it is widely understood that exposure to any increases chances of respiratory, neurological, immunological, and cardiovascular diseases.[7] It should be noted that vehicle pollutants are not exclusively attributed to the fuel emission but also, in small part, may come from tire particles and break wear.[8]

Given the toxicity associated with vehicle emissions, prolonged and consistent exposure can increase both the risk and the severity of health issues. While many studies struggle to specifically link transportation-caused air pollution to health issues, air pollution contributes to increased rates of asthma, COPD, and respiratory issues.[9] People who live in urban and suburban areas with greater vehicle emissions are at a higher risk of these diseases, especially if they work outdoors or with heavy vehicles.[10] Many of these studies were conducted decades ago and continue to be replicated

Studies have examined how job positions within the same industry can vary health and exposure. Lee et al. examined how municipal waste workers who drove the waste trucks were exposed to less carbon pollution than those who were collecting the waste outside the truck.[11]A series of studies proved that truck drivers, street cleaners, highway toll workers, and bus drivers, who are exposed to greater levels of vehicle exhaust, were at a higher risk for lung cancer, heart attack, and heart diseases.[12] [13] [14] [15]

There have been several legislative actions taken to help mitigate the risks of vehicle emissions. Given advancements in fuel technology and efficiency, emissions causing health issues have been decreasing in many areas. Recent legal and legislative actions taken by the United States to limit vehicle emissions have reduced air pollution-related deaths from 27,700 in 2008 to 19,800 in 2017 and yielded about $270 billion in social benefits.[16] Although the change was not as significant as expected, maintaining previous emissions levels would have caused 48,000 deaths as opposed to the 19,800.[17] Additionally, larger-scale transition to low-emissions vehicles, especially heavy-duty vehicles, could decrease emissions-related deaths globally by 3 million.[18]

The Benefits of Transitioning to Electric Vehicles

The overall environmental and health benefits to the transition to eclectic vehicles are well established. Xie, Dallmann and Muncrief maintain that transitioning to zero emission vehicles globally could result in a reduction of road transport CO2 emissions of 73% by 2050 compared to 2020 levels.[19] Transitioning to low and zero emission vehicles could prevent 3 million premature deaths by 2050.[20] Additionally, 100% EV sales and 100% clean electricity is estimated to generate $1.2 trillion in health benefits, and will save 110,000 lives and 2.7 million asthma attacks in the U.S. by 2050.[21] Medium and heavy duty vehicles contribute 24% of all transportation greenhouse gas emissions, despite being only 4% of vehicles on the road.[22] Additionally, electrifying medium and heavy duty vehicles can result in cost reductions in maintenance and fuel.[23] About 43 million MT CO2 emissions could be reduced annually in the U.S. and Canada, equivalent to 5 billion gallons of gas, when shifting to electric medium and heavy duty vehicles.[24]

Considerations For Transitioning to Electric Vehicles

A study by Driivz, a Smart EV Charging and Energy Management Software, suggests four pillars to consider when electrifying a fleet. They suggest a seamless integration of charging capabilities, operational excellence and stability in charging, energy management optimizations, and optimizing fleet utilization and operations.[25] The National Renewable Energy Laboratory (NREL) additionally recommends understanding a vehicle's energy needs and charging window, and understanding that locations where many vehicles are charging could increase the utility bill.[26]

Emissions

Some studies have found limitations in the electrification of vehicles. An NREL 2022 Study found that studying six university fleets, electric vehicles were a good fit to replace 10%–50% of those fleet's light-duty vehicles.[27] Timmers and Achten (2016) maintain that electric vehicles are 24% heavier than conventional vehicles, and their particulate matter (PM) emissions are comparable to those of conventional vehicles. These authors recommend that future policy should concentrate on reducing vehicle weight.[28] Conversely, the European Public Health Alliance maintains that EV cars produce less PM2.5 and PM 10 than diesel or petrol cars.[29] Conlon, Waite, Wu, and Modi suggest that to achieve overall energy emissions reductions it is important to prioritize vehicle electrification ahead of complete grid decarbonization.[30] A study in Europe showed that electric SUVs did not contribute to reducing emissions, since CO2 emissions of new cars are reduced when there is lower motorisation. The authors suggest reducing the reliance on technology fixes, downsizing, and reducing motorisation to reduce emissions.[31]

Temperature

Temperature is a factor to consider when electrifying vehicles. Temperatures of 0 °C and −15 °C reduce the battery capacity of Battery Electric Vehicles of 150 km by 53% and 40%, respectively.[32] This study suggests that Battery Electric Vehicles can replace waste management small engine vehicles, since they have a lower vehicle workload than light duty vehicles.[33] The study additionally found that Battery Electric Vehicles are cheaper than internal combustion engine vehicles. Even without government subsidies, the Total Cost of Ownership (TCO) of EV vehicles is less.[34]

Natural Disasters
Natural disasters and the potential for prolonged power outages are one of the major concerns for an all-electric vehicle fleet. As mentioned by Hines & Adderly, the number of blackout events has not declined over time, and has in fact increased the need for contingencies.[35] [36] This can be tied to infrastructure (such as frequency of charging stations, battery banks, and alternative power sources), since electricity cannot be stored or transferred as easily as liquid fossil fuels.[37] This is especially of concern for EVs with limited driving ranges when evacuations or longer drives are needed, as demonstrated in the Florida Keys case study (Appendices V & XIII).[38] As shown in the table, there is only a single fast charging station available on Marathon Key throughout the 126 mile stretch between Key West and the Florida mainland, compared to the recommended number that should be located along the highway and island chain.[39]

Another example, as shown in Energy Policy 112 (Appendix F), is that the most common occurrence for electrical disturbance events between 2003 and 2015 was storms.[40] The average duration of these outages was 64 hours or almost three days.

Vehicle Range
Another point concerning EVs sold in the United States is that their fully charged driving range can vary from 62 to 270 miles per charge (with a median of 93 miles), depending on the brand or model.[41] Even for high-end EVs, this amount pales in comparison to fossil fuel powered vehicles, which have a median range of 403 miles, with some reaching a maximum of 765 miles, in between refilling the tank.[42] As this problem is not easily solved without improvements to the technology itself, EV ranges are expected to reach 500 miles per charge in the next few years, bringing them closer to the majority of fossil fuel-powered vehicles.[43]

Micro-grids & Off-grid Charging Options
In order to act as a preventative measure against natural disasters and power failures, some municipalities are implementing micro-grid or off-grid charging options as they transition to electric vehicles. As part of New York City's initiative to become carbon neutral by 2050, it is aiming for all municipal vehicles to be converted to electric by 2035.[44] This has also included purchases by the NYPD and use of solar-powered charging stations at precincts.[45] These examples of using off-grid power are a good use of contingency planning for continuity of emergency services during natural disasters or blackout periods. The use of decentralized or independent power generation in Puerto Rico has also tested the resilience of this technology in areas without reliable electricity or other utilities.[46]

Another instance of micro-grid implementation is in cases where solar or alternative energy is available, but that source is used to offset usage from the primary grid or to assist in lessening the burden that recharging a number of EVs would put on it. This can be seen in Maryland where a transit station housing 70 electric buses has been integrated with solar panels and battery storage units in order to utilize less power from the primary grid and ensure continuity of transit services, even when electric power becomes interrupted.[47]

Electric and Low-Emission Vehicle Efficiency – MPGe

In order to make a comparison between electric or low-emission vehicles and those that primarily utilize fossil fuels, the United States Environmental Protection Agency (EPA) established the *miles per gallon of gasoline-equivalent (MPGe)* standard to act as a benchmark for consumers, as well as the industry.[48] Though the unit deems 33.7 kWh of electricity to be equivalent to the energy derived from a gallon of gasoline by the average vehicle, it is not a straightforward comparison. As the unit was later adopted by the United States Department of Transportation (DOT) and United States Department of Energy (DOE), fuel economy labels were implemented on new electric or hybrid vehicles.

While the mileage of zero- or low-emission vehicles was always considered an improvement over more traditional vehicles, this assumption is supported by a 2022 analysis published in *Future Internet*.[49] While the study showed that hybrid EVs and plug-in hybrid EVs performed at similar rates, typically within 3-5 MPGe of their counterpart models and halving CO_2 emissions, the comparison between internal combustion engine vehicles and full EVs was much more drastic. Their fuel efficiency increased three- or four-fold, while of course their emissions were reduced to zero for each comparative set of models.

The Market for Light, Medium, and Heavy Electric Vehicles

Our team has chosen to focus on solely battery electric and plug-in hybrid electric vehicles, rather than fuel hybrid vehicles. One study from 2019 has shown that hybrid electric vehicles have shown no reduction in hydrocarbon emissions and consistently higher carbon monoxide (CO) emissions compared to the conventional Internal Combustion Engine (ICE) vehicles. This was caused by the frequent stops and restarts of the HEV engines, as well as the lowered exhaust gas temperature and reduced effectiveness of the oxidation catalyst.[50] Another report from the International Council on Clean Transportation (ICCT) found that electric vehicles produce less emissions over its entire lifecycle compared to hybrid vehicles.[51] See Appendix D for the comparison of CO2 emissions from conventional, electric, and plug-in hybrid vehicles.[52] Another study found that plug-in hybrid electric vehicles are found to be more efficient and produce less CO2 than hybrid electric vehicles.[53] A 2020 ICCT study further maintains that hybrid vehicles CO2 emissions are two to four times higher than type-approval values.[54]

When determining the price and drive range of an electric vehicle, the size and capacity of the battery is the most important component.[55] Aryandi, Gunawana, and Monaghan found that Plug-in hybrid electric trucks operate with the lowest fuel costs of $0.16/kWh.[56] [57] Batteries that are currently available in the market cannot currently meet all energy requirements of all electric vehicles, but there is a plethora of research being conducted on Lithium-ion batteries, Acid batteries, Nickel– Cadmium batteries, Nickel-metal hydride batteries, and Nickel-iron batteries. There is also emerging research on new technologies of Aluminum-air, Vanadium redox, and iron-air batteries.[58] It is predicted that by 2030, the battery price will be close to half of the current price.[59] See Appendix G for actual and projected battery costs.

According to the International Energy Agency (IEA), the electric vehicle market has expanded dramatically in the past four years. Electric vehicle sales accounted for 9% of car sales in 2021, 4 times their share in 2019.[60] In the first quarter of 2022, 2 million EVs were sold globally, a 75% increase from the first quarter of 2021.[61]

New electric vehicles sales are predominantly battery electric vehicles, accounting for 75% of electric sales.[62] LaMonaca and Ryan emphasize the need for more accessible data to analyze the usage of the existing EV network.[63] Even when the market is still in early stages, there are many options for zero-emission medium and heavy-duty vehicles, inventory. Drive to Zero holds an inventory of medium and heavy-duty vehicles, both electric and fuel cell, filtered by current availability and availability in the coming years.[64]

A 2022 U.S. Department of Energy Report maintains that there are several medium and heavy electric vehicles currently available in the U.S. Market, including transit buses, delivery trucks, forklifts, mowers, tractors, and ground support equipment.[65] Zero emission trucks and buses availability has increased by 26% from 2020 to 2023, and there are 544 models currently available.[66] The North American Council for Freight Efficiency estimates that half of current M/HD vehicles and vans are currently electrifiable. As of March 2022, there were 136 medium and heavy duty zero emission vehicles for purchase, and there will be 166,000 zero-emission truck and bus deployments by the end of 2022.[67]

EV commercial vehicle markets that are considered fully mature in 2022 are transit and school buses.[68] See Appendix L for EV usability by vehicle type. Zero emission truck volume is low. In 2021, 3,000 ZEV trucks were produced, 6% of total trucks.[69] An EDF report maintains that even though there are few current EV medium and heavy-duty vehicles in the market, the market is rapidly growing. These markets are projected to be fully mature by 2025.[70] In 2022, less than 1% of medium and heavy-duty vehicles are hybrid-electric or battery-electric vehicles.[71] In 2019, there were 20 medium and heavy-duty vehicles, and in 2022 there are more than 136 models on the market.[72] See Appendix J for available medium and heavy-duty vehicles by year.

Some models of electric vehicles include Solectrac, which believes that the weight of electric vehicles can be used for traction and stability in tractors, and they have 100% solar powered tractors in the market.[73] New electric batteries are emerging in the market, such as the ePowertrain, with battery sizes ranging from 210-475 kWh. Cummins also offers transit buses and transport tractors.[74]

Market Future

Scholars predict that the future of the electric vehicle market looks bright. The combination of government policy, demand and preferences, technological developments, and concern for the environment is driving the expansion of the electric vehicle market.[75] The U.S. Department of Energy's study shows that nearly half of medium and heavy duty trucks will be cheaper to buy, operate, and maintain as zero emissions vehicles than traditional vehicles by 2030.[76] The International Council on Clean Transportation (ICCT) estimates that 45% heavy duty vehicles sales in 2030 will be zero-emission, and 100% in 2040.[77] Many companies have plans for light-duty pickups and vans, including Ford.[78] Many major manufactures have announced transitioning to being fully electric, with 40% of retailers committed to reducing emissions.[79] For example, Toyota will roll out 30 battery electric vehicles by 2030, while Lexus plans to have 100% electric vehicles by 2035. Ford projects ⅓ of electric sales by 2026, and 50% by 2030, while Volvo aims to become fully electric by 2030.[80] Appendix K shows the timeline of electric vehicle sales for all major vehicle manufacturers.

The National Academies of Sciences, Engineering, and Medicine found that "the period from 2025-2035 could bring the most fundamental transformation in the 100-plus year history of the automobile", since EVs will reach parity with conventional vehicles. Experts predict that parity will occur when battery prices reach below $100/ kWh, in about 2025. Medium and heavy-duty vehicles will reach parity by 2027.[81] They estimate that EVs will be the dominant type of vehicles by 2025. Battery prices have already fallen from $1,000/kWh in 2010 to $132/kWh in 2021, and will fall to $100/ kWH by 2025, and to $61-72/lWh by 2030.[82] It is estimated that in 2025, there will be 187 battery electric and plug-in hybrid light vehicles in the U.S.[83] See Appendix M for EV parity vehicle schedule by vehicle type.

Hydrogen Fuel
Hydrogen is a promising technology application for low emission vehicles. The range of fuel cell trucks is 600 miles, compared to the 300 miles of electric batteries.[84] The upfront cost is estimated to be lower as well, since a tractor with fuel cell is $156k, while electric tractors average $227K. The total cost of ownership, however, is higher than diesel trucks. The cost of hydrogen needs to be below $5/kg for these vehicles to be marketable.[85]

The Cost of Electric Vehicles
According to the Kelley Blue Book, new-vehicle prices are continuously rising.[86] For electric vehicles, the yearly increase in price between November 2020 and November 2021 was 6.2%. NRDC shared in 2021 that the average price of an electric vehicle was $10,000 higher than the average price for the industry. The Customer Report reports that the electric vehicles have higher upfront cost compared to internal combustion engine vehicles, there is much evidence available indicating the electric vehicles are cheaper to maintain. Harto's 2020 report on EV costliness maintains that EVs are expensive at the time of purchase but argues the maintenance of EVs is half of the cost of ICEs.[87] The estimate is based on both predicted values and recorded surveys from customers. NRDC provides similar insights, estimating the annual savings at the levels between $6,000 and $10,000.[88]

Zero emission trucks can add 30% to the sticker price. However, 9 different types of zero emission trucks have a lower total cost of ownership than conventional trucks, see Appendix H for the total cost of ownership for medium and heavy-duty vehicles.[89] Medium and heavy vehicles are estimated to drop up to 30% by 2024, and 44% by 2027. Purchase price for vehicles such as refuse trucks, shuttle buses, and delivery trucks can reach price parity to diesel version by 2023.[90] The total cost of ownership is estimated to go down. Light duty vehicles could save over $5,000 in fuel costs, and medium box trucks could save $6,269 in fuel costs over its lifetime. Other studies concluded EVs can save up to $14,500 in fuel costs for light duty vehicles over 15 years.[91]

Charging Station Infrastructure
PricewaterhouseCoopers (PwC), McKinsey, and Edison Electric Institute, among many others, indicate the necessity for development of charging infrastructure to support the increasing number of electric vehicles.[92] [93] [94] The same literature indicates the possibility of high upfront costs for development of charging infrastructure, however as noted in a market analysis conducted by the US Department of Energy, there is a general trend of decline in costs.[95] McKinsey's report on the future of EV emphasizes the importance of federal and state

governments, which have the ability to provide financial incentives to aid development of charging infrastructure. The transition to electric vehicles is expected to increase the number of charging points across the country – PwC estimates an increase from 4 million in 2021 to 35 million in 2030.[96] This section is a review of different types of EV infrastructure, costs associated with such investment, and the challenges of said investments.

Available Charging Stations

The generally approved classification of charging stations is set on a scale 1 to 5, with Level 1 having the lowest power capacity and Level 5 the highest. Henry Lee of Harvard Kennedy School of Government and Alex Clark of Climate Policy Initiative published a review of charging technology, consistent with other available sources.[97] Level 1 equipment operates using alternating current and can draw electricity directly from the local distribution system. The equipment can be operated in most buildings, including individual households, and there is no need to alter existing circuitry. It is necessary to purchase an adapter and use a conventional wall socket with a power of 1.4 kWh. Level 1 equipment is recommended for personal use of light duty vehicles at owners' houses. Level 2 equipment also uses alternative current and can draw energy from local distributional systems. It operates on upgraded, 220-volt outlets, with power ranging from 6.6 kWh to 19.2 kWh. In Level 2 charging stations, the adaptation needs, and investment range will vary based on targeted electrical capacity. Level 3 to Level 5 equipment uses direct current, charging the battery directly and delivering much more power, without the necessity of purchasing the inverter. The power of Level 3 and 5 is estimated to range from 10 kWh to 350 kWh. According to an analysis conducted by ICF, while a light-duty charging network may be sufficient for small to medium-duty vehicles, it might not be feasible for long-haul trucks, which will need significant improvements to high-powered charging ports (See Appendix O).[98]

Level 1 is a convenient form of charging EVs and accounts for approximately 50% of in-house charging stations for EV owners as of June 2022.[99] It is uniform across several studies that the most significant advantages of Level 1 charging are easy availability and marginal costs – small adapters are often the only expense. Level 2 chargers are applicable for personal use and small to medium commercial needs. The National Renewable Energy Laboratory published data on the number and types of charging infrastructure, indicating that a vast majority of public charging infrastructure is at Level 2 (as seen in figure X).[100] The U.S Department of Energy reports that the Level 2 charging equipment can meet the needs of MD/HD vehicles with low utilization and long dwell periods.[101] There might be a need for different types of equipment for MD/HD vehicles, such as inductive or overhead equipment which allows vehicles to charge while parked. Another notable benefit of Level 2 equipment is that it has a common plug that all electric vehicles can use, while Level 3-5 fast chargers are not compatible with all vehicles, as noted by the New York State Energy Research and Development Authority (NYSERDA).[102]

Costs of Charging Stations

According to a comprehensive review study by the Idaho National Laboratory, the installation cost ranged from $600 to $12,700.[103] The International Council on Clean Transportation in 2013 study estimated the minimum commercial costs at $3,000 for the Level 2.[104] The costs often depend on the type of equipment installed. Charger tower prices range from $1,000 to $4,000 in the Lee and Clark estimates, while others use a range from $469 to $9.985 per tower.[105] The big price range is dependent on the qualities of the equipment – complexity of interface, on-site payment system, or network connection. Levels 3-5 can cost $30,000 - $40,000 for a single port charger and $50,000 - $60,000 for a dual-port charger. Wide range in the estimates is caused by large variations caused by a variety of factors that can be controlled for during the planning stage of the investment.

Both Level 1 and Level 2 equipment are affordable in-house alternatives. Level 1 stations have lower energy capacity. The Appendix B[106] breakdown shows the average power of each level of charging and the time to replenish daily usage. Level 2 stations, moreover, have better durability and more features than Level 1 and are recommended for workplace stations where multiple vehicles are charged. The Department of Transportation, Forbes, and many other sources indicate that Level 2 is sufficient for needs of small- to medium- sized commercial charging stations.[107] [108] [109] Additionally, Level 2 has higher power than Level 1 stations. One hour of charging at a Level 2 station allows driving a range of 10 to 20 miles, compared to only 3 to 5 miles for vehicles charged at Level 1.[110] Level 3 to 5 have great capacity and outperform in terms of speed of charging, however require significantly higher financial investment that often does not yield returns. Moreover, these high-capacity charging stations are said to deplete the battery capacity, as shown by data gathered by the Idaho National Laboratory.[111]

Costs can be optimized by controlling the following factors: location, features, and charging form. The Energy Efficiency and Renewable Office at the Department of Energy reported that the Level 2 wall mounted charging station is 37% cheaper than the average installation cost of a pedestal unit, with an average cost of $2,035 for the mounted wall unit and $3,209 for a pedestal mount. The difference in price is attributed to less concrete and other materials associated with the installation process. Trenching is one of the reasons for higher costs of the pedestal unit. Trenching is understood as digging holes in roads, pavements, more generally concrete, to lay conduit. According to the Department of Energy, trenching of 50 feet might cost up to $5,000.[112] Additionally, limiting the number of features to necessary ones also limits the cost. Notably, a choice between a mounted wall unit and pedestal unit is very important. In terms of cost allocation, labor accounts for 55 to 60% of total costs, materials cost 30 to 35%, and permits and tax account for 5% of total costs each. Interestingly, 9% of Level 2 commercial charging stations included aesthetic components that more than doubled the average installation cost from $3,552 to $8,005.

Maintenance Costs

There are maintenance and operating costs associated with charging stations.[113] Additionally, all equipment is sold with 1 to 3 years warranty for defects. Apart from the equipment maintenance, there are operational costs associated with network connection, insurance, and any rent/costs associated with location of the station. These costs are determined on a case-by-case basis.

Hamilton, writing for the Bureau of Labor Statistics, maintains that many basic repairs and maintenance procedures are the same for EVs and traditional vehicles.[114] According to the Alternative Fuels Data Center, the emergency response for EVs is very similar and there are no significant differences from that of ICVs.[115] In the same report, however, it is indicated that technicians and mechanics must obtain certification to work on complex EV problems. National

Alternative Fuels Training Consortium (NAFTC) provides curriculum, training, and certification for workers in the automotive industry.

Power Grids and Electricity
Level 2 chargers typically require an installation of 240-volt circuit, circuit needed for household clothes dryers.[116] As noted by the J.D. Power, a customer insights and data analysis firm focusing on the automotive industry, a new circuit and outlet can be installed by any electrician (with no special qualifications needed).[117] NYSERDA's guide for charging infrastructure estimates a need for a 20-60/ 20-80 amp circuit.[118] Such parameters allow for full-range charge in 3 to 6 hours or 20 miles per hour, with the estimates being uniform across the Department of Energy, Transportation, and NYSERDA.[119]

Political Landscape of Low Emission Vehicles
New York State Policies
The literature maintains that the political landscape has become very favorable toward the electrification of vehicles in recent years. In September 2022, Governor Hochul directed the State Department of Environmental Conservation to require all new passenger cars, SUVs and pickup trucks sold in the State of New York to be zero-emission by 2035.[120] New York state is also allocating $5.75 million for the purchase of zero-emission vehicles and installation of supporting infrastructure to municipalities.[121]

Federal Policies
At a federal level, the Bipartisan infrastructure bill will provide $7.5 billion for the purchasing of medium and heavy duty electric vehicles, and $7.5 billion for a national network of electric vehicle charging stations.[122] The National Electric Vehicle Formula Program will provide funds to states to deploy EV charging infrastructure.[123] Of this, New York State will receive $175 million over the next 5 years to create an electric vehicle charging network.[124] A bill was also introduced in the Senate in 2021 that would establish a rebate program to purchase medium and heavy duty electric vehicles and charging infrastructure.[125] In June of 2022, the Department of Energy began accelerating the production of five energy technologies to lower overall energy costs.[126] In July of 2020 Washington DC signed a memorandum of understanding with 15 states, including New York, to transition medium to heavy duty trucks and buses to 30% zero emission sales by 2030, and 100% by 2050.[127]

Utility companies, such as PSE&G, offer incentives for the installation of EV chargers.[128] The Climate Mayors Electric Vehicle Purchasing Collaborative is open to all U.S. cities and provides competitive bid contracts, resources, and support for vehicle transitions.[129] There are many policies that cities must keep in mind to reduce emissions.

The American Cities Climate Challenge presented a summary of key policies to pursue at a city level to transition to electric vehicles.[130] The table in Appendix A outlines the benefits and impacts of charging infrastructure, multi-sector policies, shifts in freight, fleets, and consumer vehicles. They measure each policy according to its benefit and impact and difficulty and cost. Based on these measures, light-duty city fleet requirements, zero emissions freight/delivery zones/curb access, and EV ready buildings and businesses ranked highest as having relatively high benefits and impact, and relatively low difficulty and cost (Appendix A).[131]

Grants & Funding
The political environment is particularly supportive of investments and expansion of alternative vehicles. On the state level, there are several programs that provide partial or full support for purchase of vehicles, training of employees, and development of infrastructure. There is a preference for citizens, as most incentives are based on personal income tax that is not any benefit for municipalities. For that reason, below you can find a short list of the most beneficial programs applicable for Ardsley.

First, there is the EV Make Ready program. The objective of the program is to ensure development of infrastructure necessary to accommodate for growing number of EVs across NY State. The program supports development of infrastructure for non-residential needs. The entities might be eligible to receive up to 100% of costs associated with development of Level 2 and Level 3-5 charging stations.[132]

Evolve NY is a program promising $250 million funding by 2025. The goal is to build a fast and reliant charging facility close to 5 cities in NY State, including Yonkers. To receive more details on the program, there is a form on the website to contact the administrators.[133]

Lastly, there is Climate Smart Communities, a program supporting local governments to reduce their GHG emissions. CSC provides certifications for communities that show outstanding interest in climate change mitigation. There are 369 communities currently registered in the program. Once registered, there are 3 possible grants that one can apply for. The grants support purchase of vehicles and charging stations.[134]

Comparable Communities to The Village of Ardsley
Based on recent data collection, public charging ports within New York state experience an average of 6.6 kWh charge in 2017.[135] The national average electric energy rate for July 2022 for consumers is $0.16/kWh.[136] There is very limited literature available for communities similar to the Village of Ardsley, New York; although, there is literature from places with some geographical, budgetary, and structural similarities who have developed low emissions plans and EV infrastructure in their communities. As a reference, 2020 Census data indicates that Ardsley has a population density of 3,844.8 per square mile and encompasses 1.32 square miles.[137]

Tompkins County, NY
Tompkins County in upstate New York conducted an analysis of its electric vehicle charging stations. While both municipalities are in upstate New York, Tompkins County is geographically larger at 474.64 square miles and has a population density of 222.8 per square mile.[138] The costs for the charging station varied significantly depending on whether the building was old or new, whether it was a wall-mount or pedestal station, and whether the port was single or dual. In the conclusions of their study, installation costs of Level 2 networked stations ranged from $11,000 to $23,000.[139] Tompkins County also found that having networked charging stations increased the cost by an average of 60% per station due to the extra set-up, technology, and the ongoing operating costs. Appendix C shows the cost breakdown for each kind of EV charging station in the Tompkins County study.

Tompkins County's study also stated that damages for the changing stations came primarily from vehicles hitting them or charging cords being caught by snowplows. Tire stops, signage, monthly cleaning and inspections, and retractable cord systems were; however, effective solutions to these issues. Although these protections would increase costs, they serve an essential role in the longevity of the charging stations. It should be noted that some charging stations are designed for indoor use and should not be installed outdoors, as this may cause them to fail during extreme weather conditions and need replacement under warranty. Installing charging stations in new buildings and or using pre-existing power lines helped decrease costs a great deal.

Arroyo Grande, CA

The City of Arroyo Grande in San Luis Obispo, California conducted an audit of its municipal greenhouse gas emissions to develop reduction strategies.[140] Arroyo Grande is larger than Ardsley at 5.94 square miles and with a population density of 3,105.1 per square mile.[141] This study provides very simple and cost-effective measures for reducing emissions across various sectors of the city. Rather than opt for a great change in municipal habits, this study proposed tactics like driver efficiency training and changing vehicle routes to be more efficient or require lower miles traveled.

In terms of reducing municipal transportation emissions, a major proposed solution included changes to city work schedules, similar to one implemented by the City of Santa Barbara in 2007. Municipal buildings were open for longer hours Mondays through Thursdays and only open every other Friday. Employees were then able to opt for different schedules that were no longer restricted to their traditional 8am-5pm. This significantly lower-budget strategy was aimed to reduce the quantity of emissions at traditional commuting times, given that concentrated spikes in vehicle emissions cause more harm on human health. This modification could have human impacts outside of vehicle emissions, but has seen some successes after communication struggles at initial implementation.

Burlington, VT

Burlington is larger than Ardsley at 10.31 square miles and with a population density of 4,339.3 per square mile.[142] The City of Burlington, Vermont participated in a pilot program with the Vermont Clean Cities Coalition (VTCCC) to reduce emissions from police vehicles. They adopted a fuel management system in one of their vehicles called "IdleRight" which monitors the battery level of the emergency lights and only allows idling when absolutely necessary. Similar technology has been used by other police departments in other parts of the country. This technology being installed in one car resulted in the vehicle significantly reducing tailpipe emissions, cut vehicle maintenance and operating costs by about $800 a year, and saved 345 gallons of fuel.[143] An unintended positive outcome of the pilot included residents decreasing their complaints towards police vehicle idling and decreased wear on the vehicle.

Appendices

Appendix A: Key Policies to Pursue at a Local Level [144]

Summary of key city policies

Benefits & impact key: ● High ● Medium ● Potential Negative
Dificulty & cost key: ● Low ● Medium ● High

	Summary of key city policies	Benefits & impact: Direct GHG reduction	Health	Equity benefits	Jobs	Market impact	Difficulty to pass	Current cost to implement
Charging infrastructure	1. Infrastructure deployment	Medium	High	High	High	High	Medium	High
	2. EV-ready buildings & businesses	Medium	Medium	High	High	Medium	Medium	Low
	3. Equitable charging	Medium	Medium	High	High	Medium	Medium	Medium
	4. Streamlined charging approval (permits)	Medium	Medium	Medium	Medium	Medium	Low	Medium
Multi-sector	5. Zero emission (ZE) areas, diesel bans, or similar	High	High	High	High	High	High	Medium
	6. Road tolls and CO_2-focused congestion pricing	High	High	Potential Negative	Medium	Medium	Medium	Medium
	7. Funding for electric vehicles and charging	High	High	High	Medium	High	Medium	High
Freight	8. Zero emission freight/delivery zones/curb access	High	High	High	High	High	Medium	Medium
	9. Zero emission ports and inland hubs/ warehouse districts	High	High	High	High	High	High	High
Fleets (buses, light-duty)	10. Zero emission bus requirements & rollout	High	High	High	Medium	High	Medium	High
	11. Fleet EV funding and business models	Medium	Medium	Medium	Medium	High	Low	High
	12. Light-duty city fleet requirements	High	Medium	Medium	High	High	Low	Medium
	13. EV procurement and use policies (all classes)	High	Medium	Medium	Medium	Medium	Low	Medium
Consumer	14. ZE mobility service provider/taxi deployment	Medium	Medium	High	Medium	High	Medium	Medium
	15. City programs for faster uptake (bulk purchase agreements & dealer & education campaigns) (action)	Medium	Medium	High	Medium	Medium	Medium	Medium

Appendix B: Charging Characteristics [145]

Charger Type	Current Type	Average Power Delivered (kW)	Time taken to replenish daily usage (13.65 kW)	Time taken to charge 100 miles (37 kWh)	Range added per minute (miles)
Level 1	AC	1.4	9h 45m	26h 26m	0.06
Level 2 [standard]	AC	6.6	2h 4m	5h 36m	0.30
Level 2 [maximum]	AC	19.2	43m	1h 55m	0.86
Level 3	DC	50.0	16m	44m	2.25
Level 4	DC	150.0	5m	15m	6.76
Level 5	DC	350.0	2m	6m	15.77

Appendix C: Tompkins County Charging Station Breakdown [146]

Station Description	Installation Description	Dual Port Station Cost	Install-ation Cost	Tire stop or bollard Cost	Signage Cost	Activa-tion Cost	Net-work Cost (1 year)	Average Electricity Cost (1 year)	Total Cost (first year)
Level 1 (120V), wall mount, **not networked**	Installed with **new** building, 30' wire run, 1 tire stop	$2,500	$2,000	$350				$300	$5,150
Level 2 (240V), wall mount, networked	Installed with **new** building, 30' wire run, 1 tire stop	$6,500	$2,000	$350	$500	$1,000	$600	$300	$11,250
Level 2 (240V), wall mount, networked	Installed on an **old** building, 30' wire run, 1 tire stop	$6,500	$4,500	$350	$500	$1,000	$600	$300	$13,750
Level 2 (240V), wall mount, networked	50' wire run 1 tire stop	$7,500	$5,000	$350	$500	$1,000	$600	$300	$15,250
Level 2 (240V), pedestal mount, networked	New sidewalk square, 50' wire run, 1 bollard	$7,500	$8,000	$1,000	$500	$1,000	$600	$300	$18,900
Level 2 (240V), pedestal mount, networked	Installed with **new** parking lot, 1 bollard, 100' wire run (15' conduit)	$7,500	$3,000	$1,000	$500	$1,000	$600	$300	$13,900
Level 2 (240V), pedestal mount, networked	Sidewalk cut and repair in **old** lot, 1 bollard, 100' wire run (15' conduit)	$7,500	$7,000	$1,000	$500	$1,000	$600	$300	$17,900
Level 2 (240V), wall mount, networked	120' wire run with high ceiling work, mounted on the building **wall**	$6,500	$5,500		$500	$1,000	$600	$300	$14,400
Level 2 (240V), pedestal mount, networked	New **sidewalk** square, 1 bollard, 120' wire run (along high ceilings)	$7,500	$8,500	$1,000	$500	$1,000	$600	$300	$19,400
Level 2 (240V), pedestal mount, networked	Underground boring to **island**, 1 bollard, 50' wire run, mounting pier	$7,500	$12,500	$1,000	$500	$1,000	$600	$300	$23,400
Level 2 (240V), wall mount, networked	60' electrical run 2 bollards	$6,500	$4,500	$1,500	$500	$1,000	$600	$300	$14,900
Level 2 (240V), pedestal mount, networked	New panel from transformer, Mounting pier, 1 bollard	$7,500	$11,000	$1,000	$500	$1,000	$600	$300	$21,900

Appendix D: Comparison of life-cycle greenhouse emissions [147]

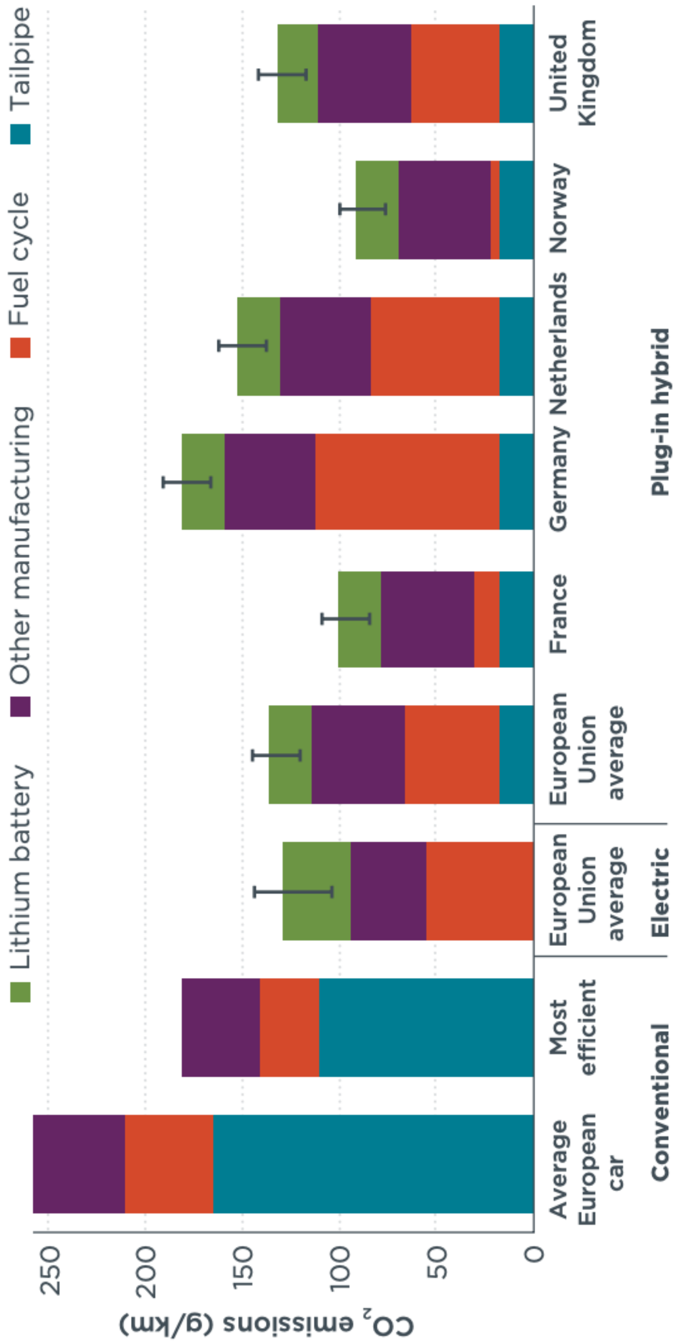
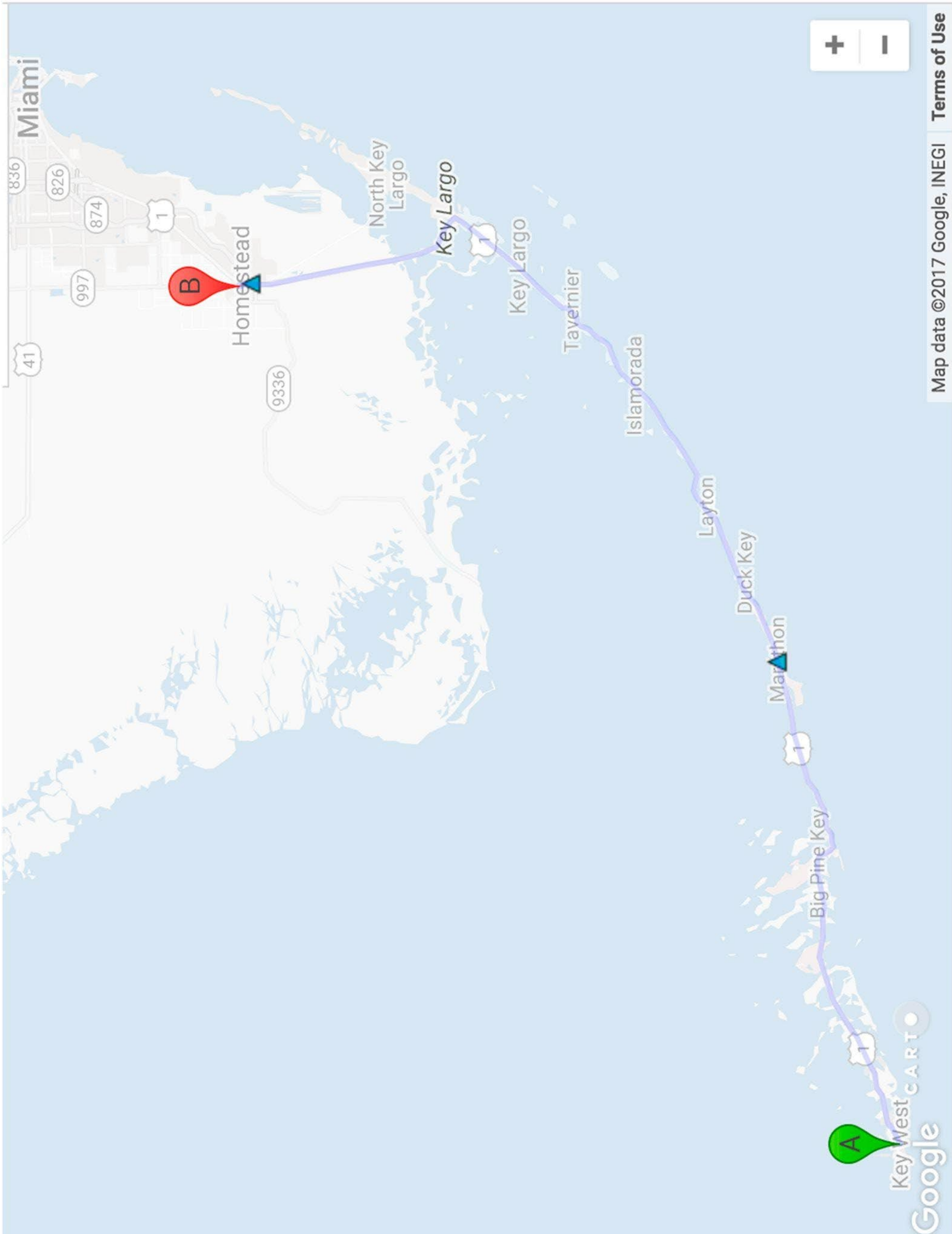


Figure 2. Comparison of life-cycle greenhouse gas emissions in conventional, electric, and plug-in hybrid vehicles in various European markets.

Appendix E: Map of the Florida Keys with DC Fast Charger Locations [148]

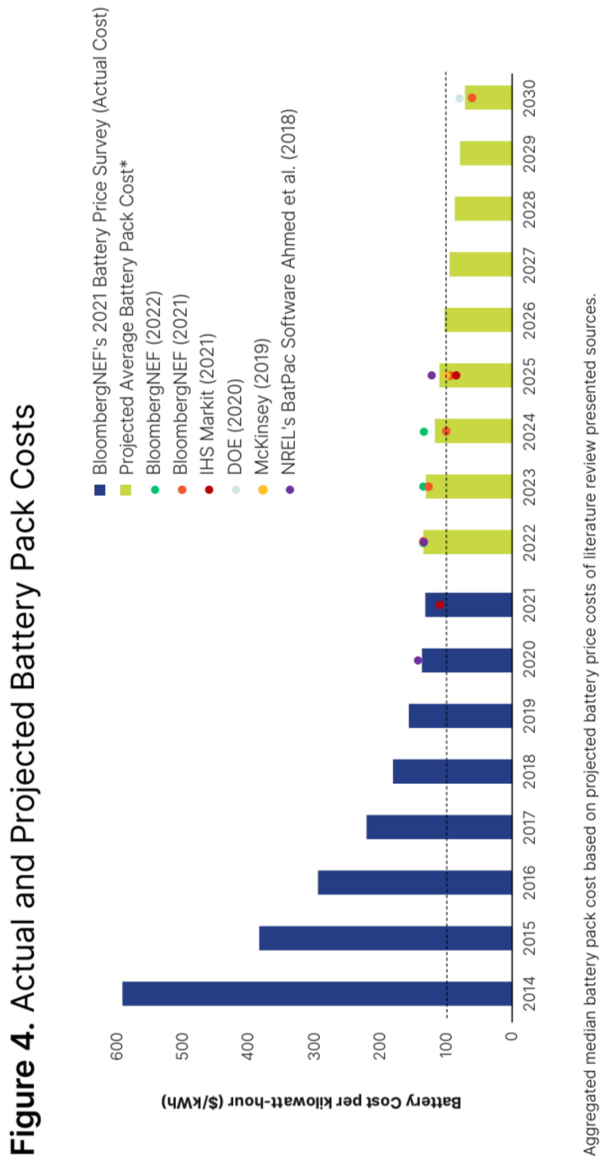


Appendix F: Electric Disturbance Events from 2003 to 2015 [149]

Table 3
Selected data for electrical disturbance events from 2003 to 2015.

Cause of outage	**Count**	**Mean size [MW]**	**Mean size in customers**	**Mean duration [h]**
Cold	109	504	166,768	80
Cyber attack	16	NA	NA	NA
Earthquake	5	398	132,659	17
Equipment Failure	154	838	131,636	15
Fire	17	307	119,250	130
Fuel Supply	216	730	141,511	51
Hurricane	113	1214	392,545	123
Lightening	14	359	181,842	14
Other	28	8131	646,513	22
Storm	659	476	165,962	64
Vandalism	391	86	2364	7
Voluntary Reduction	89	3116	207,000	21

Appendix G: Actual and Projected Battery Pack Costs [150]

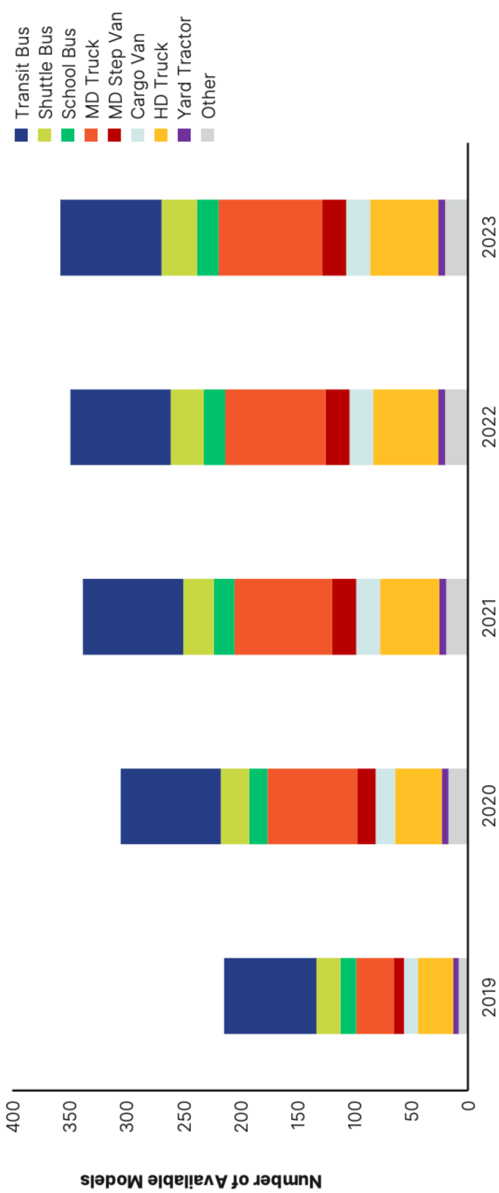


Appendix H: Total Cost of Ownership for Medium and Heavy-Duty Vehicles [151]

Figure 5. Total Cost of Ownership per Mile for M/HD Vehicles (Vehicles Purchased in 2027)[101]

Appendix J: Medium and Heavy-Duty Vehicles Available by Year [152]

Figure 7. Total Medium- and Heavy-Duty Vehicle U.S. Models Available by Year[169]



Appendix K: Estimated Sales by Manufacturer [153]

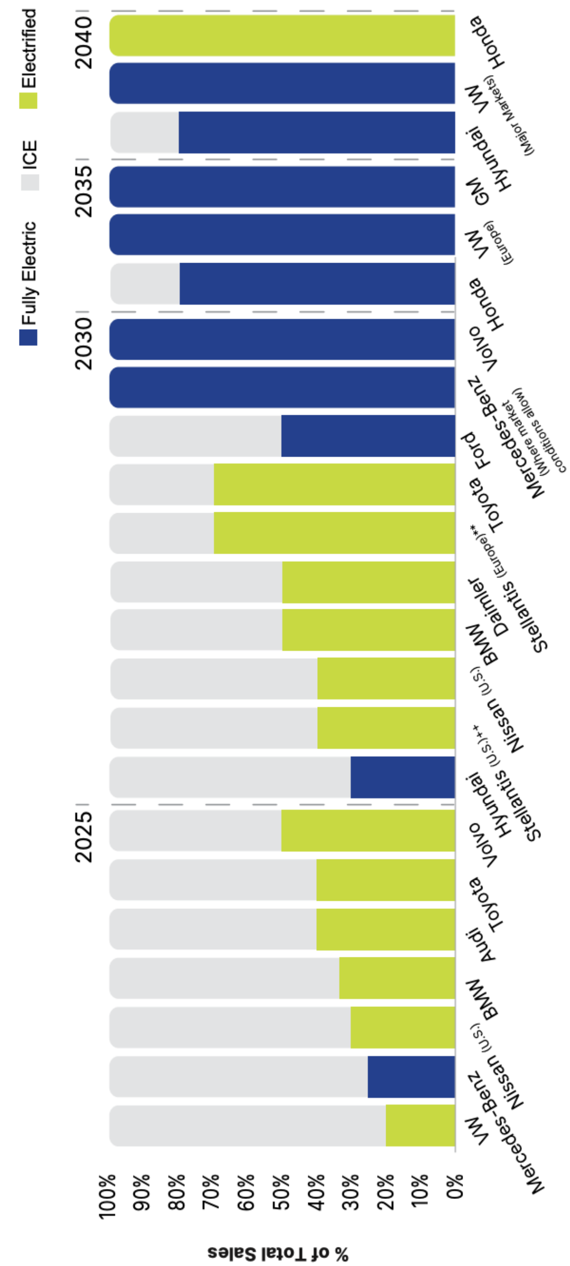


Figure 8. Global Sales Goals by Manufacturer

Appendix L: EV Usability by Vehicle Type [154]

Figure 9 EV Usability by Market Segment

Range > Average Daily Mileage	60% <Range <100% of Average Daily Mileage	Range < 60% of Average Daily Mileage
• Heavy-duty Pickup and Van	• Regional Haul Tractor	• *Long Haul Tractor*
• Transit Bus	• Delivery Truck (Class 6 – 7)	• *Shuttle Bus*
• School Bus	• Dump Truck	• *Box Truck (Class 8)*
• Delivery Van		
• Service Van		
• Service Truck		
• Refuse Hauler		
• Box Truck (Class 3 - 5)		
• Box Truck (Class 6 – 7)		
• Stake Truck (Class 3– 5)		
• Stake Truck (Class 6 – 7)		

Appendix M: Projected EV Cost Parity [155]

Figure 11 Projected EV -ICE Cost Parity by Market Segment

Projected EV Life-Cycle Cost Parity with Diesel & Gasoline Vehicles		
By 2025	**By 2030**	**After 2030**
• Heavy-duty Pickup and Van • Regional Haul Tractor • Long Haul Tractor • Delivery Van • Delivery Truck • Service Van • Refuse Hauler • Box Truck (Class 8) • Dump Truck	• Shuttle Bus • Service Truck	• Box Truck (Class 3 - 7) • Stake Truck (Class 3– 7)

Appendix N: Currently available charging stations in the Florida Keys compared to the recommended number of fast-charging stations [156]

Table 9

Currently available BEV charging stations in the Florida Keys and example of potentially required number of fast charging stations.

City	Population	Distance from mainland	Fast DC charging available	Required [10%]
Key West	25,704	126	0	111
Big Pine Key	5032	97	0	21
Marathon	8708	75.7	1	37
Duck Key	443	67.4	0	1.9
Layton	190	59.5	0	1
Islamorada	6523	45.3	0	28
Tavernier	2173	36.5	0	9.3
Key Largo	10,433	28.8	0	45
North Key Largo	1244	19.5	0	6

Appendix O: Charging Needs by Market Segment [157]

Figure 8 Charging Needs by Market Segment

Home Base, Level 2	Home Base, Level 3	Public
• Heavy-duty Pickup & Van	• Heavy-duty Pickup	• Long Haul Tractor
• School Bus	• *Regional Haul Tractor*	• *Regional Haul Tractor*
• Delivery Van	• Transit Bus	• *Box Truck (Class 6 – 7)*
• Service Van	• Shuttle Bus	• *Box Truck (Class 8)*
• Service Truck	• Delivery Truck	
• Box Truck (Class 3 – 5)	• Refuse Hauler	
• Stake Truck (Class 3 – 5)	• *Box Truck (Class 6 – 7)*	
• Stake Truck (Class 6 – 7)	• *Box Truck (Class 8)*	
	• Dump Truck	

Appendix III. Ardsley Capital Plan

CAPITAL PLAN 2022 - 2032	2022-2023	2023-2024	2024-2025	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032
PUBLIC BUILDINGS/FACILITIES										
Village Hall HVAC Replacement			150,000							
HIGHWAY										
DPW Building	6,000,000									
HIGHWAY EQUIPMENT										
Purchase of Morbark Eeger Beaver Chipper										
Replacement of John Deere Tractor w snow blower										
Landscape Trailer	$6,000									
Purchase of Scag Mower										
Replacement of Ford F-350 dump w plow & sander	$110,000									
Replacement of 15 yd dump w plow & sander	$220,000									
Replacement of John Deere Loader		$325,000								
Replacement of 2009 International Dump w/P&S			$250,000							
Highway Car #1		$65,000								
Replacement of 2007 Ford F450 Pick Up w/P&S				$80,000						
Replacement of Mack/Leach garbage truck				$325,000						
Replacement of 2014 Freightliner w/P&S					$215,000					
Replacement of 2006 John Deere Tractor 4720 w attach					$135,000					
Replacement of pickup truck w/p/s					$80,000					
Replacement of Ford F-450 w/P&S #6						$130,000				
Replacement of Ford F 450						$110,000				
Replacement of 2015 freightliner						$215,000				
Replacement of Ford F-450 w/P&S #6							$130,000			
Replacement of pickup truck w/p/s							$75,000			
Replacement of ford F450								$125,000		
Highway Car #2									$80,000	
SIDEWALKS										
Revolutionary Road	$390,647									
Heatherdell Road (Concord Rd to Chimney Pot)		$226,664								
Heatherdell Road (Chimney Pot to Revolutionary Rd)			$266,748							
American Legion				$310,478						
ROAD RESURFACING										
Felix Ave	$45,726									
Lincoln Ave - A	$39,212									
Windsong Rd	$102,156									
Lakeview Ave	$58,644									

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CAPITAL PLAN 2022 - 2032										
	2022-2023	2023-2024	2024-2025	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032
Sweetbriar Rd	$44,218									
Revolutionary Rd	$220,672									
Chimney Pot Lane		$134,010								
Euclid Ave		$312,954								
Oakhill Rd			$91,420							
Bridge St			$75,080							
Highland Dr			$9,230							
Captain Honeywell East			$40,362							
Morningside Rd			$110,570							
Heatherdell Rd				$617,528	$617,528					
Beacon Hill Rd						$495,604				
Farm Rd						$162,379				
Glen Rd						$129,651				
Huntley Dr (N)						$31,416				
Wildwood Lane						$102,088				
Franklin Ct							$51,544			
Kensington Rd							$284,651			
Colonial Ct							$41,455			
Huntley Dr (S)							$170,008			
Hilltop Road								$257,796		
Victoria Road								$479,478		
Columbia Road								$119,694		
McKinley Pl									$182,879	
Lincoln Ave									$343,412	
Dellwood, Crestview, Jordan, Flintlock										$354,632
FIRE										
Replacement of Chief Vehicles	$69,458			$80,400			$93,073			
Tools and Mounts for New Pumper Truck	$30,000									
Ladder Replacement (2010 Smeal #50)								$1,200,000		
DRAINAGE										
Village Green Detention Basin Maintenance	$50,000			$55,000			$ 60,000			
ADMINISTRATION										
Administration Office Server Replacement							$ 25,000			
Municity	$35,000									
Email Server Replacement							$ 21,600			
PD Server Replacement	$20,000							$20,000		
Financial System Server Replacement					$21,100					
PARKS/RECREATION										

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CAPITAL PLAN 2022 - 2032										
	2022-2023	2023-2024	2024-2025	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032
Resurfacing skatepark		$30,000								
Pascone Park Walking Path		$150,000								
Replacement of Community Center HVAC Unit		$20,000								
Replacement of Playground Equipment @ Pascone		$250,000								
Pascone Park Spray Bay				$250,000						
POLICE										
Police operations software system	$250,000									
Replacement of 9 portable radios and car radios and base station	$350,000									
Upgrade dispatch center		$100,000								
LIBRARY										
TOTAL ANNUAL PROJECT AMOUNTS	$8,041,733	$1,613,628	$993,410	$1,718,406	$1,068,628	$1,376,138	$952,331	$2,201,968	$606,291	$354,632
SEWER FUND										
System Engineering & Investigation										
Capital Improvements										

Appendix IV. Full Municipal Fleet Inventory

NO.	MAKE and MODEL	YEAR Purchased	DEPARTMENT	STYLE	VEHICLE TYPE	FUEL TYPE	COST New	VIN
1	MERCURY Mariner	2010	Building	SUV	Light	Unleaded	$24,785.00	4M2CN9B75AKJ26822
2	FORD F-550 Bucket Truck	2014	DPW	Light Truck	Medium	Diesel	$98,000.00	1FDUF5GT6EEB28844
3	MACK Garbage Truck	2003	DPW	Garbage Truck	Heavy	Diesel	$167,250.00	1M2AG12C83M005260
4	MACK Garbage Truck	2005	DPW	Garbage Truck	Heavy	Diesel	$163,720.00	1M2AG1C854M025741
5	INTERNATIONAL 7400 Dump Truck	2008	DPW	Heavy Truck	Heavy	Diesel	$134,275.00	1HTWEAAR78J646966
6	MACK Garbage Truck	2011	DPW	Garbage Truck	Heavy	Diesel	$130,000.00	1M2AX13C4BM013787
7	FORD F-350 Super Duty Truck	2014	DPW	Heavy Truck	Medium	Unleaded	$36,445.00	1FT8W3B64EEA61155
8	FORD F-350 Small Dump Truck	2014	DPW	Light Truck	Medium	Diesel	$80,124.00	1FDRF3HT0FEB36500
9	FORD F-550 Small Dump Truck	2015	DPW	Light Truck	Medium	Diesel	$80,124.00	1FDRF3HT2FEB36501
10	INTERNATIONAL 4300 Dump Truck	2009	DPW	Heavy Truck	Heavy	Diesel	$85,000.00	1HTMZXMGJ141891
11	FREIGHTLINER Dump Truck/SD	2014	DPW	Heavy Truck	Heavy	Diesel	$190,000.00	1FVDG5CY9EHFW4158
12	FREIGHTLINER Dump Truck	2015	DPW	Heavy Truck	Heavy	Diesel	$174,561.00	1FVDG5CYXFHGN4825
13	CHEVROLET Tahoe	2015	DPW	SUV	Light	Unleaded	$47,000.00	1GNSKAKC4DR285751
14	DODGE Charger	2013	Police	Sedan	Light	Unleaded	$33,000.00	2C3CDXATXDH548306
15	CHEVROLET Tahoe	2012	Police	SUV	Light	Unleaded	$42,000.00	1GNSK2E0XCR249677
16	SPARTAN Fire Truck	1999	Fire	Fire Truck	Heavy	Diesel	$386,000.00	4XS7AU4192XC028449
17	CHEVROLET Suburban 2011	2008	Fire	SUV	Light	Unleaded	$41,500.00	3GNGK26K88G160980
18	SMEAL Ladder Truck	2011	Fire	Fire Truck	Heavy	Diesel	$828,760.00	4S7AX2P94AC072320
19	CHEVROLET Tahoe	2012	DPW	SUV	Light	Unleaded	$40,500.00	1GNSK2E02CR292054
20	JOHN DEERE Loader 624J	2005	DPW	Mobile Equipment	Other	Diesel		DW624JZ601094
21	FORD Explorer	2016	Police	SUV	Light	Unleaded	$45,000.00	1FM5K8AR2GGA71872
22	CHEVROLET Tahoe	2016	Fire	SUV	Light	Unleaded	$48,000.00	1GNSKFKC2GR256506
23	FREIGHTLINER Sweeper/VAC	2015	DPW	Heavy Truck	Heavy	Diesel	$308,416.00	1FVACYDT0GHHF7915
24	SPARTAN Fire Truck	2016	Fire	Fire Truck	Heavy	Diesel	$710,000.00	4S7AU2E92FC079950
25	FORD Explorer	2017	Police	SUV	Light	Unleaded	$50,000.00	1FM5K8AR9HGB15397
26	CHEVROLET Tahoe	2017	Fire	SUV	Light	Unleaded	$53,000.00	1GNSKFEC3HR302115
27	DODGE Charger	2017	Police	Sedan	Light	Unleaded	$60,000.00	2C3CDXKT3HH661015
28	DODGE Charger	2017	Police	Sedan	Light	Unleaded	$60,000.00	2C3CDXKT3HH661017
29	FORD F-550 Lift Gate	2018	DPW	Light Truck	Medium	Diesel	$50,512.00	1FDUFSHT9HEF40985
30	FORD F-550 Small Dump Truck	2018	DPW	Light Truck	Medium	Diesel	$95,000.00	1FDUF5HT0JEB13799
31	MACK Garbage Truck	2019	DPW	Garbage Truck	Heavy	Diesel	$220,000.00	1M2GR2GC3KM002901
32	FORD F-550 Small Dump Truck	2019	DPW	Light Truck	Medium	Diesel	$95,000.00	1FDUF5HT6KDA03147
33	DODGE Charger	2019	Police	Sedan	Light	Unleaded	$60,000.00	2C3CDXJG4KH690571
34	CHEVROLET Tahoe	2019	DPW	SUV	Light	Unleaded	$44,649.00	1GNSKFEC6KR202436
35	DODGE Charger	2019	Police	Sedan	Light	Unleaded	$50,000.00	2C3CDXKT8KH622690
36	JOHN DEERE Tractor 2032R	2013	DPW	Mobile Equipment	Other	Diesel		2O32RKEH1123
37	JOHN DEERE Tractor 732	2001	DPW	Mobile Equipment	Other	Diesel		LV2032RKEH112837
38	JOHN DEERE Tractor 4720	2006	DPW	Mobile Equipment	Other	Diesel		LV4720H470630
39	CHEVROLET Tahoe	2020	Police	SUV	Light	Unleaded	$70,308.00	1GNSKDEC8LR229160
40	CHEVROLET Tahoe	2020	Fire	SUV	Light	Unleaded	$63,821.00	1GNSKFECXLR205082
41	MACK Packer	2021	DPW	Heavy Truck	Heavy	Diesel	$219,529.00	1FVHG3DV9MHMP4350
42	CHEVROLET Tahoe	2021	Police	SUV	Light	Unleaded	$72,889.00	1GNSKLED9MR340448
43	CHEVROLET Tahoe	2022	Fire	SUV	Light	Unleaded		1GNSKLED3NR235924
44	CHEVROLET Tahoe	2022	Police	SUV	Light	Unleaded		1GNSKLED4NR317659
45	CHEVROLET Malibu	2018	Police	Sedan	Light	Unleaded		1G1ZC5ST0JF222239
46	FREIGHTLINER Garbage Truck	2021	DPW	Garbage Truck	Heavy	Diesel	$235,000.00	1FVHG3DV9MHMP4353
47	JOHN DEERE Tractor 210 w/ Backhoe	2021	DPW	Mobile Equipment	Other	Diesel		1T0310SlINF417913
48	JOHN DEERE Tractor 2032 w/ Blower	2013	DPW	Mobile Equipment	Other	Diesel		LV2032RDCFHM1470
49	JOHN DEERE Tractor 4720 w/ Backhoe	2013	DPW	Mobile Equipment	Other	Diesel		LV4720H470636
50	MOREBARK Chipper	2022	DPW	Mobile Equipment	Other	Unleaded		458SZ1616NWO73196
51	JOHN DEERE Tractor 2025R w/ Backhoe	2021	DPW	Mobile Equipment	Other	Diesel		LV2025RVMM401295

Appendix V. Municipal Fleet Inventory Charts and Graphs

Fig. 1 Breakdown of Municipal Fleet Manufacturers

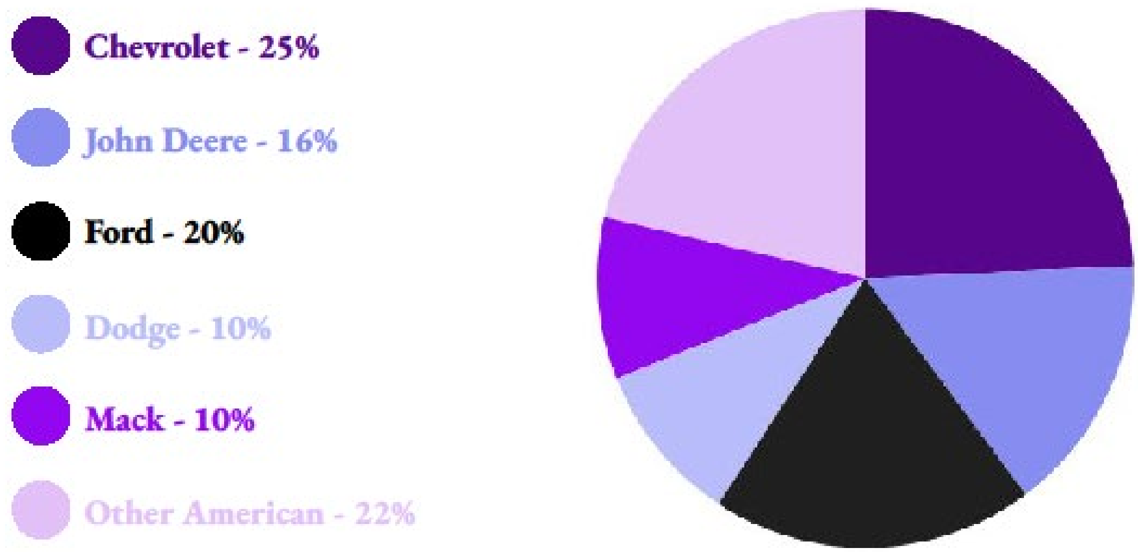


Fig. 2 Breakdown of Municipal Fleet Fuel Types

Fig. 3 Breakdown of DPW Vehicle Fuel Types

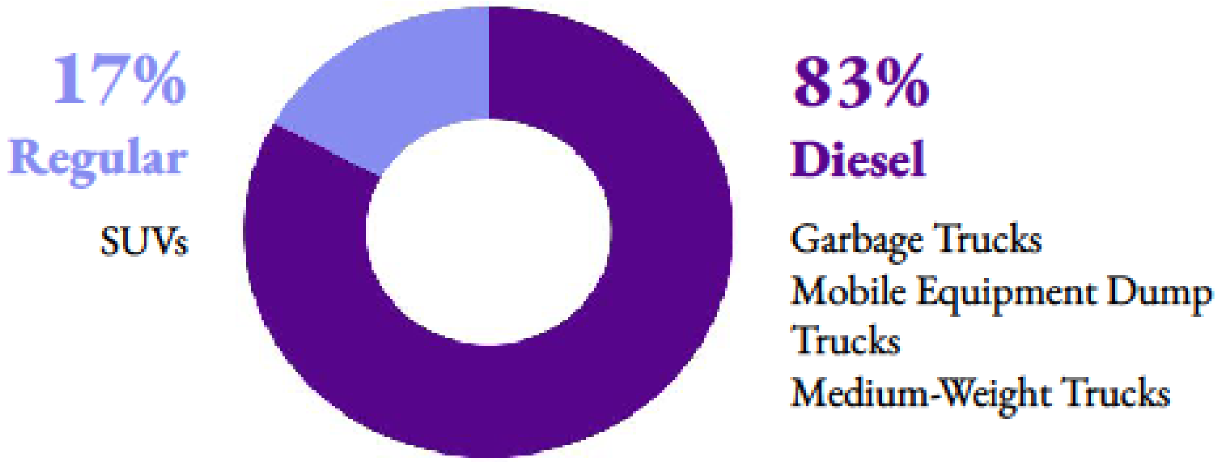


Fig. 4 Breakdown of Fire Department Vehicle Fuel Types

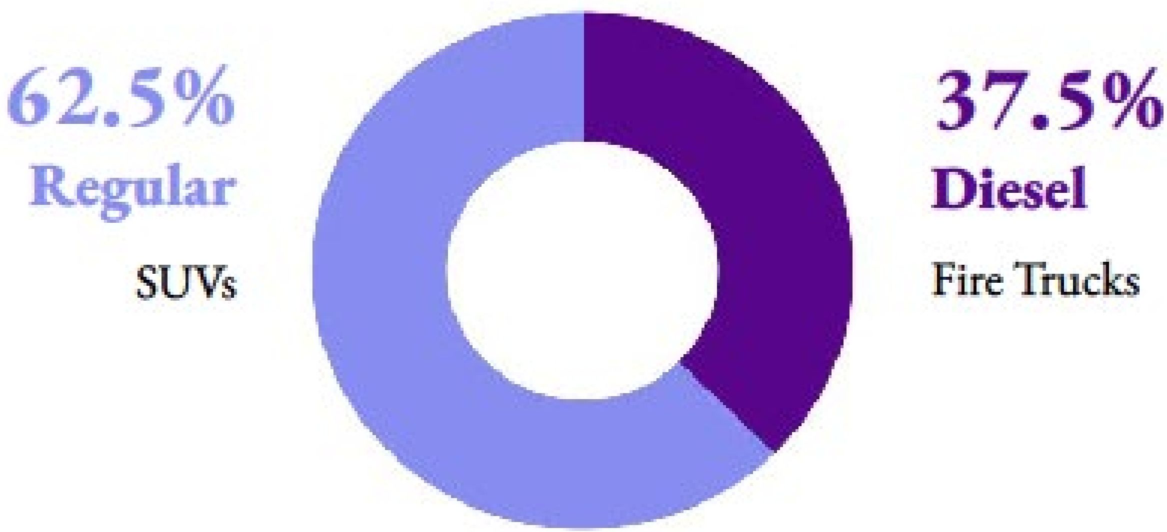


Fig. 5 Municipal Fleet Fuel Costs by Department

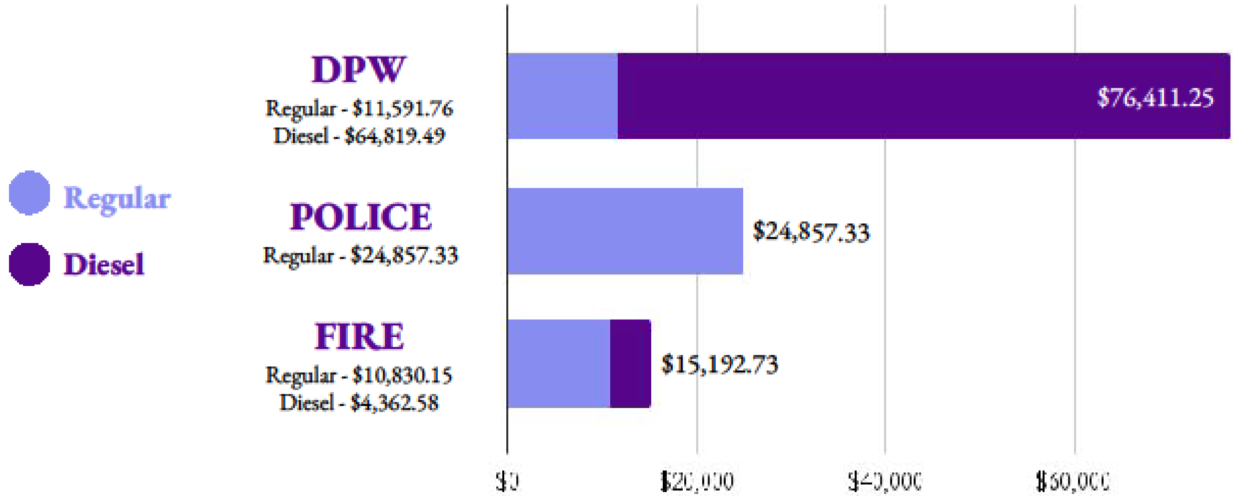


Fig. 6 Average Municipal Vehicle Fuel Cost by Department

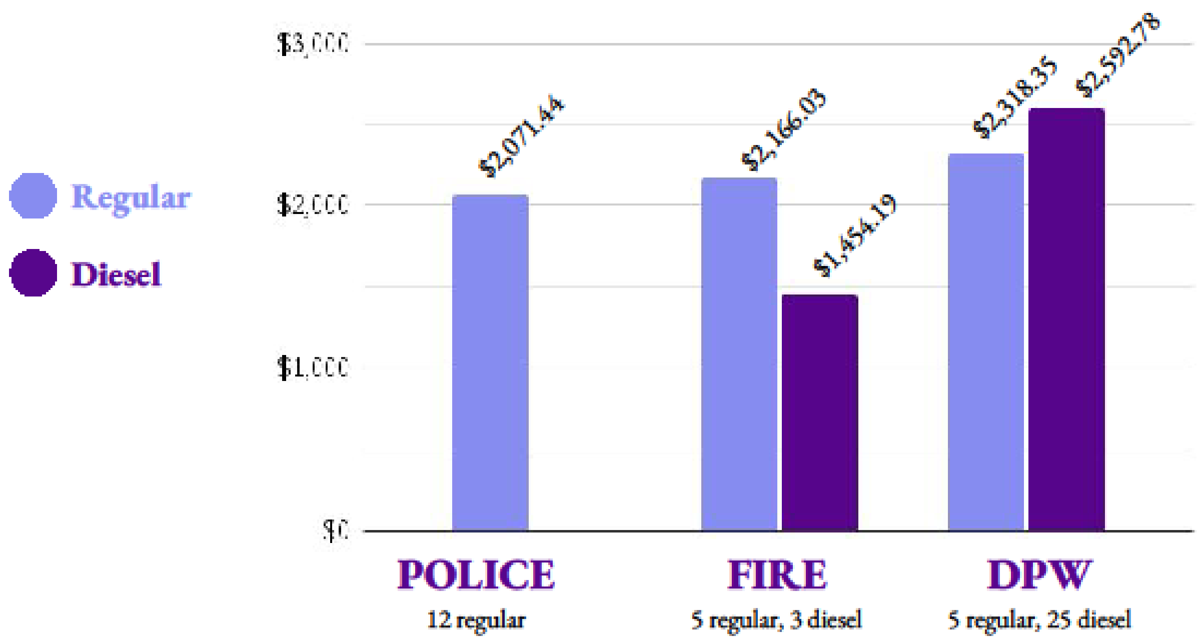


Fig. 7 Municipal Fleet Fuel Used by Department

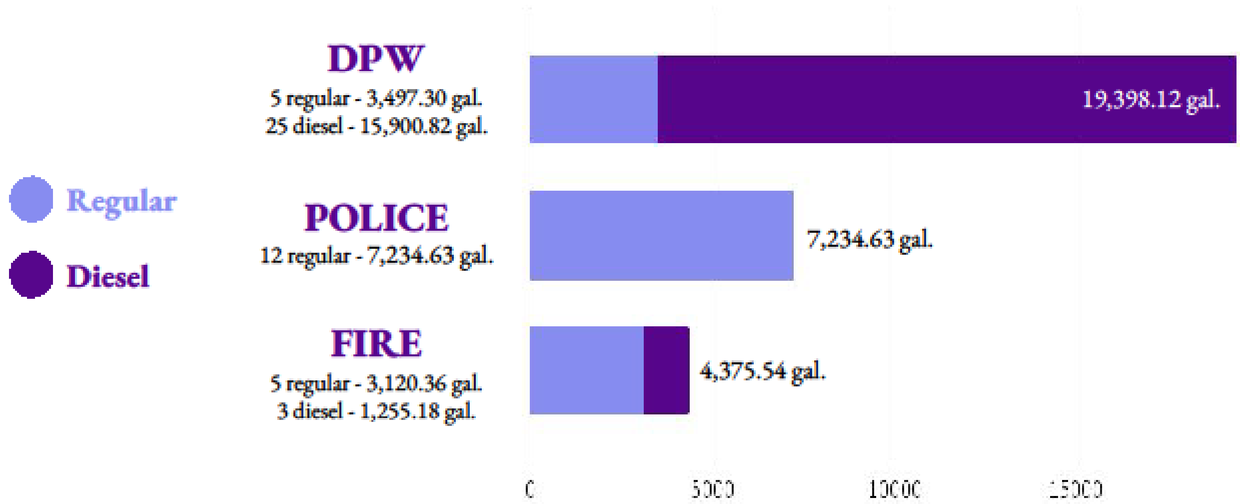


Fig. 8 Average Municipal Vehicle Fuel Use by Department

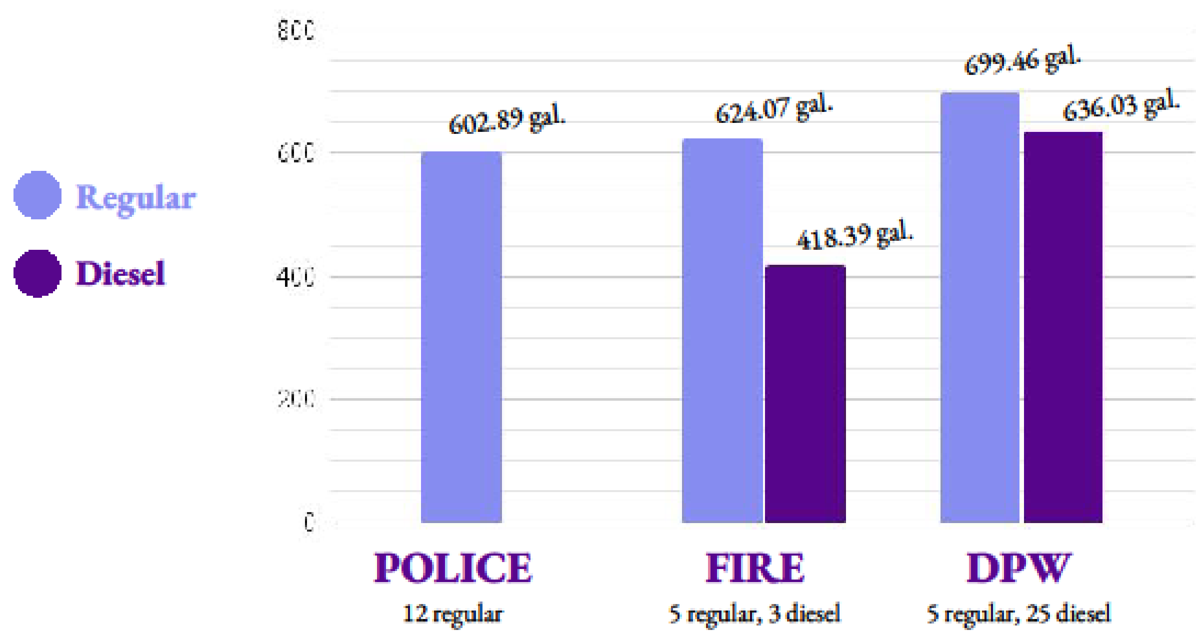


Fig. 9 Breakdown of Village Municipal Emissions

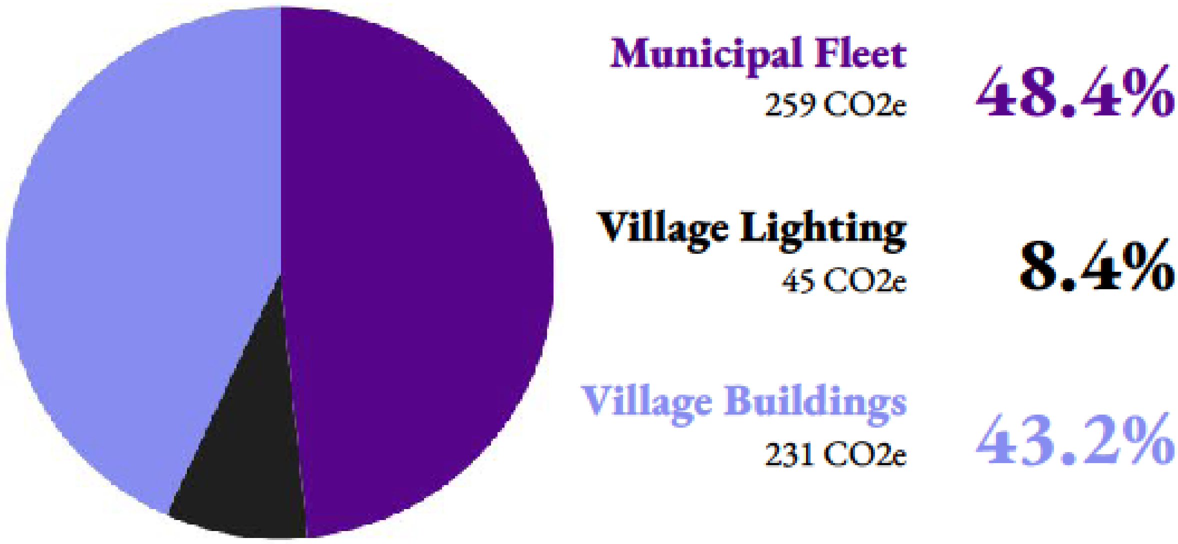


Fig. 10 Municipal Fleet Emissions by Department

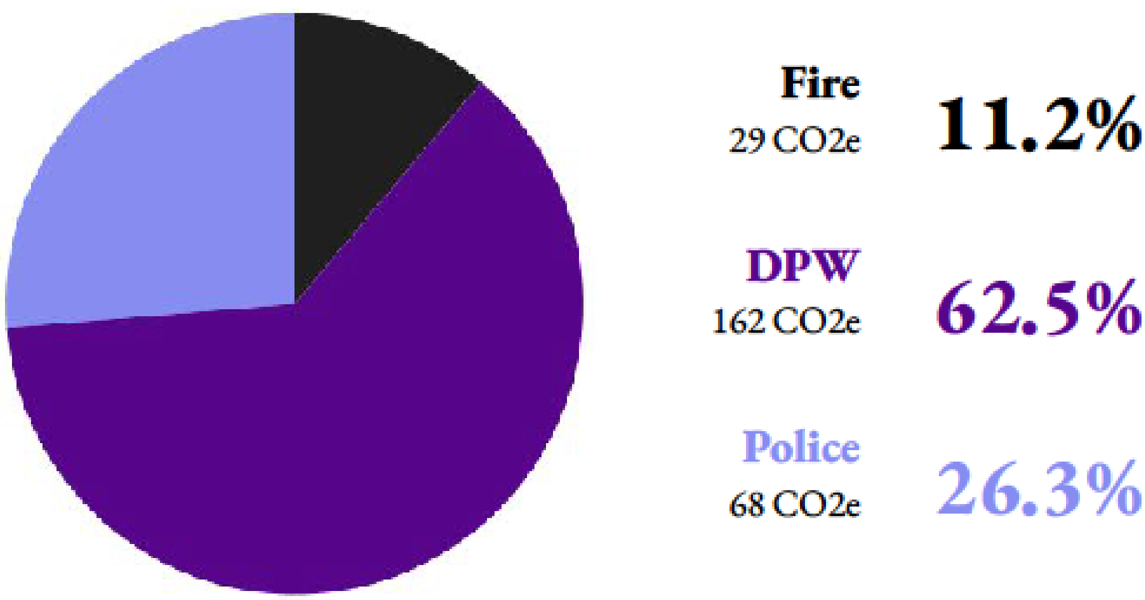
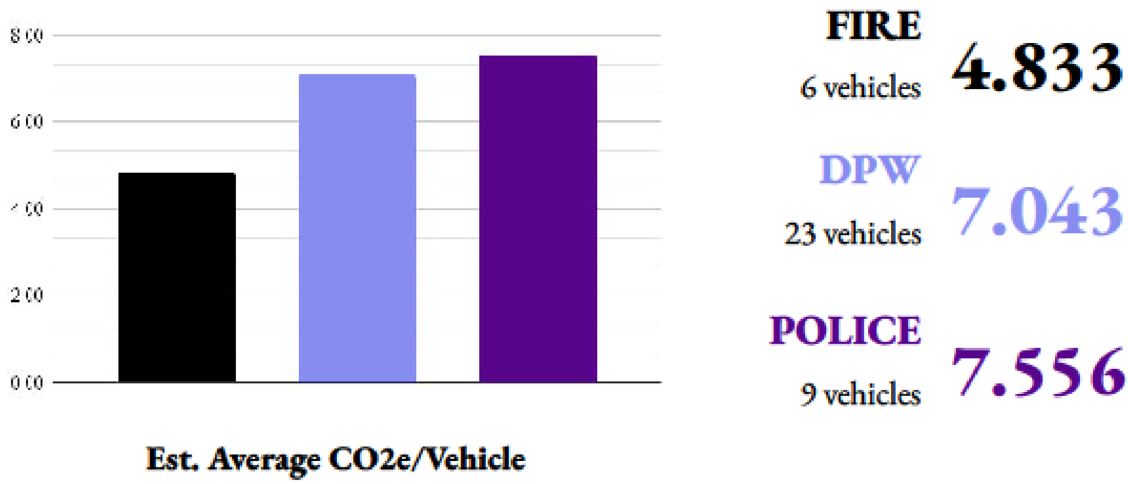


Fig. 11 Average Municipal Vehicle Emissions by Department



Appendix VI. Cost Benefit Analysis

CBA Calculations for Replacement of 4 vehicles

	Present Value with 3,5% discount rate	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Benefits												
Benefit #1 - Avoided investment in traditional vehicles	$319,760	$319,760										
Benefit #2 - Fuel savings	$81,442		$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793
Benefit #3 - Maintenance costs avoided	$37,431		$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501
Benefit #4 - Social Cost of Carbon	$8,772		$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877
Benefit #5 - Health benefits from emission reduction of PM2,5	$8,067		$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970
Total Benefits	$455,473	$319,760	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348
Costs												
Cost #1 - Upfront costs	**$260,000**	**$260,000**	$ -									
Cost #2 - Construction Costs	$14,400	$14,400										
Cost #3 - Maintenance Costs	$31,855		$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830
Cost #4 - Charging costs	$12,036		$1,447	$1,447	$1,447	$1,447	$1,447	$1,447	$1,447	$1,447	$1,447	$1,447
Total Costs	$318,291	$274,400	$5,277	$5,277	$5,277	$5,277	$5,277	$5,277	$5,277	$5,277	$5,277	$5,277

Benefit/Cost Ratio	1.43
Net Present Value	$137,182

Sensitivity Analysis: Best and worst case scenario

PART B: WORST CASE

	Present Value with 3,5% discount rate	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Benefits												
Benefit #1 - Avoided investment in traditional vehicles	$319,760	$319,760										
Benefit #2 - Fuel savings	$81,442		$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793
Benefit #3 - Maintenance costs avoided	$37,431		$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501
Benefit #4 - Social Cost of Carbon	$8,772		$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877
Benefit #5 - Health benefits from emission reduction of PM2,5	$8,067		$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970
Total Benefits	$455,473	$319,760	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348
Costs												
Cost #1 - Upfront costs	$260,000	$260,000	$ -									
Cost #2 - Construction Costs	**$20,400**	**$20,400**										
Cost #3 - Maintenance Costs	$31,855		$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830
Cost #4 - Charging costs	**$52,155**		**$6,271**	**$6,271**	**$6,271**	**$6,271**	**$6,271**	**$6,271**	**$6,271**	**$6,271**	**$6,271**	**$6,271**
Total Costs	$364,410	$280,400	$10,101	$10,101	$10,101	$10,101	$10,101	$10,101	$10,101	$10,101	$10,101	$10,101

Benefit/Cost Ratio	1.25
Net Present Value	$91,063

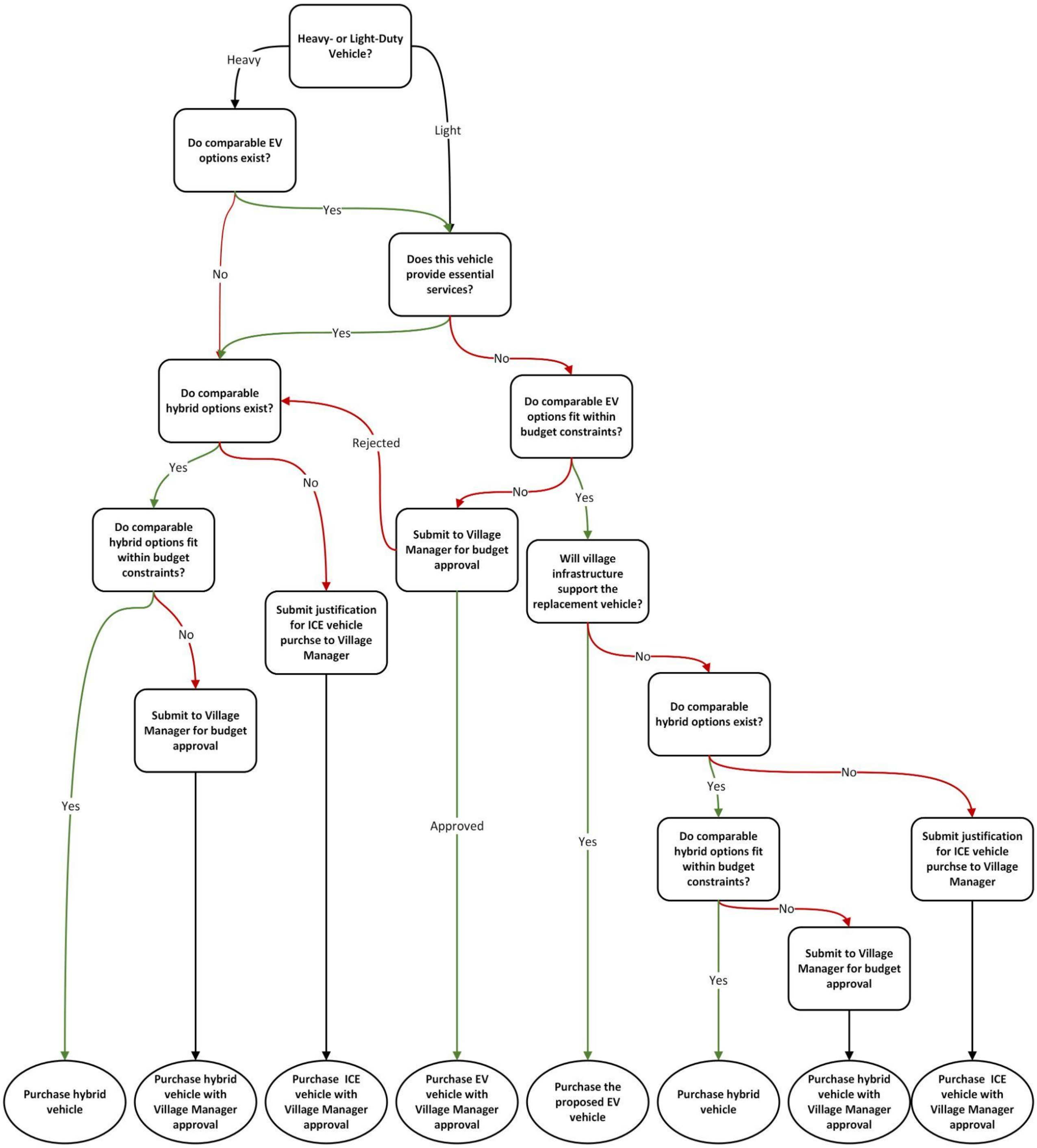
PART C: BEST CASE

Extreme case Sensitivity analysis: BEST CASE

	Present Value with 3,5% discount rate	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Benefits												
Benefit #1 - Avoided investment in traditional vehicles	$319,760	$319,760										
Benefit #2 - Fuel savings	$81,442		$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793	$ 9,793
Benefit #3 - Maintenance costs avoided	$37,431		$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501	$ 4,501
Benefit #4 - Social Cost of Carbon	$8,772		$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877	$ 877
Benefit #5 - Health benefits from emission reduction of PM2,5	$8,067		$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970	$ 970
Total Benefits	$455,473	$319,760	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348	$ 6,348
Costs												
Cost #1 - Upfront costs	**$240,000**	**$240,000**	**$ -**									
Cost #2 - Construction Costs	**$11,520**	**$11,520**										
Cost #3 - Maintenance Costs	$31,855		$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830	$3,830
Cost #4 - Charging costs	$12,036		$1,447	$1,447	$1,447	$1,447	$1,447	$1,447	$1,447	$1,447	$1,447	$1,447
Total Costs	$295,411	$251,520	$5,277	$5,277	$5,277	$5,277	$5,277	$5,277	$5,277	$5,277	$5,277	$5,277

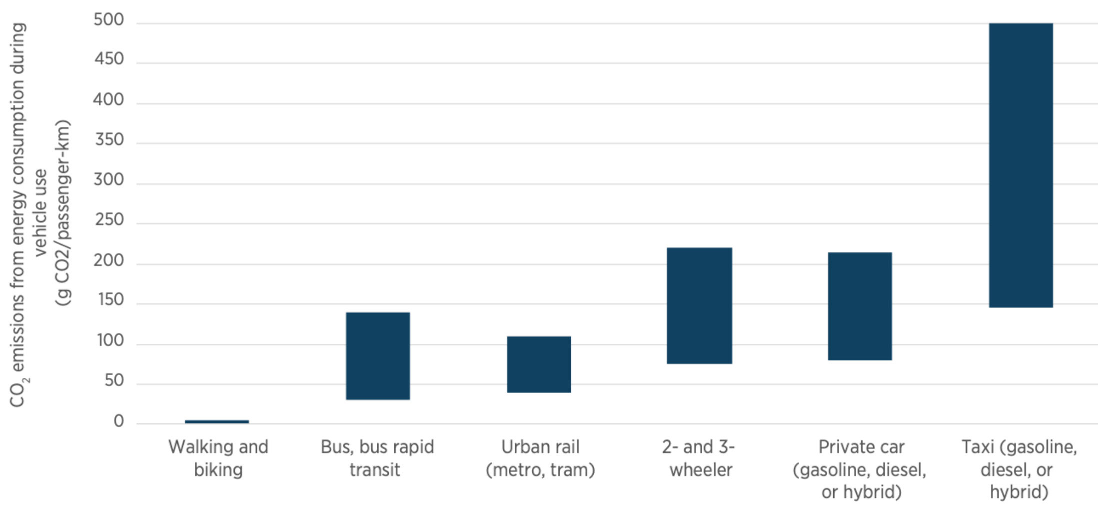
Benefit/Cost Ratio	1.54
Net Present Value	$160,062

Appendix VII. Vehicle Purchase Decision Tree



Appendix VIII. Carbon Efficiency of Modes of Transportation[107]

Figure 1. Relative carbon efficiency of urban passenger transport modes



Source: Adapted from Figure 8.6 (Sims et al., 2014).

Note: Ranges provide indication of CO_2 emissions from fuel combustion (and electricity in the case of urban rail). They exclude emissions arising from vehicle manufacture, infrastructure, and other sources of emissions included in lifecycle analyses.

Appendix IX. Funding Opportunities

ENTITY	PROGRAM LINK
Climate Mayors Collaborative	Electric Vehicle Purchasing Collaborative
Con Edison	SmartCharge
Con Edison	Power Ready Program
New York Power Authority	Evolve NY
NY Department of Environmental and Conservation	Climate Smart Communities
NY Department of Environmental Conservation	Municipal Zero-Emission Vehicle Program
NY Department of Taxation and Finance	Public and Workplace Charging Tax Credit
NY Department of Transportation	Congestion Mitigation and Air Quality Program
NY Power Authority	HVAC
NY Energy Research and Development Authority	Charge Ready NY
NY Energy Research and Development Authority	Drive Clean Rebate for Electric Cars
NY Energy Research and Development Authority	Clean Transportation Program
NY Energy Research and Development Authority	Truck Voucher Incentive Program
Sustainable Westchester	Commercial Clean Heating & Cooling Program
The Joint Utilities of New York	EV Make Ready Program
UGE International	Community Solar Project
US Department of Transportation	Zero Emission Grant Program
US Department of Transportation	Electric Vehicle Formula Program
US Department of Transportation	Rebuilding America's Infrastructure with Sustainability and Equity
US Department of Transportation	Carbon Reduction Program
US Department of Transportation	Congestion Mitigation and Air Quality Program
US Department of Transportation	Safe Streets for All Program
US Department of Transportation	Transportation Alternatives Program
US Environmental Protection Agency	Energy Star Program

Appendix X. Summary of Fleet Usage of IRT[108]

Fleet Type	Fleet Name	IRT Type	Functions Fleet Requires While Stationary	Functions IRT Provides	IRT Electric HVAC Available?	IRT Electric HVAC Selected?	New or Retrofit
Fire	Poulsbo Fire Dept. (WA)	Diesel APU	Engine stop while vehicle is stationary; electric power for lights, radios, and other electrical equipment	Same, except HVAC because baseline vehicle already has	No	n/a	New, retrofit is an option
Fire	U.S. Air Force Civil Engineer Center	Diesel APU	Engine stop while vehicle is stationary; electric power for lights, radios, and other electrical equipment	Same, except HVAC because baseline vehicle already has	No	n/a	New, retrofit is an option
Ambu-lance	Poulsbo Fire Dept. (WA)	Lead-Acid Battery APU	Engine stop while vehicle is stationary; electric power for lights, radios, HVAC for ambulance body, and other electrical equipment	Same, except HVAC because baseline vehicle already has	No	n/a	New, retrofit is an option
Ambu-lance	Austin- Travis County EMS (TX)	Lead-Acid Battery APU	Engine stop while vehicle is stationary; electric power for lights, radios, HVAC for ambulance body, and other electrical equipment	Same, except HVAC because baseline vehicle already has	No	n/a	New, retrofit is an option
Ambu-lance	Vermont DEC (VT)	EPS	Engine stop while vehicle is stationary; electric power for lights, radios, HVAC for ambulance body, and other electrical equipment	Same	Yes	Yes	n/a
Police	Raleigh Police Dept. (NC)	Lead-Acid Battery APU	Engine stop while vehicle is stationary; electric power for lights, radios, and other electrical equipment	Same	No	No	Retrofit, new is an option
Police	City of Dallas Police Dept. (TX)	Lead-Acid Battery APU	Engine stop while vehicle is stationary; electric power for lights, radios, HVAC, and other electrical equipment	Same, except for HVAC	Yes	No	Retrofit, new is an option
Police	U.S. Border Patrol (AZ)	Lithium- Ion Battery APU	Engine stop while vehicle is stationary; electric power for lights, radios, HVAC , and other electrical equipment	Same	Yes	Yes	New, retrofit is an option
Police	Tusca- loosa Police Depart- ment (AL)	Lithium- Ion Battery APU	Engine stop while vehicle is stationary; electric power for lights, radios, HVAC (cooling and heating), and other electrical equipment	Same	Yes	Yes	New, retrofit is an option
Police	Santa Barbara County Sheriff's Office (CA)	Managed Engine Stop/ Start Systems	Engine stop while vehicle is stationary; electric power for lights, radios, and other electrical equipment	Same	No	n/a	Retrofit

Appendix XI. Common Terms & Abbreviations

ABBREVIATION	DEFINITION
AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation tool (Argonne National Laboratory)
APU	Auxiliary Power Unit
ASTM	American Society for Testing and Materials
CBA	Cost-benefit Analysis
CMAQ	Congestion Mitigation and Air Quality Program
CO2e	Carbon Dioxide Equivalent
ConEd	Consolidated Edison
COPD	Chronic Obstructive Pulmonary Disease
DCFC	Direct Current Fast Charger
DEC	New York State Department of Environmental Conservation
DEQ	Diesel Emissions Qualifier (EPA)
DOE	United States Department of Energy
DOT	United States Department of Transportation
DPW	Village of Ardsley, Department of Public Works
EPA	United States Environmental Protection Agency
EPS	Electrified Parking Spaces
EUV	Electric Utility Vehicle
EV	Electric Vehicle
GHG	Greenhouse Gas
HD	Heavy-Duty Vehicle
HVAC	Heating, Ventilation, and Air Conditioning
ICCT	International Council on Clean Transportation
IRT	Idle Reduction Technology
kWh	Kilowatt-Hour
LD	Light-Duty Vehicle
LED	Light Emitting Diode
MD	Medium-Duty Vehicle
MT	Metric Ton
MV	Megavolts
NRDC	Natural Resources Defense Council
NYC	New York City
NYPA	New York Power Authority

NY or NYS	New York State
NYSEG	New York State Electric & Gas
NYSERDA	New York State Energy Research and Development Authority
PM 2.5	Fine particles or particulate matter 2.5 microns or less in width
PSE&G	Public Service Electric & Gas Company
RD	Renewable Diesel
SCC	Social Cost of Carbon
SUV	Sport Utility Vehicle
TCO	Total Cost of Ownership
VIN	Vehicle Identification Number
VTCCC	Vermont Clean Cities Coalition
WHO	World Health Organization
XFC	Extreme Fast Chargers
ZEV	Zero-Emission Vehicle program
$	United States Dollars

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