85% Decarbonization by 2050 Plan
for
The Town of Athol's
Municipal Facilities and Operations
June 1, 2022

Town of Athol
Municipal Facilities and Operations Decarbonization Plan
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Town of Athol,

Thank you for the opportunity to help develop a path for Athol to decarbonize its municipal facilities and operations. With financial assistance from the MA Department of Energy Resources (MA DOER), the Montachusett Regional Planning Commission (MRPC) has prepared the following municipal decarbonization plan for the Town of Athol's facilities and operations.

The plan was developed by MRPC and its consultant John Snell LLC who are solely responsible for the accuracy of this report. We have worked closely with Eric Smith and town staff to confirm the information in this report and to shape the timing and scale of potential activities designed to meet the state's 2030 and 2050 decarbonization goals.

The process that we followed to produce this report included:

1. Prepared a preliminary carbon emission assessment
2. Developed a preliminary set of recommendations and timeline to meet the state's decarbonization goals
3. Reviewed the draft recommendations and timeline with town staff, management, and committees
4. Prepared a final draft report and providing Athol with the supporting analysis files for future reference

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Executive Summary

Athol received a climate change planning grant from the Department of Energy Resources (MA DOER) in 2021. The grant included assistance from the Montachusett Regional Planning Commission (MRPC) to assess next steps for Athol to align the town's municipal facilities and operations with the state's net zero (85% decarbonization) goal by 2050.

Athol's municipal facilities and operations emit about 807 metric tons of CO2 equivalent (MTonsCO2e) greenhouse gas emissions per year. The two primary sources of carbon emissions that we identified for Athol's municipal facilities and operations are fuel combustion for heating and domestic hot water (DHW) and the town's vehicles.

MRPC recommends that Athol plan to convert all town facility heat and hot water systems to high efficiency electric heat pumps. In addition, MRPC recommends that Athol replace of its town vehicles to electric vehicles.

Next steps include:

1. Assign two task groups to review and identify financial support and specific equipment recommendations for these projects
2. Ratify a schedule of electric conversions based on the task group recommendations
3. Request town meeting approval for the task group recommendations and associated actions required

Athol's Decarbonization Road Map

Athol's municipal facilities and operations emit about 807 mTonsCO2e[1] greenhouse gas emissions per year. The two primary sources of carbon emissions that we identified for Athol's municipal facilities and operations were fuel combustion for heating and domestic hot water (DHW) and the town's vehicles. Athol procures 100% renewable energy electricity generation. Recommendations to reduce carbon emissions from these sources include:

1. Convert heating and domestic hot water (DHW) systems from fuel to high efficiency electricity
2. Convert town vehicles from internal combustion engines to electric motors

This approach focusses on fossil fuel replacement with electric equipment. However, converting heavy equipment like highway department dump trucks and fire department fire trucks to electric is not realistic in the near term. Unknown technologies like hydrogen or biodiesel might be better solutions longer term for heavy equipment.

The following sections detail our findings and specific recommendations for these three areas.

Appendices A-E include detailed facility-by-facility and vehicle-by-vehicle carbon emissions, potential energy savings, fuel reductions, conversion costs, electricity use increases, and local renewable energy opportunities.

[1] Metric tons of carbon dioxide equivalent

Heating and Domestic Hot Water

Athol has 10 facilities with about 139,943 square feet that burn oil and propane for heat and domestic hot water (DHW). Schools are not included in this list because Athol's students attend a regional school district.

Total fuel energy use for these facilities in fiscal year 2019[2] included:

- Oil – 33,125 gallons
- Propane – 13,416 gallons

This energy use is equivalent to about 4,542 MMBtu[3]. In addition, these facilities consumed about 622,802 kWh of electricity which is equivalent to about 2,125 MMBtu[4].

In addition, Athol has municipal water and wastewater facilities with about 18,406 square feet that burn oil and propane for heat and DHW. We've separated these facilities from the other facilities because of their high electricity use. Total energy use for the water and wastewater facilities in fiscal year 2019 included:

- Oil – 6,964 gallons
- Propane – 626 gallons

This energy use is equivalent to about 1,025 MMBtu. These facilities consumed about 1,655,041 kWh of electricity which is equivalent to about 5,647 MMBtu.

Energy Efficiency Projects

Energy efficiency investments are the most cost-effective solution to reduce total energy use in Athol's facilities. Energy efficient buildings are often more comfortable, durable, and healthier to work in than less efficient buildings. In addition, energy efficient buildings require smaller heating systems and are less susceptible to high energy use and cost spikes caused by extreme weather or other energy-related conditions than less efficient buildings.

A reasonable high performance energy target for new construction is about 25 kBtu[5] per square foot for all energy use including electricity. This metric is termed energy use intensity (EUI). We used this value to identify potential energy efficiency opportunities for buildings with heating and DHW EUIs higher than 25 kBtu/SF. These measures can be implemented as part of scheduled building maintenance and/or major renovation and rehabilitation investments.

Table 1 (on the next page) includes the energy savings assumptions and target implementation dates for the potential energy efficiency opportunities that we identified. Three projects at Town Hall, the Senior Center, and the Upton Fire Station are already underway. Please refer to Appendix C for additional detail.

[2] We selected FY2019 utility data for the baseline energy conditions because FY2019 was the last full year pre-COVID19.
[3] Million British Thermal Units
[4] All utility and facility data is from MassEnergyInsight
[5] Thousand British Thermal Units

Facility name	Gross Floor Area (SF)	FY 2019 Heat/DHW (MMBtu)	FY 2019 Heat/DHW (kBtu/SF)	Target Heat/DHW (kBtu/SF)	Heat/DHW Reduction (%)	Target Efficiency Project Date (Year)
Town Hall	30,507	1,671	55	50	9%	2025
Police Station	22,500	430	19	19	0%	
Highway Garage	21,463	802	37	37	0%	
Library Building	20,068	-	0	0	0%	
Animal Control Facility	11,030	107	10	10	0%	
Downtown Fire Station #1	10,700	63	6	6	0%	
Senior Center	9,000	529	59	50	15%	2025
MREC-100 Main Street	7,200	171	24	23	3%	
Uptown Fire Station #2	5,300	515	97	85	13%	2025
Mechanics Shop	2,175	196	90	70	22%	
Total	139,943	4,484				

Table 1. Energy efficiency project assumptions and savings

Energy efficiency investments require close coordination with related building renovations and upgrades. Athol will need to request and review more detailed energy engineering assessments to identify specific energy efficiency recommendations as part of these projects. The incremental cost for high performance building best practices should be about 10% or less of total project costs for new construction. Please refer to Appendix C for additional energy efficiency documentation.

Fuel to Electricity Conversions

Converting Athol's buildings from fuel combustion to high efficiency electric heating and domestic hot water equipment is key to the town's decarbonization efforts. Carbon emission rates will remain high until this equipment is replaced.

Table 2 lists very preliminary estimated replacement cost[6] for the existing equipment and the estimated cost per ton[7] to install three alternative types of high efficiency electric heat pump equipment[8]. The estimated standard replacement cost assumes $100,000 per MMBtu to replace an existing boiler with the same type of boiler. Please refer to Appendix D for additional detail.

Facility name	Gross Floor Area (SF)	Estimated Standard Replacement Cost ($)	$10,000 Ductless Cost ($)	$16,000 VRF Cost ($)	$26,000 Ground Cost ($)
Town Hall	30,507	106,775	593,192	949,107	1,542,298
Police Station	22,500	78,750	437,500	700,000	1,137,500
Highway Garage	21,463	75,121	417,336	667,738	1,085,074
Library Building	20,068	70,238	390,211	624,338	1,014,549
Animal Control Facility	11,030	38,605	214,472	343,156	557,628
Downtown Fire Station #1	10,700	37,450	208,056	332,889	540,944
Senior Center	9,000	31,500	175,000	280,000	455,000
MREC-100 Main Street	7,200	25,200	140,000	224,000	364,000
Uptown Fire Station #2	5,300	18,550	103,056	164,889	267,944
Mechanics Shop	2,175	7,613	42,292	67,667	109,958
Total	139,943	$489,801	$2,721,114	$4,353,782	$7,074,896

Table 2. Estimated fuel conversion equipment costs

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

[6] The replacement cost for existing equipment assumes $100,000 per MMBTU heating output.

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

[8] Actual equipment costs will vary significantly depending on site specific conditions. The emphasis here is that ductless heat pumps are significantly less expense to install than VRF and ground source heat pumps. Estimated costs per ton are from an oil-fired steam retrofit to high efficiency electric conversion engineering analysis for an historic city hall.

The third heat pump option is ground-source heat pumps (Ground) sometimes referred to as geothermal. Ground-source heat pumps require a large water source in the form of a pond, stream, or well. Ground source heat pumps are used both in residential and commercial applications.

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

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

Domestic hot water conversion options include solar, heat pump, and electric resistance water heating systems. Solar and hybrid heat pump domestic hot water systems are better for high-use municipal systems such as school kitchens. Small well insulated electric resistance or heat pump domestic hot water systems are better for low-use municipal settings such as rest rooms.

Vehicles

Athol has 58 vehicles and other equipment that have gasoline or diesel-powered internal combustion engines and fuel use that we've been able to document. Please refer to the Appendix E for a complete list of these vehicles and equipment[9]. Total energy use for these vehicles in fiscal year 2019 was:

- Gasoline – 16,678 gallons
- Diesel – 23,881 gallons

This fuel use is equivalent to about 5,628 MMBtu. Individual vehicle fuel use was unavailable for this report. For the purposes of this report, we estimated the average gasoline and diesel fuel use per vehicle.

Light-Duty Vehicles

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

Heavy-Duty Vehicles

Heavy-duty vehicles are the primary source of diesel fuel consumption. Few affordable electric-powered vehicles exist to replace the town's heavy-duty vehicles. In addition, heavy-

[9] Data source: 2019 Town vehicle insurance records

duty vehicles provide services such as around-the-clock snowplowing that may be challenging for electric-powered vehicles to provide.

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

Charging Stations and Load Management

Part and parcel with converting vehicles from fuel to electricity, Athol needs to anticipate how to pay for, locate, and manage associated electric charging stations. Athol will need to purchase and place electric charging stations in convenient locations and get approval to connect them to the utility grid. Vehicles that Athol should consider with its electric charging station deployment include town-owned vehicles, town staff-owned vehicles, and town resident-owned vehicles.

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

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

Electricity

Athol uses electricity for its buildings, water and wastewater facilities, other structures, streetlights, and other services. Total municipal facility and operations electricity purchased from National Grid in fiscal year 2019 was about 2,664,219 kWh or about 7,772 MMBtu.

Electricity that Athol customers purchase from National Grid include electricity generated from fossil-fuel and multiple grades of renewable energy electrical generation plants. National Grid's electricity generation sources in 2019 were 80% fossil fuel (mostly natural gas) and 20% renewable energy.

Table 3 (on the next page) summarizes the projected increase in the default electricity supply that utility companies must provide customers. State legislation requires National Grid to increase the percent of renewable energy generation 2% each year until 2029 when the increase is reduced to 1% each year. The state added a formulaic (starting at 20%) clean existing generation standard in 2021. Other electricity suppliers offer higher levels of renewable energy.

Year	Total	Class I	Class II	Class II Biomass	Estimated CES-E
2019	20.2%	14.0%	2.7%	3.5%	
2025	54.1%	26.0%	3.6%	3.5%	21.0%
2030	63.1%	35.0%	3.6%	3.5%	21.0%
2035	68.1%	40.0%	3.6%	3.5%	21.0%
2040	73.1%	45.0%	3.6%	3.5%	21.0%
2045	78.1%	50.0%	3.6%	3.5%	21.0%
2050	83.1%	55.0%	3.6%	3.5%	21.0%

Table 3. Renewable Energy Portfolio Standard[10].

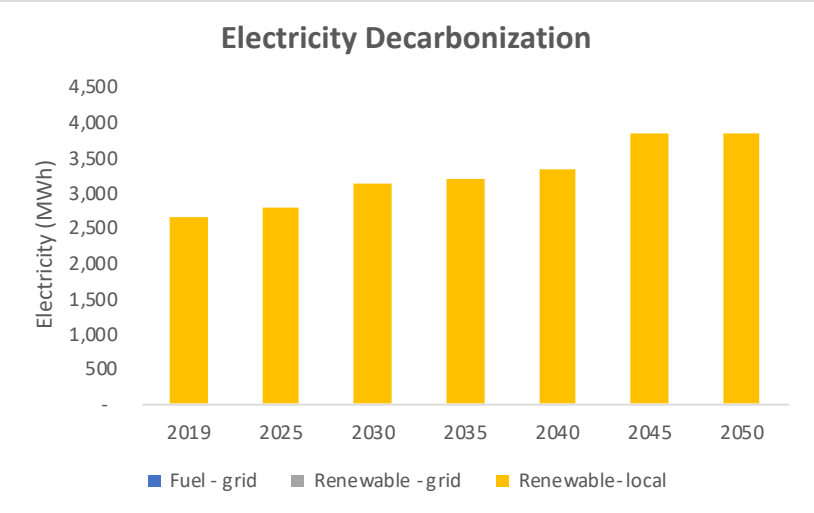
However, renewable energy generation supports 100% of municipal electricity consumption by the Town of Athol, through onsite generation by a 24-kW solar PV system at the Athol Public Library, which began producing solar energy in September 2015, and through the purchase of net metering credits from a 3.4MW solar PV array at Dunroamin Country Club in Hardwick, MA, a project built in response to a public procurement in 2010[11].

We project that the total electricity use by Athol's facilities and operations will increase by about 44% by 2050. This includes additional electricity use for proposed electric heating and DHW fuel to electric conversions and proposed vehicle fuel to electricity conversions. It also takes into consideration proposed energy efficiency projects. Other variables that will affect future electricity use include the economy and the electricity industry's historic 3% per year increase. Recent events and technologies have disrupted and will most likely continue to disrupt small, predictable annual electricity use increases.

Grid Electricity

We assume that the source of Athol's municipal electricity will continue to be 100% renewable energy from local renewable generation by 2050. Athol will continue to connect to the local and regional ISO NE[12] electric grid but the source of electricity will continue to be from local sources.

Figure 1 summarizes our forecast for Athol's electricity use through 2050.



[10] Per H3708. See https://www.cityofbostoncce.com/ma-renewable-energy-requirement/ for more detail.

[11] The land lease between the solar vendor and Dunroamin Country Club has a 25-year term plus two options to renew for five years each. The agreement was originally dated in 2013. The town's solar power purchase agreement is for 25-year term from the commercial operation date. The town is currently in year 6 or 7 of the contract.

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

Figure 1. Projected electricity load and fuel mix

Athol plans to construct two ground-mounted local renewable energy solar PV initiatives constructed in 2035. The two installations would be located on the former landfill and at the wastewater treatment plant.

Local Renewable Electricity

Table 4 identifies current and potential solar PV installation locations on town facilities, town-owned land, and independent power purchase agreements.

Facility name	Available Roof Area (SF)	Available Land Area (Acres)	Estimated Solar PV Peak Output (kW)	$3,496 < 250 kW Roof ($)	$5,000 < 1 MW Parking ($)	$1,500 <1 MW Ground ($)	$1,200 >1 MW Ground ($)	Total Solar PV ($)	Solar Electric kWh	Target Installation Date (Year)
Town Hall	6,101		18.4	64,430				64,430	23,498	2025
Police Station	4,500		13.6	47,520				47,520	17,331	2030
Highway Garage	4,293		13.0	45,330				45,330	16,532	2030
Library Building			20.0					-	25,500	2015
Animal Control Facility	2,206		6.7	23,295				23,295	8,496	2030
Downtown Fire Station #1	2,140		6.5	22,598				22,598	8,242	
Senior Center	1,800		5.4	19,008				19,008	6,932	
MREC-100 Main Street	1,440		4.3	15,206				15,206	5,546	
Uptown Fire Station #2	1,060		3.2	11,194				11,194	4,082	
Mechanics Shop	435		1.3	4,594				4,594	1,675	2040
school parking lots		2.0	263.2		1,315,789			1,315,789	335,526	
3.4 MW Hardwick PV		-	-		-			-	-	2010
Athol Landfill PPA		12.0	1,578.9				1,894,737	1,894,737	2,013,158	2035
Wastewater PPA		2.0	263.2			394,737		394,737	335,526	2035
	23,975	16.0	2,132.7	$253,175	$1,315,789	$394,737	$1,894,737	$3,858,438	2,802,046	

Table 4. Solar PV costs, output, and target installation dates

Variables to consider regarding grid-level renewable energy procurement include class, source (local, regional, or national), and renewable energy credit (REC) status. Class I local renewable energy that have not sold the renewable energy credits are the highest quality. Athol can consider transitioning from "lower quality" to "high quality" renewable energy over time to keep grid-level renewable energy procurement more cost-effective.

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

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

We recommend that Athol prepare or hire a consultant to assess all potential solar PV sites on municipally owned or controlled land for public review. Sites to review include the rooftop, parking lot, and potential open land sites listed in Table 3. The assessment should include aerial surveys of the sites, potential electricity peak output and annual electricity generation, estimated costs, and solar site ratings.

Athol will need to stay attuned to potential grant opportunities, rapidly changing federal and state incentive programs, and the price of large-scale renewable energy installations. Current municipal sector best practice is to negotiate a solar PV power purchase agreement.

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

Net Carbon Emissions Reduction

The actions recommended in this decarbonization plan will reduce overall carbon emissions from Athol's municipal facilities and operations by about 41% in 2030 and about 96% by 2050. This gets close to the state's 50% by 2030 and exceeds the net zero (85%) by 2050 carbon reduction targets.

Carbon Emissions Reduction

Figure 2 represents Athol's carbon emissions reduction through 2050.

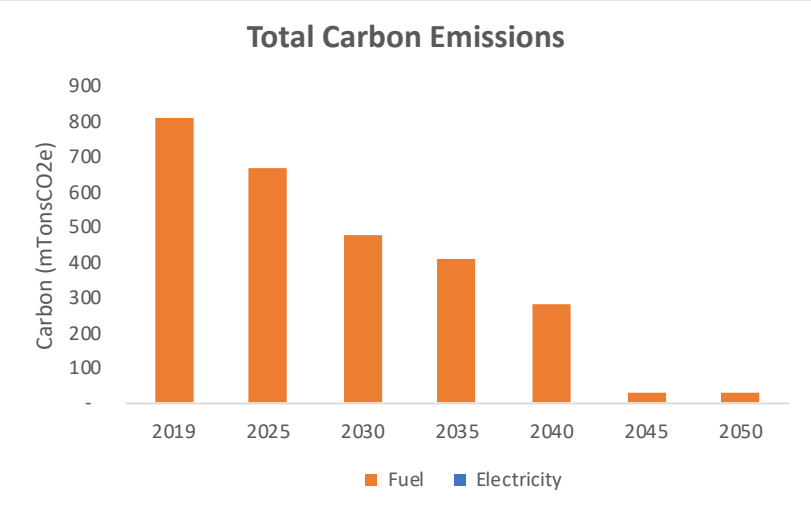


Figure 2. Total carbon emissions reduction

As figure 2 indicates, 100% of Athol's carbon emissions are currently from building and vehicle-related fuel combustion and no carbon emissions are from electricity generation fuel consumption.

Fuel-related carbon emissions will drop in close correlation with the speed and scale that Athol can convert fuel-based combustion equipment to electric-powered equipment. At the same time, Athol needs to transition to local renewable energy electricity generation.

Carbon Capture

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

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

Athol could either sell the carbon credits to offset the cost of the forest management plan and sequestration forest management tasks or not. Selling the carbon credits would allow a buyer the opportunity to continue emitting carbon but offset the emissions with Athol's carbon sequestration efforts. MA Audubon is the best resource to contact for more information and regional examples of successful projects. and qualify for in-house or voluntary carbon market credits.

Next Steps

1. Share the roadmap with Athol's technical and financial partners at MA DOER and MRPC

The Green Communities program run by MA DOER is the primary conduit between municipalities and the state's decarbonization efforts. Share this roadmap with its Green Community Regional Coordinator is an opportunity to help inform the state how Athol and other community's decarbonization efforts align with the state's 2050 plan. MRPC can assist with this communication.

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

a. Buildings

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

The reports should document each buildings current energy performance, utility bill rates and cost, existing equipment, and provide budget level cost estimates for the proposed equipment and building energy performance upgrades. The report should include examples of comparable upgrades to similar buildings in Massachusetts and lessons learned.

In addition, on a building portfolio wide basis, the town would benefit from town facility management staff agreement on preferred approaches and associated preferred technology for high efficiency electricity and energy performance upgrades. Managing buildings with different technologies and equipment is very challenging. Building controls will play an increasingly important role as the primary tool to connect multiple pieces of equipment and every changing electrical loads and manage associated electric costs. Athol should anticipate deploying a portfolio-wide building (and vehicle charging/solar PV/battery) control system. The town's budget should include regular (every 2-3 years) software and hardware updates.

b. Vehicles

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

Vehicle procurement will continue through the state's COMMBUYS program. Additional collective procurement opportunities may arise that the Green Communities program. MRPC can alert the town about

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

c. Renewable Electricity

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

2. Work closely with National Grid and Mass Save to shape, manage, and fund Athol's transition to high efficiency electric equipment and vehicles.

National Grid and Mass Save are the primary conduits for the state's renewable energy and energy efficiency project implementation support.

National Grid serves two roles in the implementation process. The first role is faciliatory. National Grid can help identify and coordinate technical and financial support that's available through Mass Save and National Grid. The second role is to help coordinate the nuts-and-bolts details of connecting proposed projects to the local electric grid.

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

Mass Save is the primary source for high efficiency project funding support. The town and all vendors will need to apply for and comply with Mass Save's programs. Athol should be aware that Mass Save's programs are reviewed and updated every three years. Financial incentives and program requirements may change from one triennial program term to another. Athol should at a minimum be aware of the incentive programs that are approved every three years. Vendors that Athol hires are responsible for requesting financial assistance and managing the documentation required for specific energy-related projects.

3. Develop a financial model to implement the roadmap

Financing and procuring the projects and equipment recommended in this roadmap will be a major challenge and test Athol's financial resiliency. The town will need to weave funding for these projects with ongoing funding requirements and financial limitations imposed on municipal governments.

Athol should charge a task force with representatives from the Business Manager's office and the Finance and Capital Planning Committees to investigate and report back on financial alternatives to support these projects. Financial alternatives should include but not be limited to municipal ownership, private ownership, and lease-to-own and related power purchase agreement options. The financial framework should be flexible enough to integrate more detailed reports

as they are developed for the proposed building, vehicle, and renewable energy projects.

4. Communicate the findings and recommendations

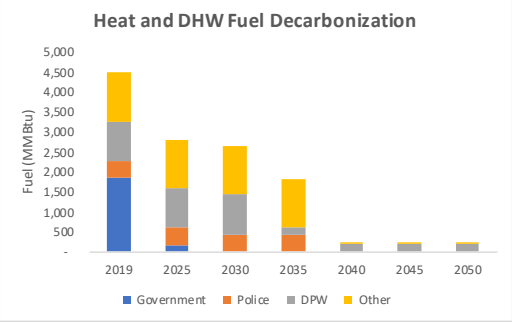
The scale of the proposed projects in this roadmap are significant. The scale of effort proposed in this roadmap reflects the urgent call for rapid change in the state's 2050 Decarbonization Roadmap[14]. Effective, transparent communication with the town's citizens, businesses, and industry will be critical to the success of these projects.

Conclusion

Athol's municipal facilities and operations emit about 807 mTonsCO2e greenhouse gas emissions per year. Methodical replacement of fuel-powered equipment with electric-powered equipment and fuel-generated electricity with local renewable energy-generated electricity provides a framework for the town reduce carbon emissions 41% by 2030 and 96% by 2050. Our report's recommendations and proposed implementation timeline balance the town's need for rapid deployment and prudent fiscal town management.

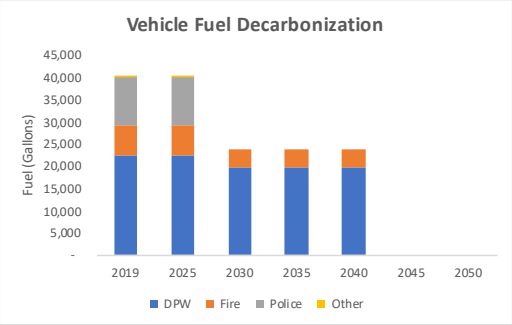
[14] https://www.mass.gov/info-details/ma-decarbonization-roadmap

Appendix A: Decarbonization Summary



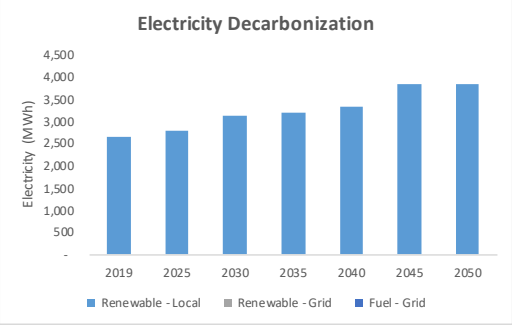
Heating and Domestic Hot Water (DHW) Fuel Decarbonization

Year (Fiscal)	Government Fuel (MMBtu)	Police Fuel (MMBtu)	DPW Fuel (MMBtu)	Other Fuel (MMBtu)	Total Fuel (MMBtu)
2019	1,842	430	998	1,214	4,484
2025	171	430	998	1,214	2,813
2030	**-**	**430**	**998**	**1,214**	**2,642**
2035	-	430	196	1,214	1,840
2040	-	-	196	63	259
2045	-	-	196	63	259
2050	**-**	**-**	**196**	**63**	**259**



Vehicle Fuel Decarbonization

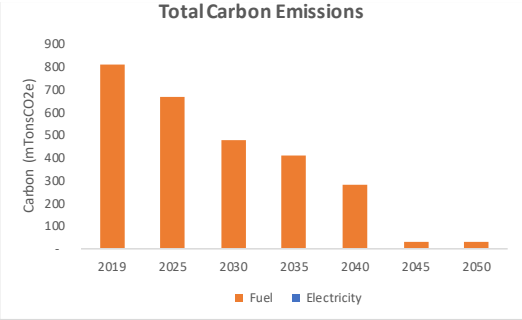
Year (Fiscal)	DPW Fuel (Gallons)	Fire Fuel (Gallons)	Police Fuel (Gallons)	Other Fuel (Gallons)	Total Fuel (Gallons)
2019	22,514	6,876	10,689	480	40,559
2025	22,514	6,876	10,689	480	40,559
2030	**19,920**	**3,961**	**-**	**-**	**23,881**
2035	19,920	3,961	-	-	23,881
2040	19,920	3,961	-	-	23,881
2045	-	-	-	-	-
2050	**-**	**-**	**-**	**-**	**-**



Grid Electricity Decarbonization

Year (Fiscal)	Fuel - Grid Electricity (MWh)	Renewable - Grid Electricity (MWh)	Total - Grid Electricity (MWh)	Renewable - Local Electricity (MWh)	Total Electricity (MWh)
2019	-	-	-	2,663	2,663
2025	-	-	-	2,797	2,797
2030	**-**	**-**	**-**	**3,139**	**3,139**
2035	-	-	-	3,210	3,210
2040	-	-	-	3,349	3,349
2045	-	-	-	3,836	3,836
2050	**-**	**-**	**-**	**3,836**	**3,836**

Appendix B: Carbon Emissions Summary



Total Carbon Emissions

Year (Fiscal)	Fuel Carbon (mTonsCO2e)	Electricity Carbon (mTonsCO2e)	Fuel (MMBTU)	Electricity Fuel (MWh)	Fuel Change (%)	Electricity Change (%)
2019	807		9,872	1,761		
2025	670		8,201	1,064	17%	
2030	**478**		**5,851**	**966**	**41%**	
2035	413		5,049	110	49%	
2040	283		3,468	130	65%	
2045	28		347	213	96%	
2050	**28**		**347**	**167**	**96%**	

Appendix C: Potential Energy Efficiency Impacts

Building floor area, energy use (MMBtu), current and target energy use (kBtu/SF), proposed project dates, and estimated building heat loss and DHW energy (MMBtu).

Facility name	Gross Floor Area (SF)	FY 2019 Electric (MMBtu)	FY 2019 Oil (MMBtu)	FY 2019 Propane (MMBtu)	FY 2019 Total (MMBtu)	FY 2019 Heat/DHW (MMBtu)	FY 2019 Heat/DHW (kBtu/SF)	Target Heat/DHW (kBtu/SF)	Heat/DHW Reduction (%)	Target Efficiency Project Date (Year)	Estimated Baseline Fuel Efficiency (%)	Estimated Building Heat/DHW (MMBtu)
Town Hall	30,507	235	1,671		1,906	1,671	55	50	9%	2025	75%	1,253
Police Station	22,500	339		430	769	430	19	19	0%		75%	323
Highway Garage	21,463	239	802		1,041	802	37	37	0%		75%	602
Library Building	20,068	824			824	-	0	0	0%		75%	-
Animal Control Facility	11,030	47		107	213	107	10	10	0%		75%	80
Downtown Fire Station #1	10,700	9		63	72	63	6	6	0%		75%	47
Senior Center	9,000	158		529	686	529	59	50	15%	2025	75%	397
MREC-100 Main Street	7,200	18	171		189	171	24	23	3%		75%	128
Uptown Fire Station #2	5,300	200	480	35	715	515	97	85	13%	2025	75%	386
Mechanics Shop	2,175	56	196		252	196	90	70	22%		75%	147
Total	139,943	2,125	3,320	1,164	6,667	4,484						3,363

Note: The estimated building heat/DHW MMBtu is the current fuel consumption in MMBtu divided by the estimated baseline heating and DHW system fuel efficiency. Shaded areas represent entries and assumptions that can be changed or adjusted.

Estimated efficiency savings potential (MMBtu)

Facility name	Gross Floor Area (SF)	2025 Efficiency Savings (MMBtu)	2030 Efficiency Savings (MMBtu)	2035 Efficiency Savings (MMBtu)	2040 Efficiency Savings (MMBtu)	2045 Efficiency Savings (MMBtu)	2050 Efficiency Savings (MMBtu)	Total Efficiency Savings (MMBtu)
Town Hall	30,507	44						44
Police Station	22,500							-
Highway Garage	21,463							-
Library Building	20,068							-
Animal Control Facility	11,030							-
Downtown Fire Station #1	10,700							-
Senior Center	9,000	24						24
MREC-100 Main Street	7,200							-
Uptown Fire Station #2	5,300	19						19
Mechanics Shop	2,175							-
Total	139,943	87	-	-	-	-	-	87

Note: The efficiency savings assume a post fuel conversion 250% heat pump efficiency

Appendix D: Facility Fuel to Electricity Conversions

Estimated standard efficiency and high efficiency costs and post conversion electricity (MMBtu) and (MWh) energy use

Facility name	Gross Floor Area (SF)	Estimated Fuel Equipment Output (MMBtu)	Estimated Standard Replacement Cost ($)	Estimated Electric Equipment Output (Tons)	Estimated Electric Efficiency (%)	$10,000 Ductless Cost ($)	$16,000 VRF Cost ($)	$26,000 Ground Cost ($)	Electric MMBtu	3.412 Electric MWh
Town Hall	30,507	1.1	106,775	59	250%	593,192	949,107	1,542,298	501	147
Police Station	22,500	0.8	78,750	44	250%	437,500	700,000	1,137,500	129	38
Highway Garage	21,463	0.8	75,121	42	250%	417,336	667,738	1,085,074	241	71
Library Building	20,068	0.7	70,238	39	250%				-	-
Animal Control Facility	11,030	0.4	38,605	21	250%	214,472	343,156	557,628	32	9
Downtown Fire Station #1	10,700	0.4	37,450	21	250%	208,056	332,889	540,944	19	6
Senior Center	9,000	0.3	31,500	18	250%	175,000	280,000	455,000	159	47
MREC-100 Main Street	7,200	0.3	25,200	14	250%	140,000	224,000	364,000	51	15
Uptown Fire Station #2	5,300	0.2	18,550	10	250%	103,056	164,889	267,944	155	45
Mechanics Shop	2,175	0.1	7,613	4	250%	42,292	67,667	109,958	59	17
Total	139,943		$489,801			$2,330,903	$3,729,444	$6,060,347	1,346	395

Projected fuel use reduction (MMbtu)

Facility name	Gross Floor Area (SF)	Target Conversion Date (Year)	2025 Heat DHW Conversion (MMBtu)	2030 Heat DHW Conversion (MMBtu)	2035 Heat DHW Conversion (MMBtu)	2040 Heat DHW Conversion (MMBtu)	2045 Heat DHW Conversion (MMBtu)	2050 Heat DHW Conversion (MMBtu)	Total Heat DHW Conversion (MMBtu)
Town Hall	30,507	2025	1,671						1,671
Police Station	22,500	2040				430			430
Highway Garage	21,463	2035			802				802
Library Building	20,068	Completed							-
Animal Control Facility	11,030	2040				107			107
Downtown Fire Station #1	10,700								-
Senior Center	9,000	2040				529			529
MREC-100 Main Street	7,200	2030		171					171
Uptown Fire Station #2	5,300	2040				515			515
Mechanics Shop	2,175								-
Total	139,943		1,671	171	802	1,581	-	-	4,225

Appendix E: Vehicle Fuel to Electricity Conversions

Diesel fuel vehicle age, replacement cost, estimated fuel use (gallons), and target electric conversion dates

Department nar	Vehicle name	Insurance Year	Insurance Cost New ($)	2025 Vehicle Conversion (Gallons)	2030 Vehicle Conversion (Gallons)	2035 Vehicle Conversion (Gallons)	2040 Vehicle Conversion (Gallons)	2045 Vehicle Conversion (Gallons)	2050 Vehicle Conversion (Gallons)	Total Vehicle Conversion (Gallons)
Fire	AFD A-1 2015 Dodge Ram Life Line Ambulance	2015	207,485					1,700		1,700
Fire	AFD A-3 2010 CHEVY G4500 AMBULANCE	2010	180,597					343		343
Fire	AFD E-1 1976 MAXIM FIRE TRUCK	1976	65,001					158		158
Fire	AFD E-2 2006 CENTRAL STATES PUMPER	2006	132,917					82		82
Fire	AFD E-3 1998 HME CENTRAL STATES FIRE TRUCK	1998	190,545					226		226
Fire	AFD E-4 2012 KME	2012	375,000					1,132		1,132
Fire	AFD L-1 2006 E-ONE LADDER TRUCK	2006	800,000					320		320
DPW	CPT C-1 07 CHEVY KODIAK DUMP TRUCK	2007	66,187					807		807
DPW	CPT C-2 2012 JCB BACKHOE	2012						84		84
DPW	CPT P-1 2019 FORD F550 DUMP TRUCK	2019						1,416		1,416
DPW	CPT P-2 2011 FORD 350	2011						604		604
DPW	CPT T-1 09 INT DUMP TRUCK	2009	108,058					294		294
DPW	CPT T-2 03 JD FLAIL MOWER	2003	78,687					614		614
DPW	HWY H-1 09 INT DUMP TRUCK	2009	100,878					794		794
DPW	HWY H-10 22 FREIGHTLINER DUMP	2022						954		954
DPW	HWY H-11 03 INT DUMP/COMBO TRUCK	2002	131,236					759		759
DPW	HWY H-12 04 INT DUMP TRUCK	2003	98,577					983		983
DPW	HWY H-15 07 INT DUMP/SLIP SANDER W/PLOW	2007	121,830					1,269		1,269
DPW	HWY H-16A 13 ELGIN PELICAN SWEEPER	2013	183,029					370		370
DPW	HWY H-17 08 JD 544J	2008	39,789					982		982
DPW	HWY H-18 13 CASE BACKHOE	2013	113,000					421		421
DPW	HWY H-19 88 JD LOADER 644E	1988	109,000					40		40
DPW	HWY H-20 84 INT CATCH BASIN	1984	35,000					139		139
DPW	HWY H-4 17 INT DUMP COMBO TRUCK	2017	161,019					990		990
DPW	HWY H-5 17 INT DUMP	2017	134,819					1,266		1,266
DPW	HWY H-6 11 F350	2011						690		690
DPW	HWY H-7 22 FREIGHTLINER DUMP	2022						790		790
DPW	HWY H-8 19 FORD F550 DUMP	2019						853		853
DPW	HWY H-9 2002 JCB LOADER 416	2002						211		211
DPW	M-2 12 FORD F350	2012	33,717					1,112		1,112
DPW	TRS 08 FORD F350 PU	2008	52,693					263		263
DPW	TRS 95 JCB BACKHOE 214S	1995	69,656					138		138
DPW	WAT W-3 17 F350	2017	40,277					826		826
DPW	WAT W-4 21 FORD F550	2021						715		715
DPW	WAT W-5 15 FORD F550 DUMP	2015	55,140					437		437
DPW	WAT W-7 12 INT DUMP TRUCK	2012	134,213					705		705
DPW	WAT W-8 07 JCB BACKHOE 215S	2007	106,539					394		394

Diesel fuel vehicle projected electric conversion cost ($) and projected electricity use (MWh)

Department nar	Vehicle name	Insurance Year	Insurance Cost New ($)	2025 Vehicle Conversion ($)	2030 Vehicle Conversion ($)	2035 Vehicle Conversion ($)	2040 Vehicle Conversion ($)	2045 Vehicle Conversion ($)	2050 Vehicle Conversion ($)	Total Vehicle Conversion ($)	2025 Vehicle Conversion (MWh)	2030 Vehicle Conversion (MWh)	2035 Vehicle Conversion (MWh)	2040 Vehicle Conversion (MWh)	2045 Vehicle Conversion (MWh)	2050 Vehicle Conversion (MWh)	Total Vehicle Conversion (MWh)
Fire	AFD A-1 2015 Dodge Ram Life Line Ambulance	2015	207,485					311,228		311,228					35		35
Fire	AFD A-3 2010 CHEVY G4500 AMBULANCE	2010	180,597					270,896		270,896					7		7
Fire	AFD E-1 1976 MAXIM FIRE TRUCK	1976	65,001					97,502		97,502					3		3
Fire	AFD E-2 2006 CENTRAL STATES PUMPER	2006	132,917					199,376		199,376					2		2
Fire	AFD E-3 1998 HME CENTRAL STATES FIRE TRUCK	1998	190,545					285,818		285,818					5		5
Fire	AFD E-4 2012 KME	2012	375,000					562,500		562,500					23		23
Fire	AFD L-1 2006 E-ONE LADDER TRUCK	2006	800,000					1,200,000		1,200,000					6		6
DPW	CPT C-1 07 CHEVY KODIAK DUMP TRUCK	2007	66,187					99,281		99,281					16		16
DPW	CPT C-2 2012 JCB BACKHOE	2012						-		-					2		2
DPW	CPT P-1 2019 FORD F550 DUMP TRUCK	2019						-		-					29		29
DPW	CPT P-2 2011 FORD 350	2011						-		-					12		12
DPW	CPT T-1 09 INT DUMP TRUCK	2009	108,058					162,087		162,087					6		6
DPW	CPT T-2 03 JD FLAIL MOWER	2003	78,687					118,031		118,031					13		13
DPW	HWY H-1 09 INT DUMP TRUCK	2009	100,878					151,317		151,317					16		16
DPW	HWY H-10 22 FREIGHTLINER DUMP	2022						-		-					19		19
DPW	HWY H-11 03 INT DUMP/COMBO TRUCK	2002	131,236					196,854		196,854					16		16
DPW	HWY H-12 04 INT DUMP TRUCK	2003	98,577					147,866		147,866					20		20
DPW	HWY H-15 07 INT DUMP/SLIP SANDER W/PLOW	2007	121,830					182,745		182,745					26		26
DPW	HWY H-16A 13 ELGIN PELICAN SWEEPER	2013	183,029					274,544		274,544					8		8
DPW	HWY H-17 08 JD 544J	2008	39,789					59,684		59,684					20		20
DPW	HWY H-18 13 CASE BACKHOE	2013	113,000					169,500		169,500					8		8
DPW	HWY H-19 88 JD LOADER 644E	1988	109,000					163,500		163,500					1		1
DPW	HWY H-20 84 INT CATCH BASIN	1984	35,000					52,500		52,500					3		3
DPW	HWY H-4 17 INT DUMP COMBO TRUCK	2017	161,019					241,529		241,529					20		20
DPW	HWY H-5 17 INT DUMP	2017	134,819					202,229		202,229					26		26
DPW	HWY H-6 11 F350	2011						-		-					14		14
DPW	HWY H-7 22 FREIGHTLINER DUMP	2022						-		-					16		16
DPW	HWY H-8 19 FORD F550 DUMP	2019						-		-					17		17
DPW	HWY H-9 2002 JCB LOADER 416	2002						-		-					4		4
DPW	M-2 12 FORD F350	2012	33,717					50,576		50,576					23		23
DPW	TRS 08 FORD F350 PU	2008	52,693					79,040		79,040					5		5
DPW	TRS 95 JCB BACKHOE 214S	1995	69,656					104,484		104,484					3		3
DPW	WAT W-3 17 F350	2017	40,277					60,416		60,416					17		17
DPW	WAT W-4 21 FORD F550	2021						-		-					15		15
DPW	WAT W-5 15 FORD F550 DUMP	2015	55,140					82,710		82,710					9		9
DPW	WAT W-7 12 INT DUMP TRUCK	2012	134,213					201,320		201,320					14		14
DPW	WAT W-8 07 JCB BACKHOE 215S	2007	106,539					159,809		159,809					8		8

Gasoline fuel vehicle age, insurance replacement cost, estimated current fuel use (gallons), and target electric conversion dates

Department nar	Vehicle name	Insurance Year	Insurance Cost New ($)	2025 Vehicle Conversion (Gallons)	2030 Vehicle Conversion (Gallons)	2035 Vehicle Conversion (Gallons)	2040 Vehicle Conversion (Gallons)	2045 Vehicle Conversion (Gallons)	2050 Vehicle Conversion (Gallons)	Total Vehicle Conversion (Gallons)
Police	ACO 2018 FORD TRANSIT	2018	23,639		-					-
Fire	AFD A-2 2008 FORD ROAD RESCUE AMBULANCE	2008			-					-
Fire	AFD A2-2019 Ambulance	2019			-					-
Fire	AFD B-2 1970 INTERNATIONAL FARRAR BRUSH TRI	1970	15,000		10					10
Fire	AFD Brush 1 2005 FORD PICKUP TRUCK	2005	29,136		84					84
Fire	AFD Car-2 2017 Ford Explorer	2017			494					494
Fire	AFD R-1 2010 FORD EXPEDITION	2010	35,678		1,320					1,320
Fire	AFD R-2 2016 Chevy Pickup	2016	35,000		809					809
Fire	AFD R-2 2016 Chevy Pickup	2016	35,000		93					93
Fire	AFD R-3 2002 CHEVROLET TAHOE	2002			-					-
Fire	AFD R-6 1980 FORD FIRE ALARM BUCKET TRUCK	1980	15,000		105					105
Police	APD 00-1 00 FORD TAURUS	2000			-					-
Police	APD 04-1 2004 FORD EXPEDITION - SUPER	2004	31,436		-					-
Police	APD 04-4 2004 FORD FREE STAR - ACO	2004	12,000		480					480
Police	APD 06-1 JEEP	2006			-					-
Police	APD 09-1 2009 FORD CROWN VIC	2009	28,260		-					-
Police	APD 09-2 DODGE CHARGER - LT	2009	26,142		316					316
Police	APD 09-3 DODGE CHARGER - CHIEF	2009	27,987		583					583
Police	APD 10-1 2010 FORD ESCAPE - DET	2010	25,970		474					474
Police	APD 12-1 2012 JEEP DETECTIVE	2012	14,000		-					-
Police	APD 13-1 INTERCEPTOR	2013			223					223
Police	APD 14-1 INTERCEPTOR	2014			911					911
Police	APD 14-2 2014 FORD EXPEDITION	2014			-					-
Police	APD 16-1 2016 FORD EXPLORER	2016	37,615		1,462					1,462
Police	APD 16-2 2016 FORD EXPLORER	2016	37,615		1,911					1,911
Police	APD 17-1 2017 Ford Explorer	2017	40,914		1,868					1,868
Police	APD 17-2 2017 Ford Explorer	2017	39,380		2,217					2,217
Police	APD 18-2 18 INTERCEPTOR	2018			-					-
Police	APD 20-1 JEEP CHEROKEE DETECTIVE	2020			-					-
Police	APD 20-2 2020 FORD EXPLORER	2020			-					-
Police	APD 20-3 2020 FORD EXPLORER CHIEF	2020			-					-
Police	Card 0010				724					724
DPW	M-1 2018 FORD EXPLORER	2018	33,715		455					455
DPW	STP 2018 F250	2018			528					528
General Governi	Town Manager's Car	1999	25,000		-					-
DPW	WAT W-1 12 FORD F350PU	2011	39,726		1,611					1,611

Gasoline fuel vehicle projected electric conversion cost ($) and projected electricity use (MWh)

Department nar	Vehicle name	Insurance Year	Insurance Cost New ($)	2025 Vehicle Conversion ($)	2030 Vehicle Conversion ($)	2035 Vehicle Conversion ($)	2040 Vehicle Conversion ($)	2045 Vehicle Conversion ($)	2050 Vehicle Conversion ($)	Total Vehicle Conversion ($)	2025 Vehicle Conversion (MWh)	2030 Vehicle Conversion (MWh)	2035 Vehicle Conversion (MWh)	2040 Vehicle Conversion (MWh)	2045 Vehicle Conversion (MWh)	2050 Vehicle Conversion (MWh)	Total Vehicle Conversion (MWh)
Police	ACO 2018 FORD TRANSIT	2018	23,639		28,367					28,367		-					-
Fire	AFD A-2 2008 FORD ROAD RESCUE AMBULANCE	2008			-					-		-					-
Fire	AFD A2-2019 Ambulance	2019			-					-		-					-
Fire	AFD B-2 1970 INTERNATIONAL FARRAR BRUSH TRI	1970	15,000		18,000					18,000		-					-
Fire	AFD Brush 1 2005 FORD PICKUP TRUCK	2005	29,136		34,963					34,963		2					2
Fire	AFD Car-2 2017 Ford Explorer	2017			-					-		10					10
Fire	AFD R-1 2010 FORD EXPEDITION	2010	35,678		42,814					42,814		27					27
Fire	AFD R-2 2016 Chevy Pickup	2016	35,000		42,000					42,000		16					16
Fire	AFD R-2 2016 Chevy Pickup	2016	35,000		42,000					42,000		2					2
Fire	AFD R-3 2002 CHEVROLET TAHOE	2002			-					-		-					-
Fire	AFD R-6 1980 FORD FIRE ALARM BUCKET TRUCK	1980	15,000		18,000					18,000		2					2
Police	APD 00-1 00 FORD TAURUS	2000			-					-		-					-
Police	APD 04-1 2004 FORD EXPEDITION - SUPER	2004	31,436		37,723					37,723		-					-
Police	APD 04-4 2004 FORD FREE STAR - ACO	2004	12,000		14,400					14,400		10					10
Police	APD 06-1 JEEP	2006			-					-		-					-
Police	APD 09-1 2009 FORD CROWN VIC	2009	28,260		33,912					33,912		-					-
Police	APD 09-2 DODGE CHARGER - LT	2009	26,142		31,370					31,370		6					6
Police	APD 09-3 DODGE CHARGER - CHIEF	2009	27,987		33,584					33,584		12					12
Police	APD 10-1 2010 FORD ESCAPE - DET	2010	25,970		31,164					31,164		10					10
Police	APD 12-1 2012 JEEP DETECTIVE	2012	14,000		16,800					16,800		-					-
Police	APD 13-1 INTERCEPTOR	2013			-					-		4					4
Police	APD 14-1 INTERCEPTOR	2014			-					-		18					18
Police	APD 14-2 2014 FORD EXPEDITION	2014			-					-		-					-
Police	APD 16-1 2016 FORD EXPLORER	2016	37,615		45,138					45,138		30					30
Police	APD 16-2 2016 FORD EXPLORER	2016	37,615		45,138					45,138		39					39
Police	APD 17-1 2017 Ford Explorer	2017	40,914		49,097					49,097		38					38
Police	APD 17-2 2017 Ford Explorer	2017	39,380		47,256					47,256		45					45
Police	APD 18-2 18 INTERCEPTOR	2018			-					-		-					-
Police	APD 20-1 JEEP CHEROKEE DETECTIVE	2020			-					-		-					-
Police	APD 20-2 2020 FORD EXPLORER	2020			-					-		-					-
Police	APD 20-3 2020 FORD EXPLORER CHIEF	2020			-					-		-					-
Police	Card 0010				-					-		15					15
DPW	M-1 2018 FORD EXPLORER	2018	33,715		40,458					40,458		9					9
DPW	STP 2018 F250	2018			-					-		11					11
General Governi	Town Manager's Car	1999	25,000		30,000					30,000		-					-
DPW	WAT W-1 12 FORD F350PU	2011	39,726		47,671					47,671		33					33