I. PURPOSE AND ACKNOWLEDGEMENTS

Town of Carlisle
Decarbonization Roadmap
August 29, 2024

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II. EXECUTIVE SUMMARY

The Town of Carlisle occupies a unique place in Middlesex County. With a population of just 5,237[1], it stands apart from its larger, more developed neighbors, which include Billerica, Concord, and Acton. Carlisle is known for its pastoral beauty, historic houses, and a forward-thinking population. Energy efficiency is a high priority for the town, as solar panels, EV chargers, and heat pumps are added to private homes nearly every week[2]. When it comes to municipal operations, Carlisle became a Green Community in 2011, and received funding that year, as well as in 2014, 2015, 2016, 2018, and most recently, in 2023. The town is starting to increase planning capacity, having hired a Town Planner and Land Use and Sustainability Coordinator within the past two years. Recent clean energy projects include installing a heat pump at the town library, EV chargers at the Carlisle Public School, and an upcoming Police Station renovation that will electrify the building. Every year, Carlisle hosts "Route to Sustainability Day," organized by the town's Environmental Sustainability Committee, attended by residents and non-residents alike.

Table 1: Summary of Municipal Emissions: Most Recent Fiscal Year (FY 2024)

Facility	**FY2024 Emissions (MT CO2)**
Brick	0
Carlisle School Buildings: Corey, Wilkins, Robbins, Grant, Spalding	384.2
Carlisle School Wastewater Treatment Plant	7.2
Cemetery Chapel	0
DPW Main Bldg	38.3
DPW Sheds	2
Streetlights	3.1
Church Street Pump	0
Fire Station	14
Gleason Public Library	35.7
Highland School	5
Police Station	29.4
Town Hall	28.6
Total	**547.5**

[1] 2020 Census Data; See Appendix
[2] Carlisle Building Department; See Appendix

Table 2: Vehicle Emissions Breakdown - FY2024

Total 2024 CO_2 Emissions - Gasoline (MT)		140.9
Total 2024 CO_2 Emissions - Diesel (MT)		113.4
	Total Fleet Emissions	**254.3**

Table 3: Summary of Emissions Reductions

Targets	**2022**	**2027**	**2030**	**2040**	**2050**
Reduce emissions from onsite fossil fuels via electrification	0%	8%	20%	91%	99%
Zero Emission Vehicles (ZEVs) in light-duty fleet adoption (% of fleet)	0%	14%	43%	62%	100%
Zero Emission Vehicles (ZEVs) in heavy-duty fleet adoption (% of fleet)	0%	0%	6%	28%	72%
Energy Use Intensity reduction (deep energy retrofits/retrocommissioning) kBtu/ft^2	547.7	-5%	-20%	-25%	164.31
Total Emissions Reduction Goals (% of 2022 Emissions)	**0**	**8%**	**21%**	**81%**	**97%**

Table 4: Trigger Event Outline

Building	Trigger Event Year Estimate	Trigger Event Description
Police Station	2024	Planned full-building renovation; fully electrified
CPS: Robbins	2025	RTUs will need replacement
CPS: Brick	2025	Heating system replacement
Gleason Public Library	2026	Planned full-building renovation
Town Hall	2027	RTU end of life
Fire Station	2027	Planned full-building renovation
DPW Sheds	2028	Planned renovation
DPW Main Building	2028	Planned renovation
Cemetery Chapel	2030	Oil system will be 30 years old, will need replacing
CPS: Highland	2035	Ductwork will be 20 years old, heating system in need of upgrade
CPS: Corey	2040	RTU end of life
CPS: Spalding	2040	RTU end of life
CPS Wilkins	2040	Heating system upgrade
CPS: Grant	2045	Heat and A/C upgrade
Wastewater Treatment Plant	2045	Equipment end of life

Table 5: Trigger Event Timeline for New Construction or Major Renovation

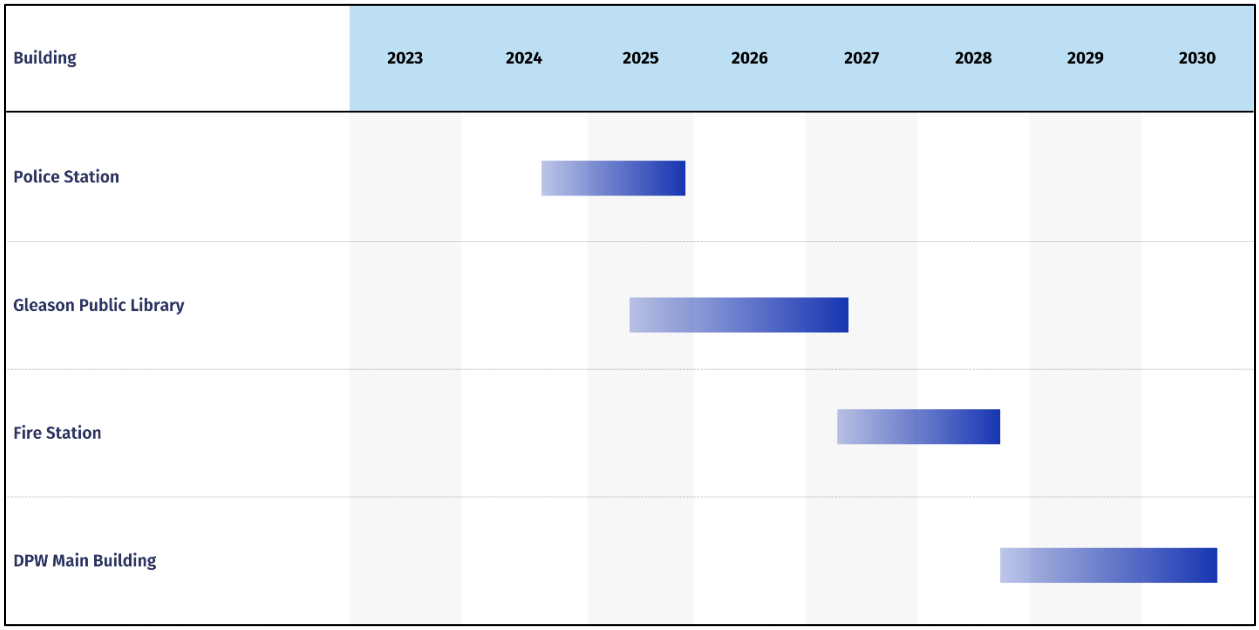
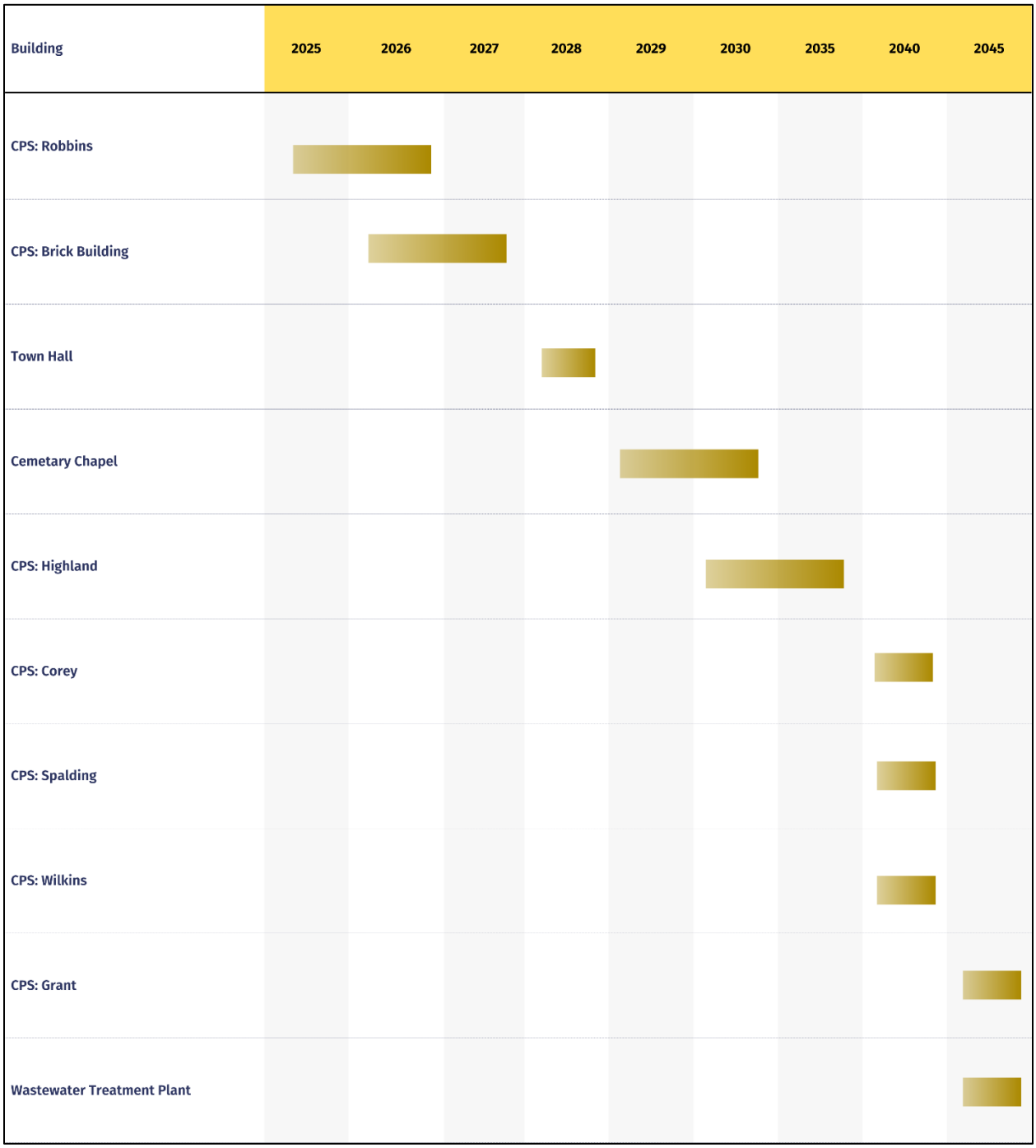


Table 6: Trigger Event Timeline for Major Equipment Replacement



III. MUNICIPAL EMISSION BASELINE

A. Baseline was calculated using MassEnergyInsight and EPA MPGe data.

B. Municipal Emission for the Baseline Year

Table 7: Emissions FY2022

Facility	FY2022 (MT CO2)
Brick	2.6
Carlisle School Buildings	627.3
Carlisle School Wastewater Treatment Plant	34.6
Cemetery Sheds	0
DPW Main Bldg	32.5
DPW Sheds	1.6
Streetlights	3.4
Church Street Pump	0.3
Fire Station	23.7
Gleason Public Library	49.5
Highland School	40.5
Police Station	35.9
Town Hall	31.5
Total	**883.4**

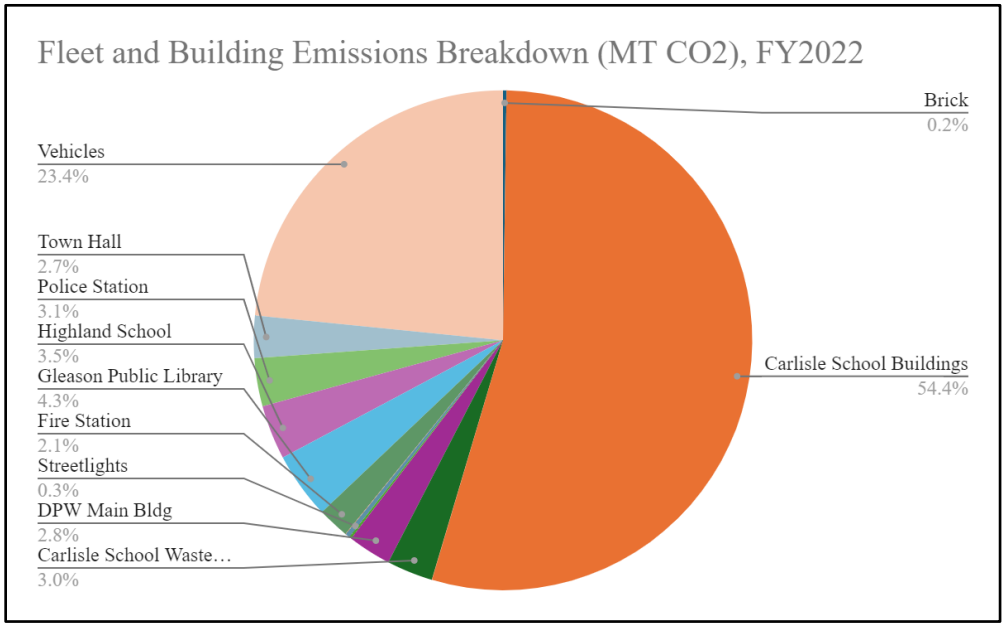


Figure 1: Total municipal emissions in FY 2022 in Metric Tons CO_2

Table 8: Facilities Breakdown by Fuel Type, FY 2022

Facility	Area (ft2)	Year built	Electric	Gas	Propane	Total
Brick	1500	1848	2.6	-	-	2.6
Carlisle School Building Complex: Corey, Wilkins, Robbins, Grant, Spalding	140499	Corey: 1987 Wilkins: 1963 Robbins: 1967 Grant: 1987 (1st), 1996 (2nd) Spalding: 2012	196.5	430.8	-	627.3
Carlisle School Wastewater Treatment Plant	1935	2003	9.4	-	25.2	34.6
Cemetery Sheds	420	1972	0	-	-	0
Church Street Pump	0	N/A	0.3	-	-	0.3
DPW Main Bldg	7200	1972	9.2	23.3	-	32.5
DPW Sheds	2576	1972	1.6	-	-	1.6
Fire Station	6425	1985	11.5	12.2	-	23.7
Gleason Public Library	9707	1895	22.5	27	-	49.5
Highland School	7572	1908	1.9	38.6	-	40.5
Police Station	7808	1987	24.8	11.2	-	35.9
Town Hall	7664	1996	15.4	16.1	-	31.5
Streetlights	0	N/A	3.4	-	-	3.4
Total			**299.1**	**559.1**	**25.2**	**883.4**

Table 9: Vehicle Emissions Breakdown

Total 2022 CO_2 Emissions - Gasoline (MT)		139.36
Total 2022 CO_2 Emissions - Diesel (MT)		130.7
	Total Fleet Emissions	270.06

IV.DECARBONIZATION ROADMAP NARRATIVE

A. Summary –

1. Overview of Goals for implementation to 2027 and 2030

The Town of Carlisle's goals for initial roadmap implementation include: continuing to identify trigger events with greater specificity through building assessments, incorporating electrification into upcoming renovation plans, and beginning to transition the municipal fleet to EVs, starting with police cruisers and facilities vehicles (pickup trucks). Carlisle will also seek out feasibility studies for larger projects, including geothermal/ground-source energy and microgrids.

2. Overview of Goals for calendar years 2040 and 2050

In the years closer to 2050, Carlisle will have continued transitioning municipal buildings away from fossil fuel through renovations and equipment replacements. The town will employ a variety of strategies, including air- and ground- source energy and solar. To solidify Carlisle's resilience against climate factors such as increasing storms and economic factors such as energy market instability, the town will pursue microgrid opportunities. Carlisle will also continue replacing fleet vehicles with EVs on a replacement basis, in accordance with the Zero Emission Vehicle First policy.

3. Identify Areas of highest emissions and greatest opportunities for impact

The area of highest emissions is the school building complex (54.4%) and the municipal fleet (23.4%). The school represents the greatest opportunity for impact. The complex has been assessed as having a high potential for geothermal. Given that Carlisle's municipal fleet is approximately 40 vehicles, this is also an area for high impact. Police cruisers are of particular focus because of the amount of idling involved in daily police activity.

B. Achieving Elimination of Onsite Fossil Fuel Use by 2050

Elimination of onsite fossil fuel use will be achieved by 2050 through incremental steps. By taking advantage of already planned near-term renovations, Carlisle will be able to make a large impact on emissions by 2030. The first planned renovation, which, as of this writing, is already in the OPM hiring stage, is a full Police Building renovation. The plans, already approved at Town Meeting, will electrify the building using air-source heat pumps. Following the Police Station, later in the decade, the Fire Station will undergo an addition and equipment upgrade that can be a pathway towards fully eliminating fossil fuel use. Around 2030, the DPW will also receive a major renovation. Relevant committees and Town staff are already discussing the

installation of solar panels that will have immense emissions offset potential. These near-term changes are incorporated into EUI predictions. Following 2030, the Town's attention will shift to the School complex, which is the largest consumer of fossil fuels in Town. The Town aims to assess the School's potential for a full deep-well geothermal conversion, and if able to proceed, will be able to significantly reduce School emissions once this project is complete – likely not until 2040. The bulk of the work on buildings happening between 2027-2040, the following decade gives the Town room to adjust and to convert the final, smaller buildings such as the Wastewater Treatment Plant from fossil fuel use.

The municipal fleet is comprised of 22 light-duty and 18 heavy-duty vehicles. Several of the light-duty vehicles are police cruisers, and the Police department plans on purchasing an EV for administrative use in the coming year to evaluate its performance. Given the electric police cruiser fulfills its advertised role, and saves the department on fuel costs as predicted, the department will continue converting its fleet. Other light duty vehicles that will be converted as they are replaced include personnel vehicles for the DPW, Fire, and Council on Aging. Heavy-duty vehicles, where technology is still evolving, are shifted towards the end of the timeline, later than 2040. It is worth noting that the calculations represented in Table 4 account for the potential that it may not be financially feasible or advisable to completely replace all emergency vehicles with electric vehicles.

Even with these concessions, the Town still reaches a predicted 97% total emissions reduction by 2050.

C. Program Management Plan for Implementation, Monitoring and Oversight

   The primary staff member responsible for implementation of the Decarbonization Roadmap will be Sarah Wasserman, Land Use and Sustainability Coordinator. Stephen Connearney, Facilities Director, will be responsible for monitoring, as well as DPW Director Jim Hall, and the Municipal Facilities Committee. Oversight will be led by the Municipal Facilities Committee, Finance Committee, Town Administrator, and Select Board. The Land Use and Sustainability Coordinator will attend monthly facilities meetings to stay up-to-date on issues and adjust efficiency planning as needed.

D. Carlisle will update this roadmap by **August 29, 2027**.

Appendix

II. Executive Summary

1. Retrieved from: https://data.census.gov/all?g=060XX00US2501711525&d=DEC%20Demographic%20and%20Housing%20Characteristics
2. Retrieved from Patriot Permit Pro, Permits Issued January 1, 2024, through July 1, 2024.

Table 1: MassEnergyInsight – Organization View Table
Table 2: MassEnergyInsight – Climate Leader Indicators Table, Vehicles only.
Table 3: Calculations done using MEI data from Organization View Table and Buildings emission reductions calculated using estimated footprint of individual buildings and timeline of expected trigger events such as major renovations. Fleet calculations were done by first separating the fleet into light duty (21) and heavy duty (18), then estimating turnover years. EUI reduction estimated based on deep energy retrofit timelines.
Table 4: Building inventory informed by discussions with Facilities Manager Stephen Connearney and Municipal Facilities Committee Vice Chair William Risso.
Table 5 & 6: Trigger Event worksheet supplied by DOER, graphics created on Canva.

III. Municipal Emission Baseline

Figure 1: MassEnergyInsight - Organization View Table by facility for FY 2022 converted to pie chart via Google Sheets.
Figure 2 :MassEnergyInsight - Organization View Table for all municipal emissions for FY 2022 converted to pie chart via Google Sheets.
Table 7: MassEnergyInsight Organization View table
Table 8: MassEnergyInsight Climate Leaders: Top Buildings
Table 9: MPG information from: totalmotorcycle.com (2007 Harley-Davidson), metrommp.com (2014 Ford E-450), fueleconomy.gov (All Other Vehicles).

Department	Year	Make	Model	2022 CO_2 Emissions - Gasoline (MT)	2022 CO_2 Emissions - Diesel (MT)
Police	2023	Chevrolet	Tahoe + Upfit Equipment	Not in baseline	Not in baseline
Police	2022	Ford	Explorer Hybrid	8.21	
Police	2021	Ford	Explorer Hybrid	7.9	
Police	2020	Ford	F-150	17.57	
Police	2019	Chevrolet	Tahoe	15.55	
Police	2018	Chevrolet	Tahoe	11.24	
Police	2018	Chevrolet	Tahoe	14.52	
Police	2017	Chevrolet	Tahoe	8.42	
Police	2016	Chevrolet	Tahoe	9.42	
Police	2016	Chevrolet	Tahoe	8.21	
Police	2007	Harley Davidson - Motorcycle		0.72	
DPW	2022	Ford Dump Truck	F-550 Super Duty	1.75	
DPW	2022	Ford Dump Truck	F-550 Super Duty	2.63	
DPW	2020	Ford	F-350 Super Duty	5.15	
DPW	2020	International - Roll Off Truck	HV613		28.3
DPW	2019	Ford	F-350 Super Duty	5.75	
DPW	2018	Ford - Dump Truck	F-750 Super Duty		2.74
DPW	2016	Chevrolet	Tahoe	7.35	
DPW	2016	International - Dump Truck	WorkStar 7400		4.18
DPW	2013	International - Dump Truck	WorkStar 7300		4.03
DPW	2012	International - Dump Truck	WorkStar 7300		3.44
DPW	2010	International - Roll Off Truck	WorkStar 7600		38.85
DPW	2008	International - Sander Truck	WorkStar 7300		4.61

DPW	2006	Ford - Dump Truck	F-450 Super Duty		12.18
DPW	2002	International	4700		6
Fire	2019	Ford - Ambulance	F-550 Super Duty		10.67
Fire	2018	Ford	Explorer	1.33	
Fire	2017	Ford	Expedition	4	
Fire	2016	E-ONE - Cyclone	Truck		2.85
Fire	2016	Ford	Explorer	4.21	
Fire	2012	International - Fire Truck	WorkStar 7400		1.04
Fire	2012	Ford	F-350 Super Duty		1.49
Fire	2009	Ford - Ambulance	F-450 Super Duty		3.63
Fire	2007	E-ONE - Fire Truck	Truck		4.08
Fire	2002	E-ONE - Aerial HP100	Truck		1.72
Fire	2000	E-ONE - Hurricane Pumper	Truck		4.96
School	1996	Ford Pickup	F-250	2.91	
COA	2015	Nissan	Rogue	3.14	
COA	2014	Ford - Elkhart Van	E-Series	7.35	
School	2007	Ford Van #E31	E-Series	1.43	