

Town of Wawa, ON Community GHG Inventory and Net-Zero Modelling Baseline 2023



Photo Credit: Town of Wawa Website

Prepared by:



**Motivating Net-Zero Action in Rural,
Remote and Indigenous Communities**

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List of Abbreviations

BAU	Business-As-Usual
CDD	Cooling Degree Days
EV	Electric Vehicle
GHG	Greenhouse Gas
GJ	Gigajoule
HDD	Heating Degree Days
ICE	Internal Combustion Engine
K	Kilo denoting a factor of 1000. For example 5k = 5000
Kg	Kilogram
KgCO ₂ e	Kilograms Carbon Dioxide Equivalent
LED	Light Emitting Diode
MNZA	Motivation Net-Zero Actions
PCP	Partners for Climate Protection
RNG	Renewable Natural Gas
TCO ₂ e	Tonne Carbon Dioxide Equivalent

Executive Summary

As part of the QUEST Motivating Net-Zero Action (MNZA) program, a technical assessment was undertaken for the Municipality of Wawa to provide valuable technical data and information to support the community's climate initiatives and net-zero planning.

Climate Neutral conducted an inventory assessment of emissions, energy consumption and energy costs for Wawa for 2023. The inventory was conducted for three main areas: buildings, transportation and waste. The buildings sector included residential, and commercial/institutional buildings. This inventory serves as the baseline to establish future emissions projections and emissions reduction targets. The baseline levels were benchmarked against other municipalities in Ontario and across Canada to determine the relative environmental performance of the community. The cold climate of Wawa results in a higher heating demand and therefore higher emissions and energy consumption relative to communities with milder temperatures.

Future emissions projections were created using the results of the inventory assessment. The projections included the effects of population growth as well as the anticipated changes to the Ontario electricity grid. It was determined that without action the community emissions levels would increase a small amount over the 2030, 2040 and 2050 planning horizons in response to the growing population and associated minimal increase in demand for housing, transportation and waste management. These future projections highlight the need for climate change mitigation initiatives which work to reduce emissions levels over time through behavioral changes, the integration of low-carbon technologies and the implementation of sustainable development policies.

Using input from community engagement conducted by QUEST in combination with low-carbon planning best practices, fourteen (14) actions were identified and investigated for their impact in reducing emissions and increasing energy efficiency. Participation rates for these actions were adjusted to reach the net-zero goal and can be further refined through further community feedback and input. Special considerations for Wawa's cold climate were factored into the mitigation model. It was determined through the model that per capita emissions levels could be decreased significantly by applying practical, actionable, realistic and trackable measures.

An important consideration for Wawa is the high energy costs incurred by the community. These costs can be reduced through the conservation and efficiency actions presented in the net-zero model.

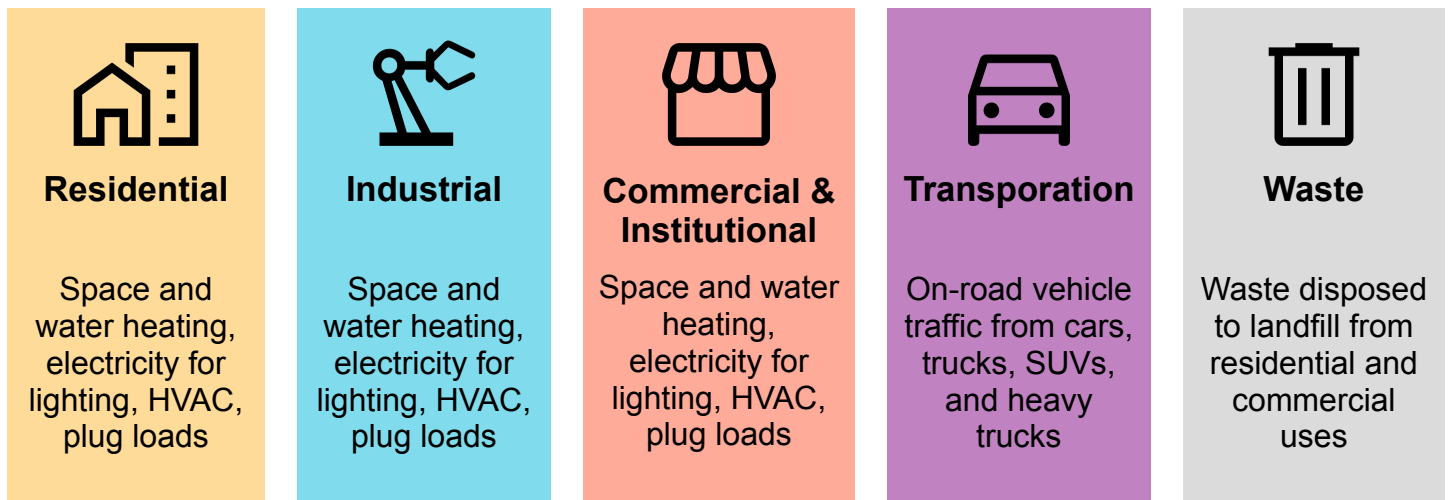
The intention is that this report will support grant funding applications and accelerate the implementation of mitigation measures thereby motivating the community towards net-zero emissions by 2050.

Baseline Inventory Details

Baseline Inventory Sectors

The inventory follows the standard sectors and methods outlined by the Partners for Climate Protection (PCP) which is a non-profit organization which establishes protocols for climate change mitigation analysis in Canada [1]. Commercial and Industrial sectors have been combined for the Inventory due to the format in which the data was provided by the electrical utility company.

Emissions Sectors



For comprehensive data results, including data tables and additional technical details, please refer to Appendix A - Inventory Data Tables.

Baseline Population

The baseline population of Wawa residents used for the inventory is 2705. This value is based on data from the 2021 Statistics Canada Census of Population [2]. This value is used to determine the population-weighted metrics.

Why Per Capita Metrics Matter

The per capita emissions of Wawa are a valuable metric used throughout the energy planning process. These population-weighted values are representative of the emissions efficiency of the community. This allows for emissions in Wawa to be understood in context of other communities within Ontario and across the country and facilitates comparisons through emissions benchmarking.

Baseline Inventory Energy and Emissions Sources

The community inventory is based upon the annual consumption of the seven main energy sources which power the community's buildings and vehicles. The solid waste generated by households and businesses is included for its emissions impacts when sent to the regional landfill.

Electricity



Electricity for Wawa is supplied by the Ontario electricity grid and provides energy for lighting, appliances, and heating, ventilation and air conditioning (HVAC) equipment for Wawa's buildings. It also supplies electricity for a small proportion of electric vehicles. Data for building electricity consumption was provided by Algoma Power Inc.

Natural Gas



Natural gas provides thermal energy for heating of buildings, hot water and cooking. There is no natural gas connection for the Municipality of Wawa.

Propane



Propane provides thermal energy for heating of buildings and hot water. Data for propane consumption was derived from the comprehensive energy usage database [3].

Heating Oil



Heating oil provides thermal energy for heating of buildings and hot water. Data for heating oil consumption was derived from the comprehensive energy usage database.

Wood



Wood provides thermal energy for heating of buildings and hot water. Data for wood consumption was derived from the comprehensive energy usage database.

Gasoline



Gasoline is used as the primary fuel for vehicles. Gasoline consumption data was obtained using an analytical model based on Ontario averages. The composition of gasoline in Ontario includes 10% ethanol biofuel.

Diesel



Diesel is used as a secondary fuel for vehicles. Diesel consumption data was obtained using an analytical model based on Ontario averages. The composition of diesel in Ontario includes 4% biodiesel biofuel.

Landfill Waste

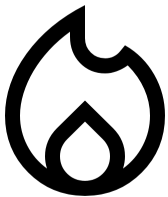


Solid waste is generated by households and some businesses within the community and collected via curbside collection or dropped off at a depot. Data for waste disposal was provided by the municipality.

Emissions Scopes

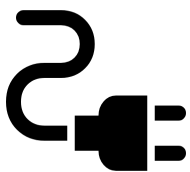
Emissions can be further classified by the scope in which they occur as defined by the Greenhouse Gas Protocol. These scopes describe the general location and source of emissions. This inventory focuses on Scope 1 and Scope 2 emissions for which data is readily available and accurate.

Scope 1



Direct emissions from the combustion of fossil fuels and decomposition of waste within the community's geographical boundary. For this inventory Scope 1 includes emissions from natural gas, gasoline and diesel fuels. Methane emissions from landfill waste is included in Scope 1

Scope 2



Indirect emissions from the use within the boundary of grid-supplied electricity, heat, steam and/or cooling generated outside the boundary. For this inventory Scope 2 includes electricity consumption from residential, commercial and industrial buildings.

Scope 3



Indirect emissions outside the geographical boundary from the goods and services purchased by community members within the boundary. Scope 3 emissions are not included in this inventory.

Baseline Inventory Assessment

Emissions Inventory Results

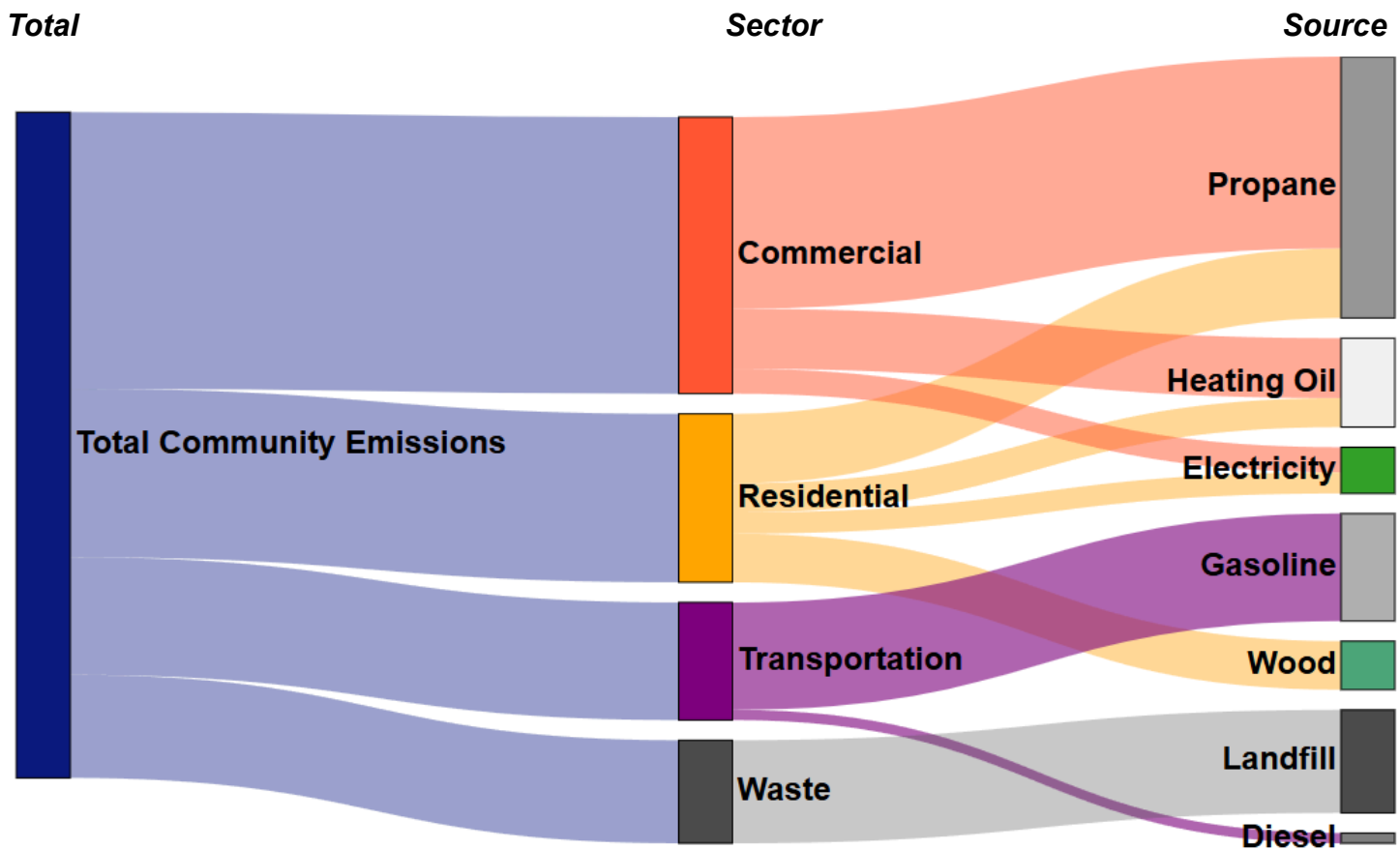
In 2023, 28,310 tonnes of Carbon Dioxide equivalent (TCO₂e) was emitted by the Municipality of Wawa. This equates to 10.47 TCO₂e per capita and 68 Tonnes per square kilometer (spatial intensity). Commercial/Institutional buildings are the largest source of emissions (41.5%) followed by residential buildings (25.3%), transportation (17.7%) and solid waste (15.5%) as illustrated in the Sankey flow diagram below.

Results for each sector are discussed on pages 18 through 21.

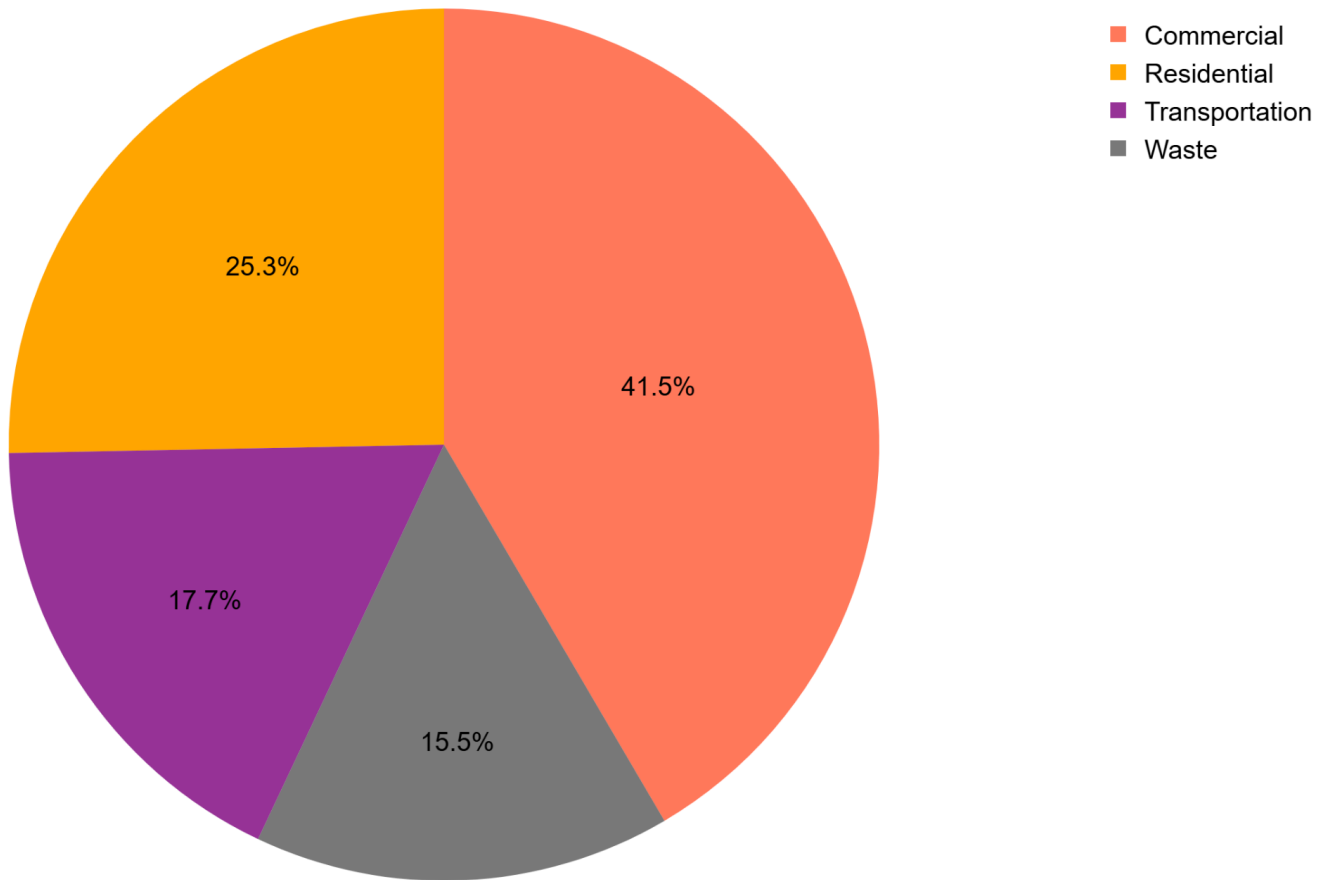
Greenhouse Gas Emissions Overview



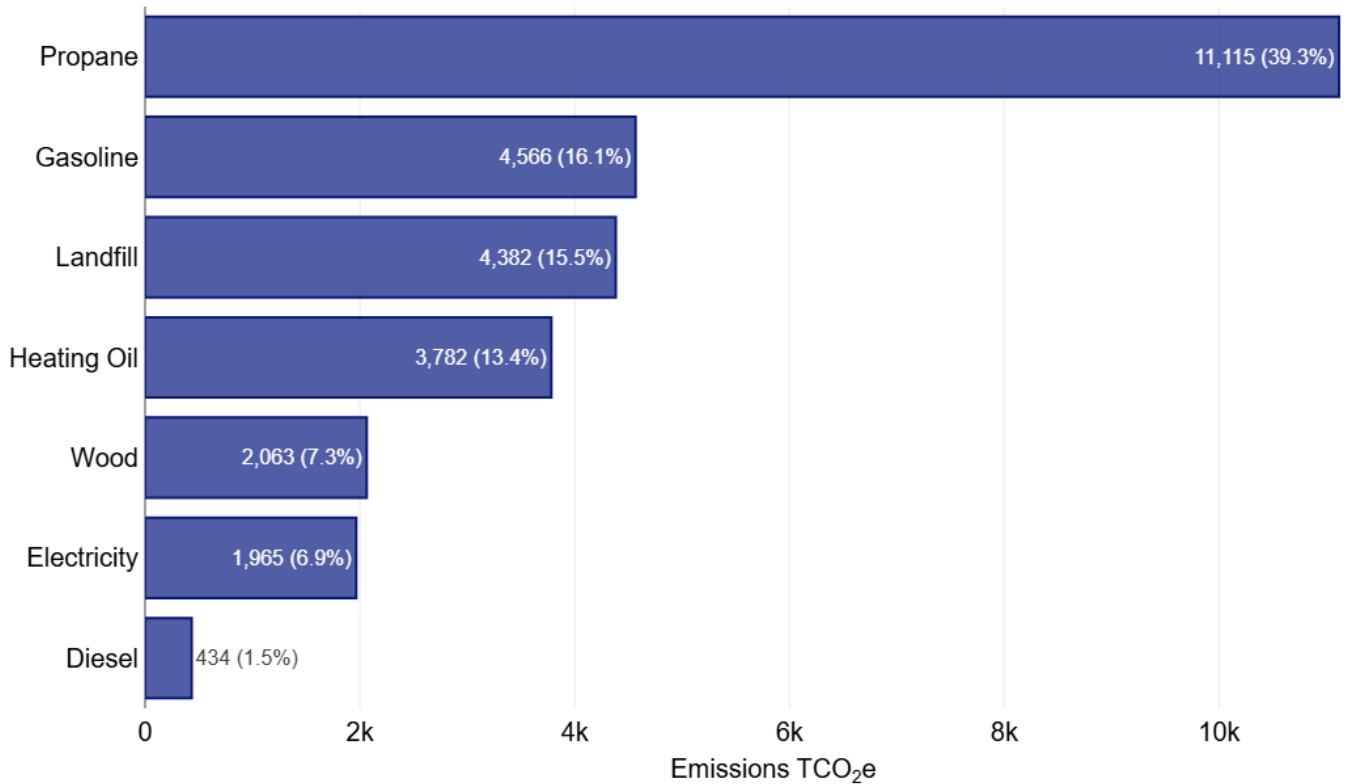
Emissions Sankey Diagram



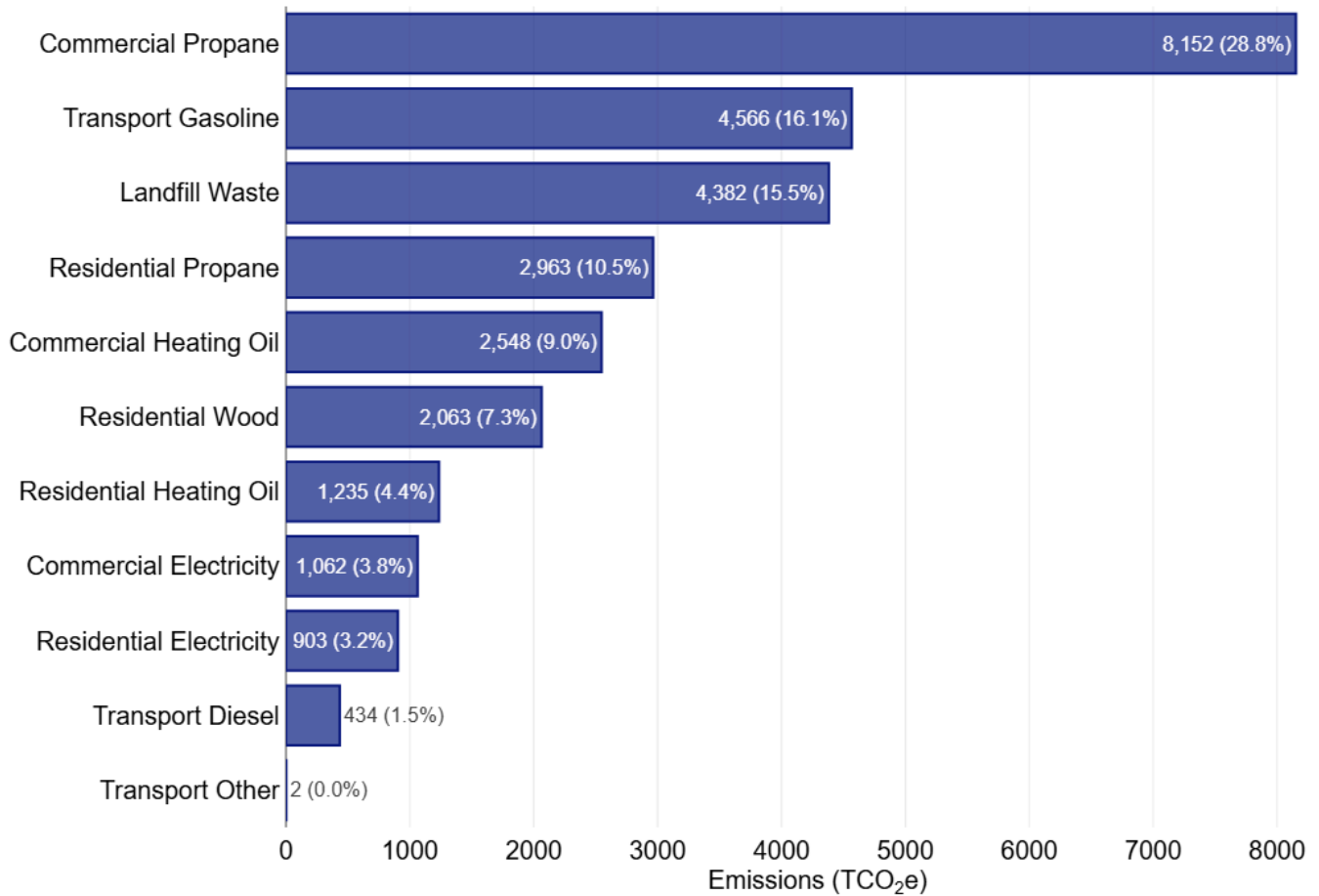
Emissions Per Sector



Emissions Per Source (TCO₂e)

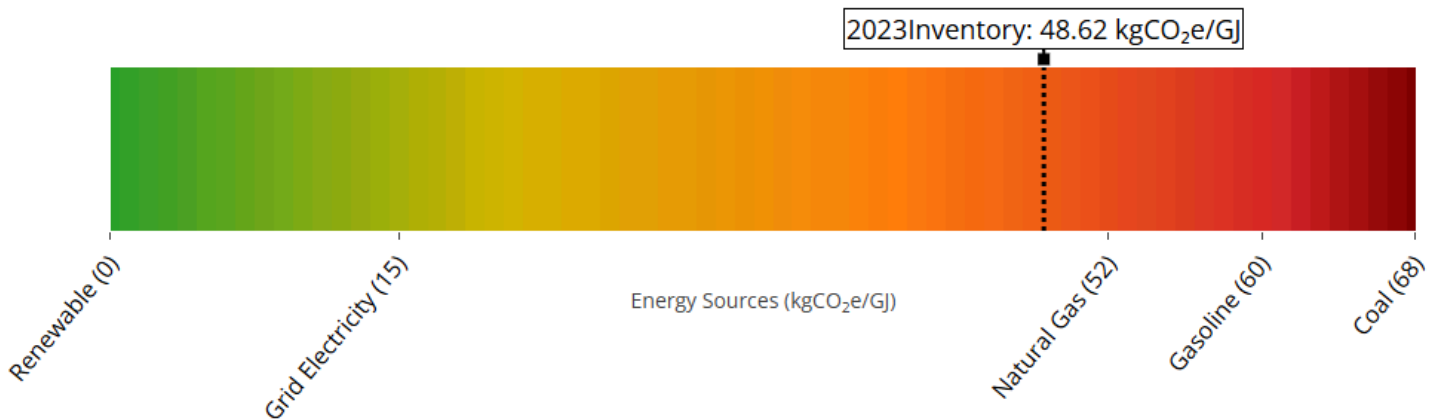


Emissions Per Source Sector (TCO₂e)

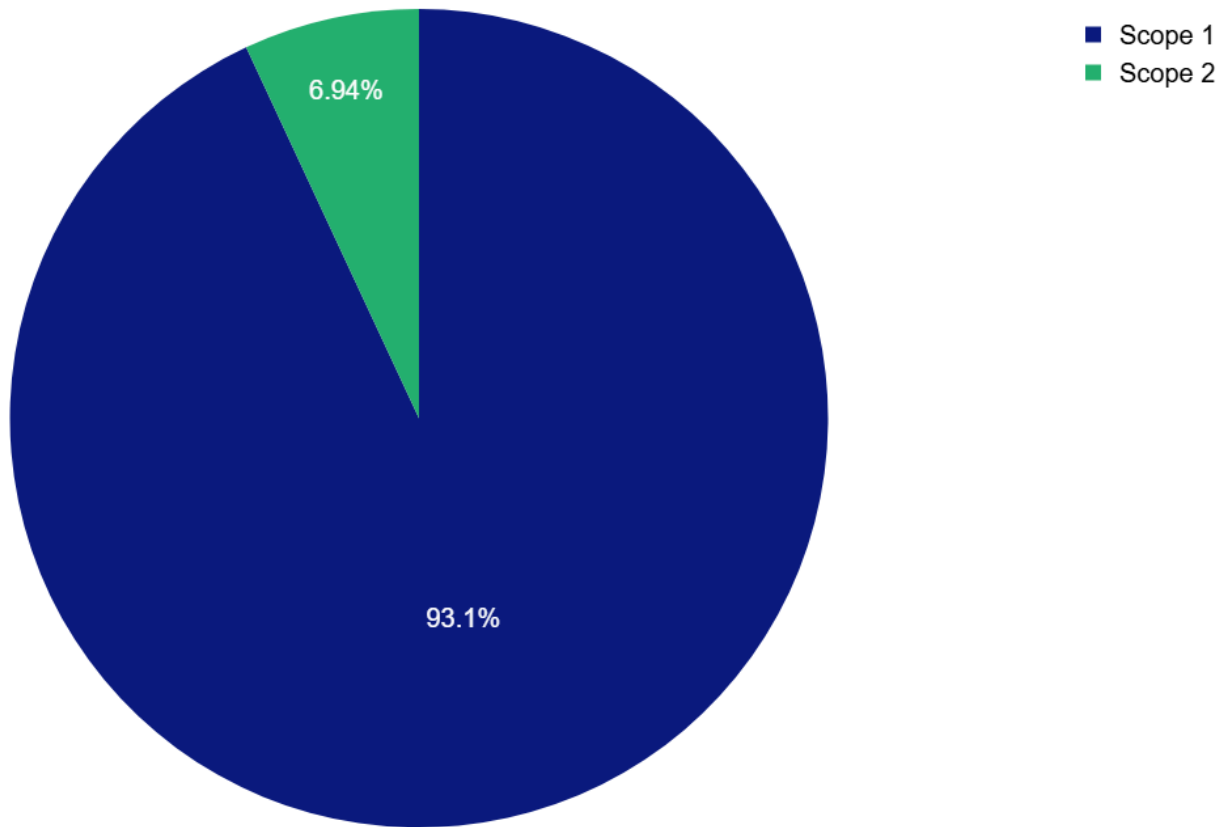


Emissions Intensity Spectrum

The emissions intensity of energy consumed was 48.62 KgCO₂e per Gigajoule (GJ) which is representative of the distribution of energy supply between low emitting sources (electricity) and high emitting sources. As low-carbon solutions are implemented and fossil fuel sources switched to renewables, this value will become lower and move toward the green (left) side.



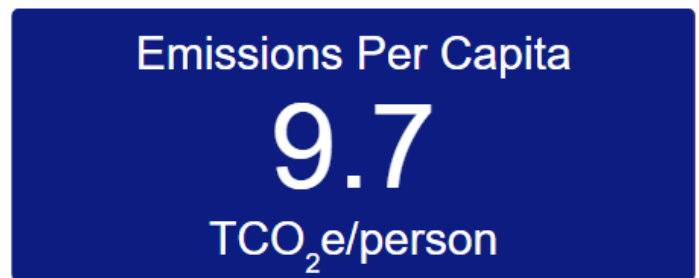
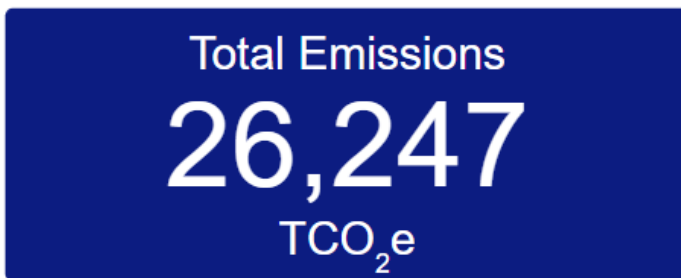
Emissions Per Scope



Notes on Emissions of Biogenic Origin

A significant proportion (2063 TCO₂e representing 7.3%) of emissions from the Wawa community comes from wood biomass. For the purposes of net-zero planning, emissions from wood can be considered carbon neutral as the emissions released during burning had previously been absorbed by the tree as it grew. This causes no net increase in atmospheric carbon. Emissions metrics without biogenic emissions are outlined below.

Greenhouse Gas Emissions Metrics (Non-Biogenic)



These metrics are used throughout this report for pathway analysis and mitigation modelling.

Trees Equivalent to Total Emissions



Total 2023 emissions are equivalent to:

433,996

tree seedlings grown for ten years [4]

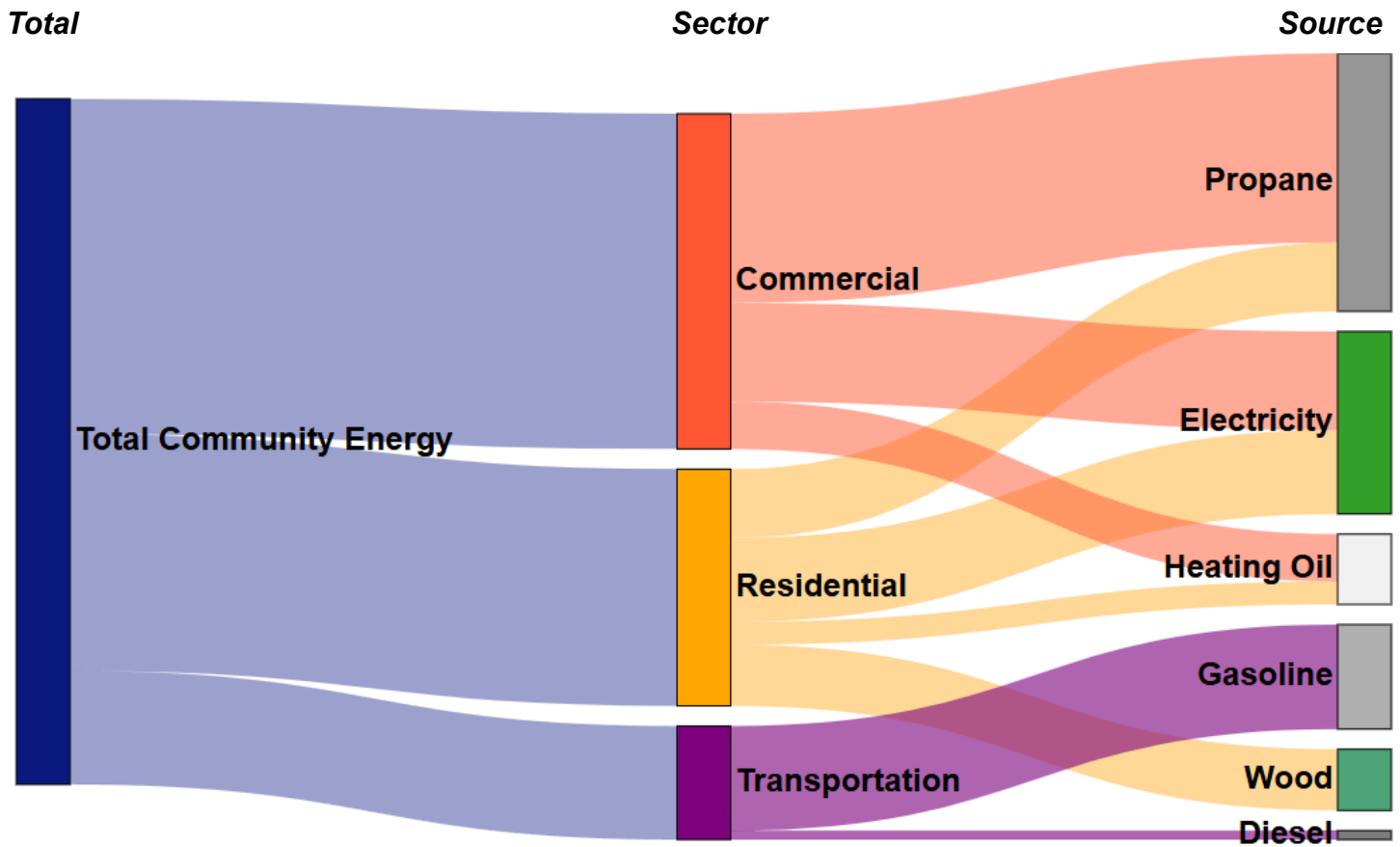
Energy Consumption Inventory Results

In 2023, Wawa consumed 492,191 GJ of energy. This equates to 181.96 GJ per capita and 1,194 GJ per square kilometer. The commercial buildings consumed the most energy representing 48.9% (240,658 GJ) followed by residential buildings at 34.5% (169,952 GJ), and transportation with 16.6% (81,582 GJ). Propane was the largest energy source.

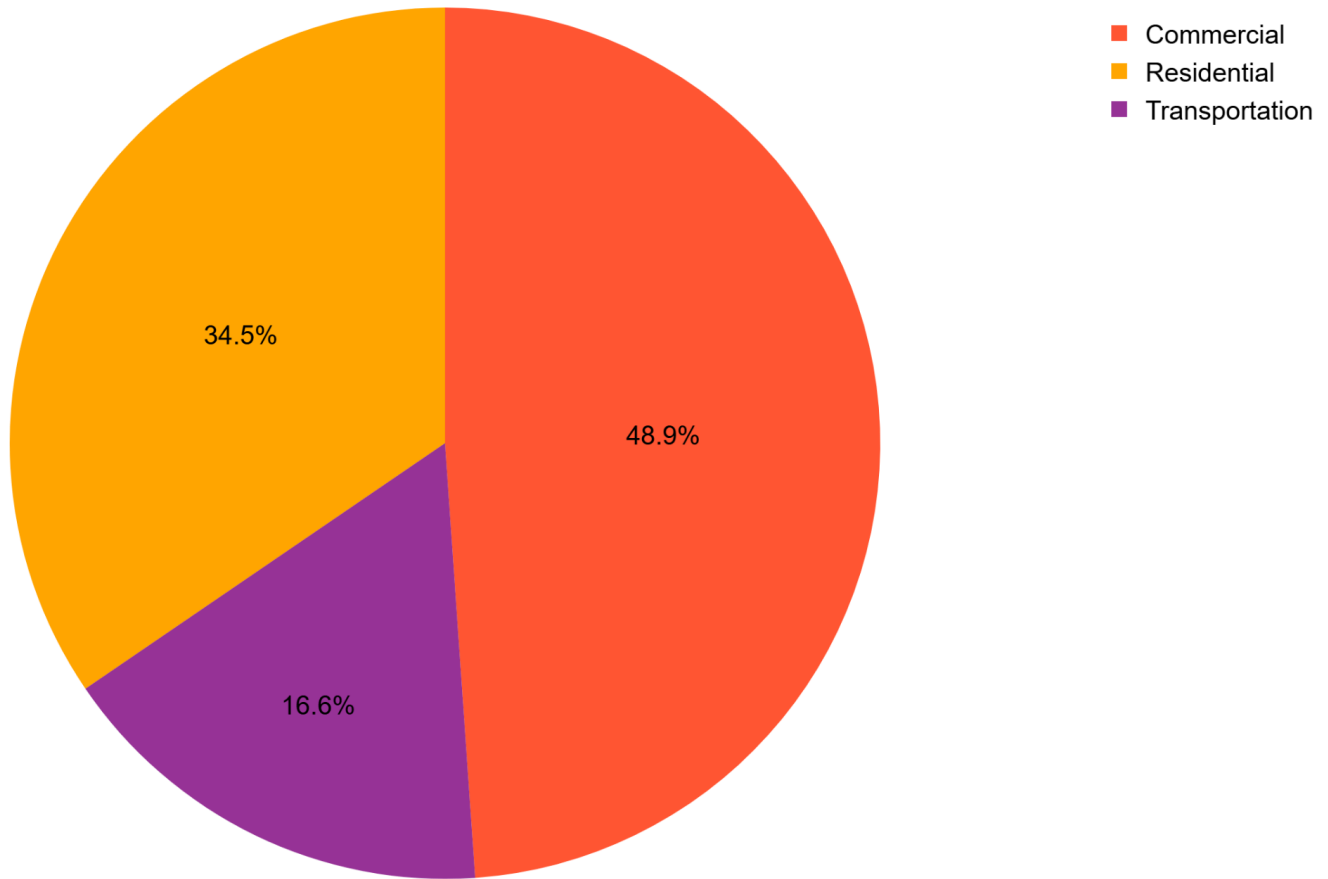
Energy Consumption Overview



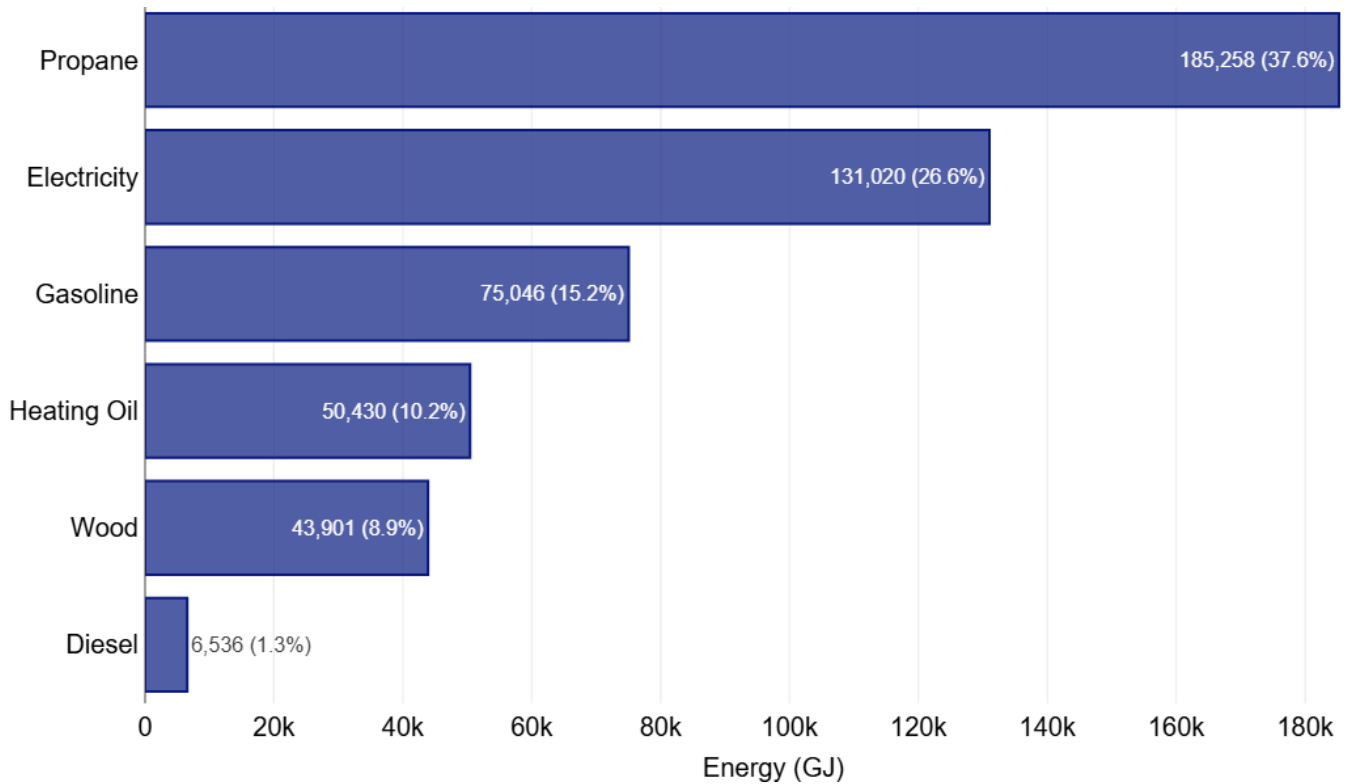
Energy Sankey Diagram



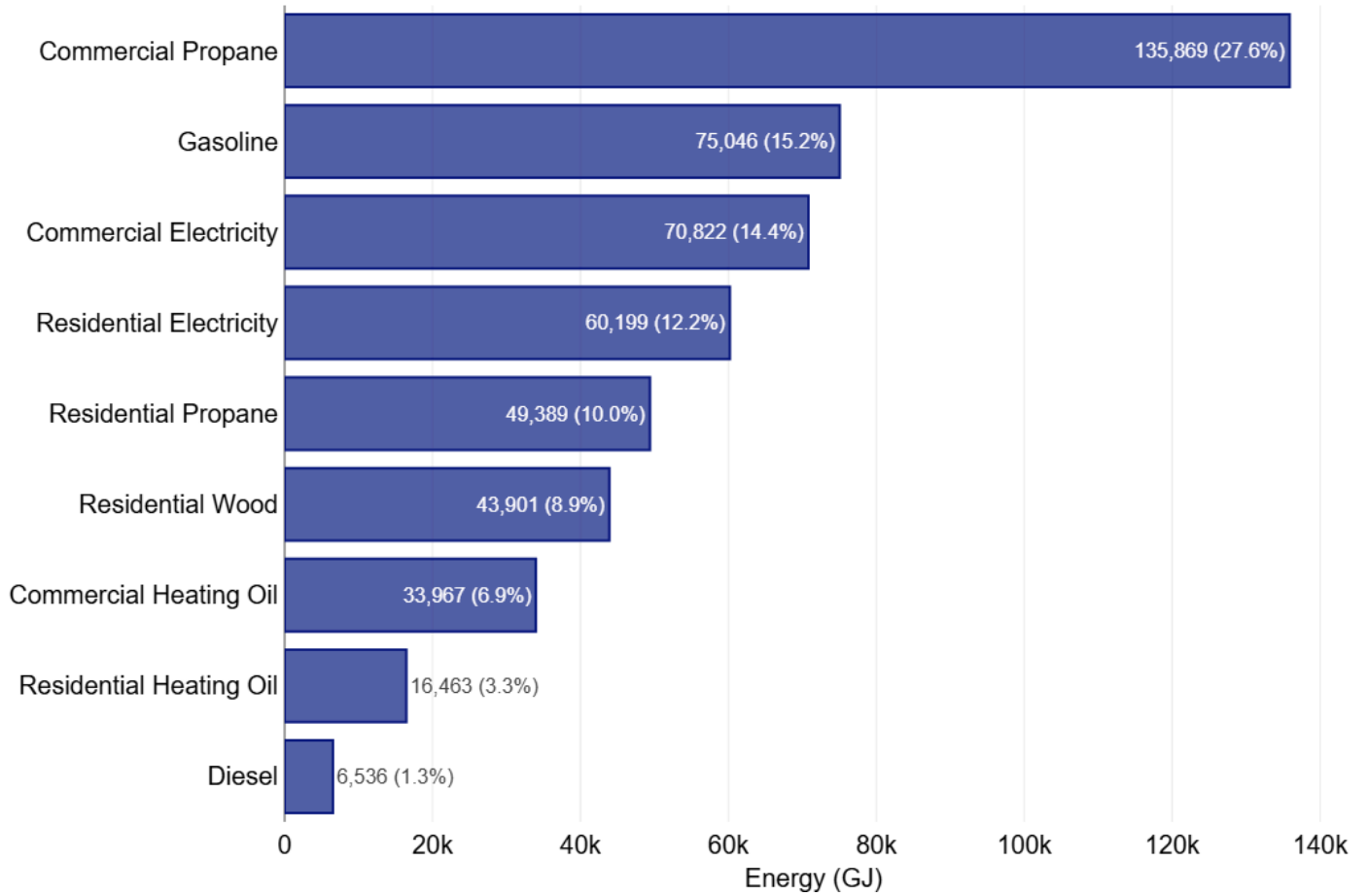
Energy Per Sector



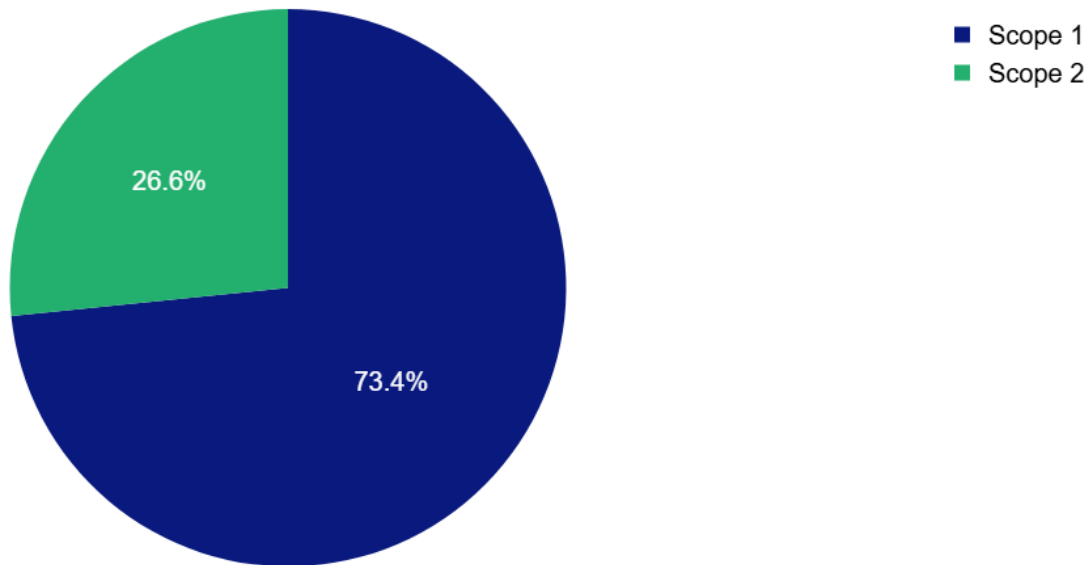
Energy Per Source (GJ)



Energy Per Source Sector



Energy Per Scope



Energy Cost Inventory Results

The estimated energy costs can be determined based on average annual prices for electricity, natural gas, propane, gasoline and diesel. An estimated \$17.5 million dollars was spent on energy in 2023 representing approximately \$6472 per capita. Propane had the greatest associated (34.7%) costs followed by electricity (29.1%), gasoline (19.8%) and heating oil (14.9%) and diesel (1.6%). The commercial sector had the highest associated costs (51.2%) followed by residential buildings (27.5%) and transportation (21.4%).

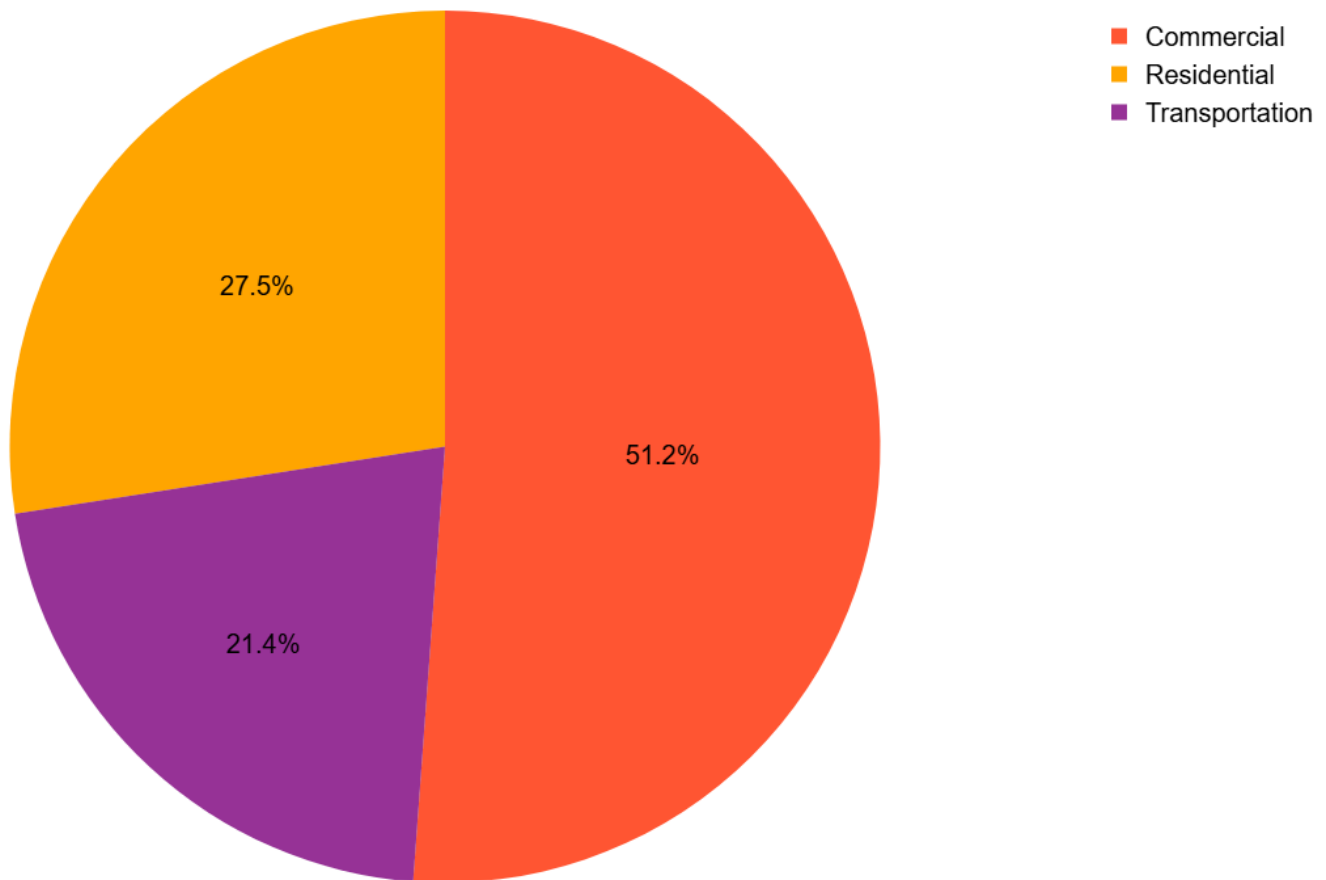
Energy Cost Overview

Total Energy Cost
\$17,507,596
\$CAD

Energy Cost per Capita
\$6,472
\$CAD / Person

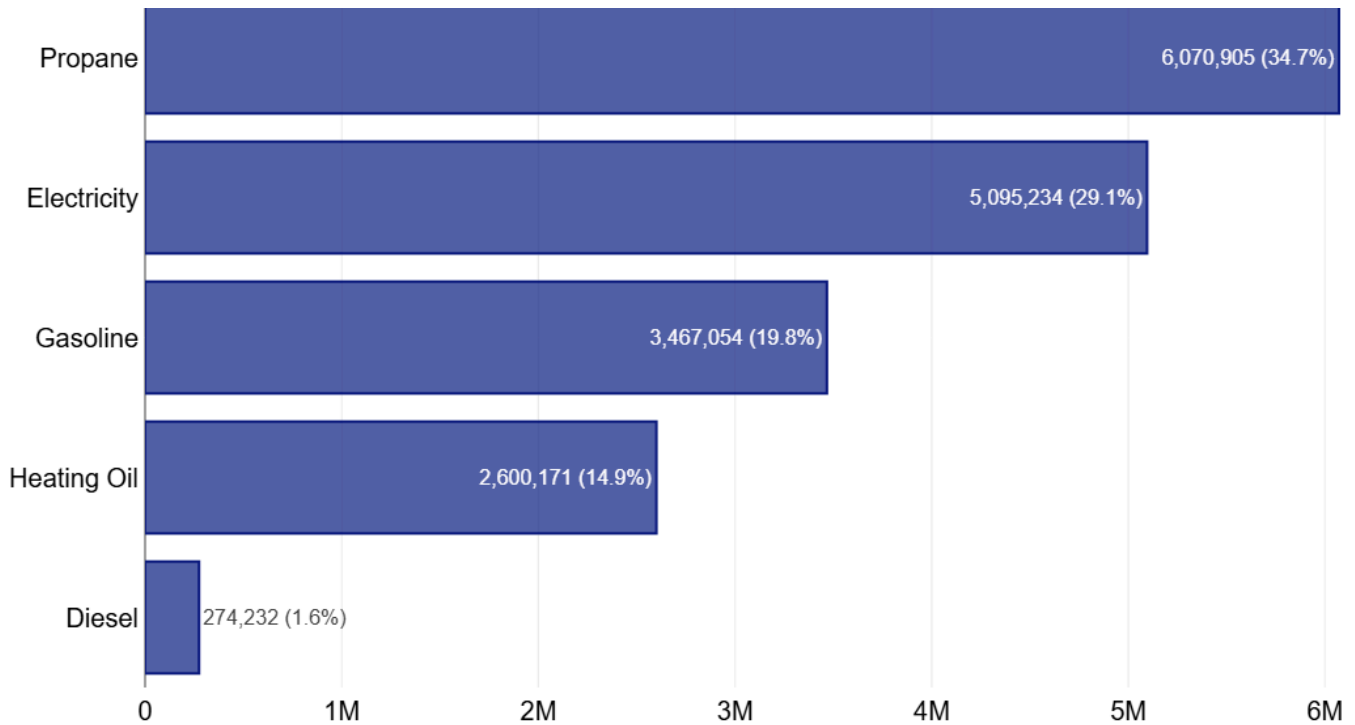
Average Cost per GJ
\$35
\$CAD

Energy Cost Per Sector

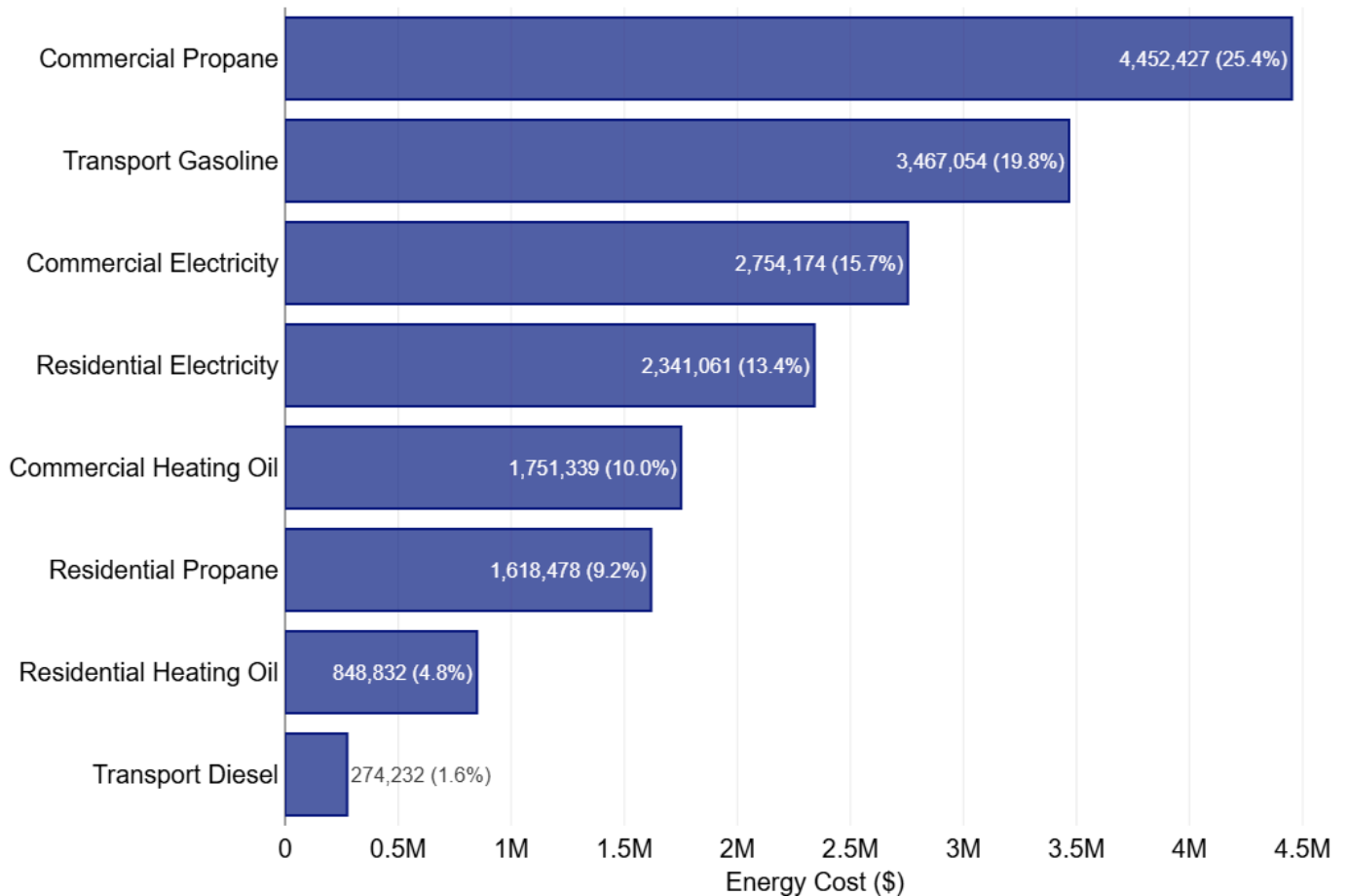


These energy cost metrics highlight the opportunity for significant savings when energy conservation actions are undertaken. A large proportion of energy costs leave the community. Energy cost savings can help stimulate economic development in the community, as more money is available for goods and services which support local businesses.

Energy Cost Per Source



Energy Cost Per Source and Sector

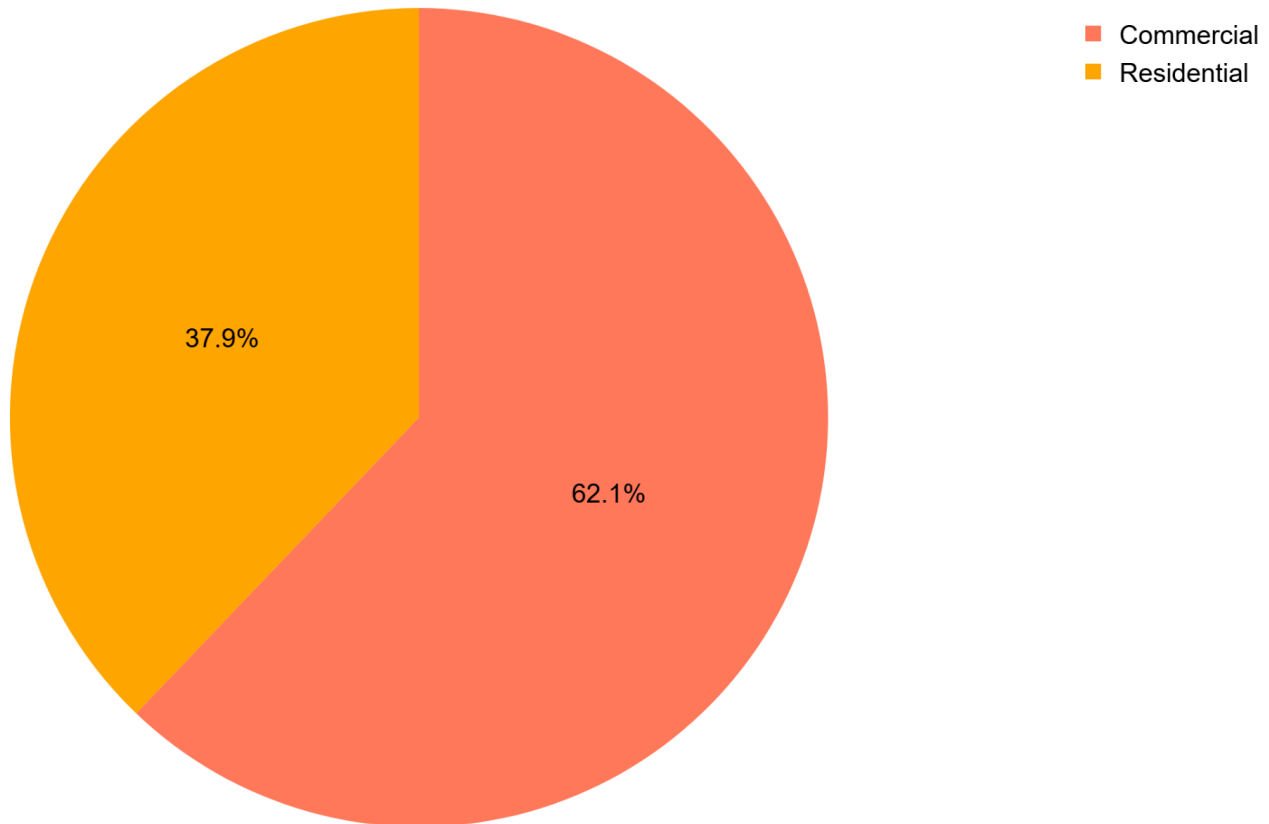


Baseline Results Discussion

Building Sectors

The building sectors include Residential, Commercial/Institutional, and Industrial buildings. Energy for these buildings is provided by natural gas and electricity. The supplied electricity data from Algoma Power has small commercial and large commercial consumption values. It can be ascertained that the large commercial classification would include industry as well, which accounts for the large proportion of building emissions allocated to commercial buildings.

Building Emissions by Building Type



Commercial buildings make up the majority of emissions (62.1%) for Wawa's buildings followed by residential buildings at (37.9%). According to the 2021 Statistics Canada Census of Population, Wawa consists of 1377 total private dwellings with 1213 residential dwellings occupied by usual residents. 82% of the occupied houses are single-detached houses (990). It has a very low population density of 6.6 persons per square kilometer.

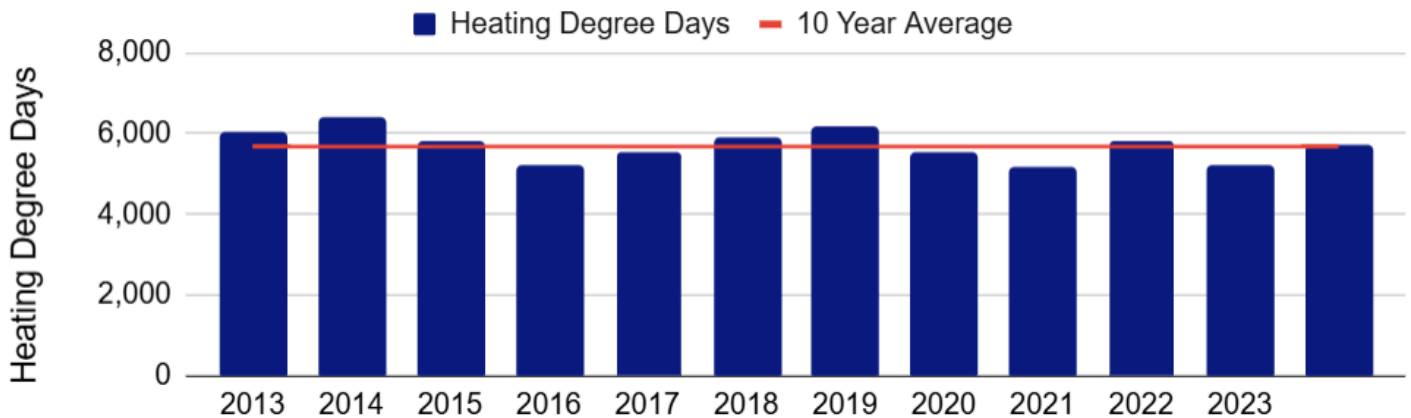
There is no direct source data available for consumption of heating oil, propane or wood. The quantities of these fuels for residential use was determined by considering the average Ontario energy consumption per household and adding an additional 30% to account for Wawa's colder temperatures. The total energy demand was then distributed between heating oil, propane and wood. This represents an estimate of consumption.

Impacts of Weather - Heating Degree Days and Cooling Degree Days

Emissions within the building sectors will be impacted by the weather conditions they experience throughout the inventory year. Heating Degree Days (HDD) and Cooling Degree Days (CDD) are two metrics which can be used to provide context to an inventory with regards to weather conditions.

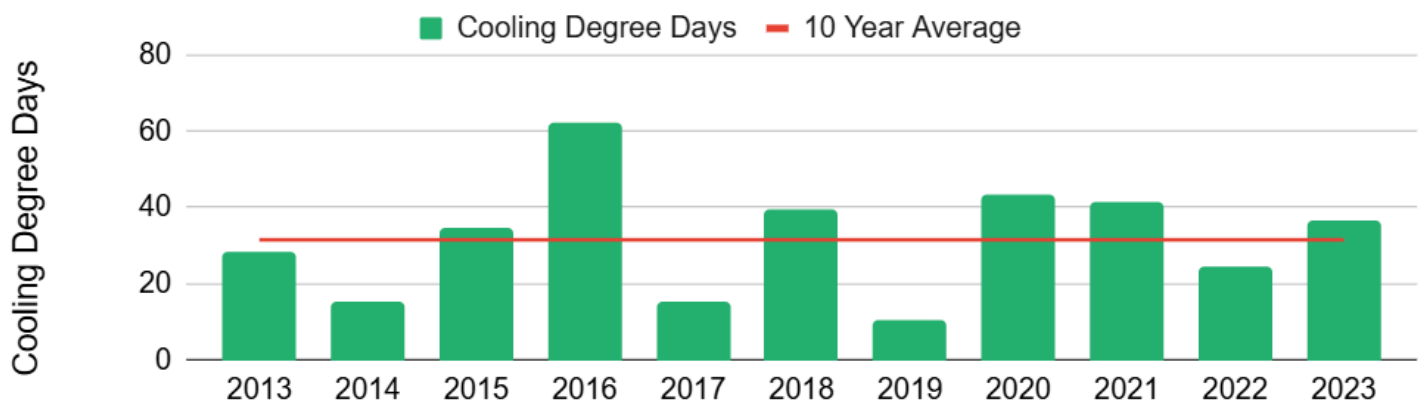
HDD is a measurement used to determine the heating demand on a building and is determined by adding together the hourly differences between outdoor air temperature and the indoor base temperature of 18 degrees celsius. For Wawa in 2023 there were 5,164 HDDs. This is slightly below the 10 year average of 5,678.

Heating Degree Days in 2023



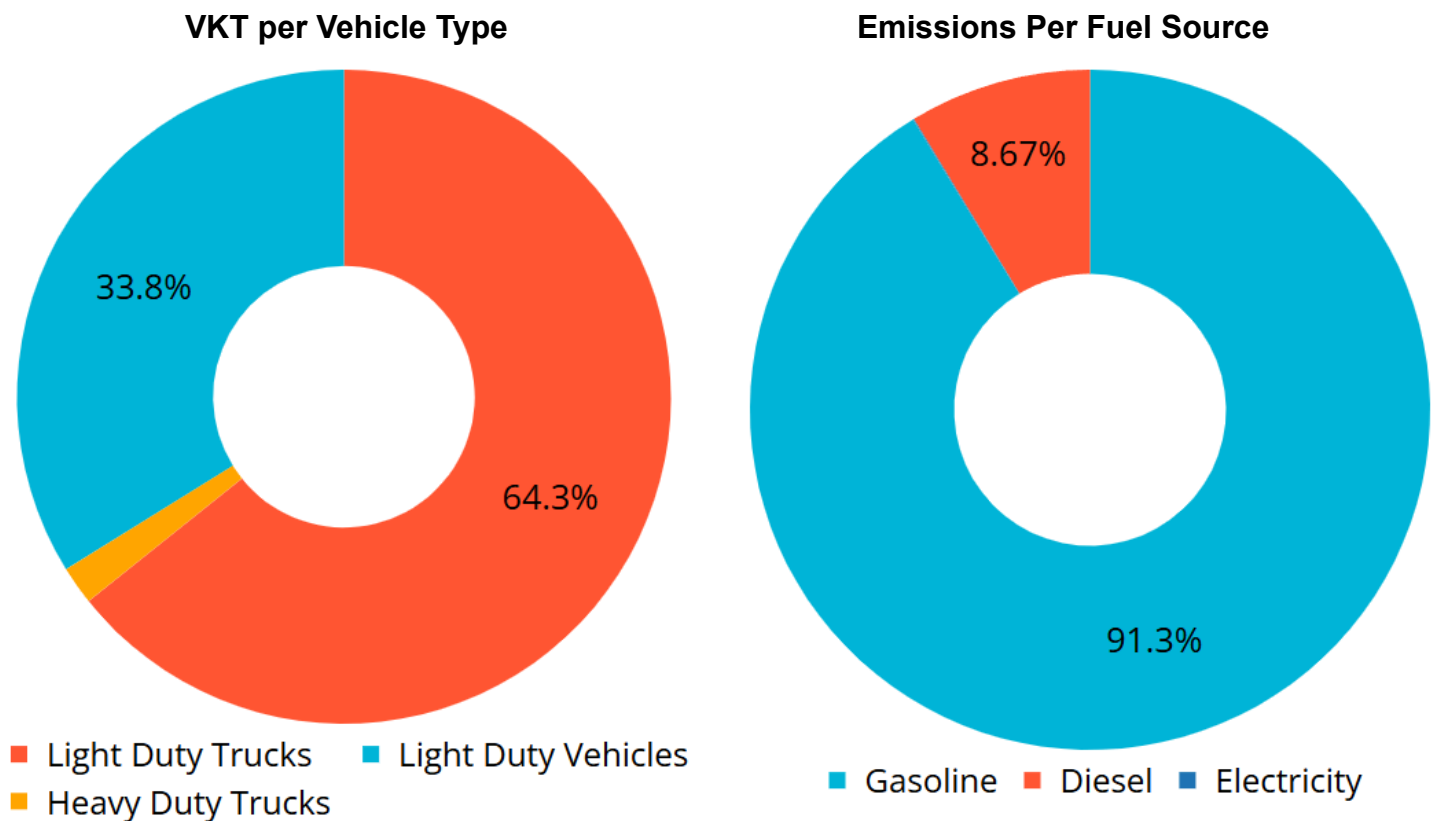
CDD are measured similarly for when the outdoor temperature is greater than the indoor temperature. For Wawa in 2023 there were 36 CDDs which is slightly higher than the ten year average of 32. Please see appendix A for temperature-weighted emission parameters.

Cooling Degree Days in 2023



Transportation Sector

The transportation sector results are based upon an analytical model called a Vehicle Kilometer Travelled (VKT) model which estimates the kilometers travelled by each vehicle type within the community based on provincial averages provided by the Natural Resources Canada Comprehensive Energy Use Database [5]. Ontario vehicle registration data is used to determine the average number of each vehicle type per Ontario household as well as the distribution of these vehicles between gasoline, diesel and electricity. Municipality of Wawa's average household size of 2.2 persons per household and population was applied to the model to determine the approximate number of vehicles in the community. The total vehicle kilometres travelled in the community for 2023 is 27,747,890 km which equates to 10,258 km per person. Given Wawa's northern location, it is likely that transportation sector emissions are underestimated by the model.



Light duty trucks are the most popular vehicles in Ontario and include trucks, sports utility vehicles (SUV) and vans weighing 4,526 kg or less. The model does not include emissions from heavy duty freight trucks with weights in excess of 11,794 kg.

The vast majority of transportation is provided by vehicles powered by internal combustion engines (ICE). The model includes 1.4% EVs and 2.2% hybrids for light duty vehicles and 0.4% EVs and 1.4% hybrids for light duty trucks. The emissions from electricity do not appear on the emissions per fuel source pie chart as they are extremely low. It is anticipated that these proportions will increase as infrastructure and Canadian EV manufacturing develops.

Waste Sector

The waste sector includes emissions from solid waste that result from the decomposition of organic waste material in a landfill. Solid waste generated in Wawa is disposed of at the Municipality of Wawa Landfill. This landfill does not feature any landfill gas recovery.

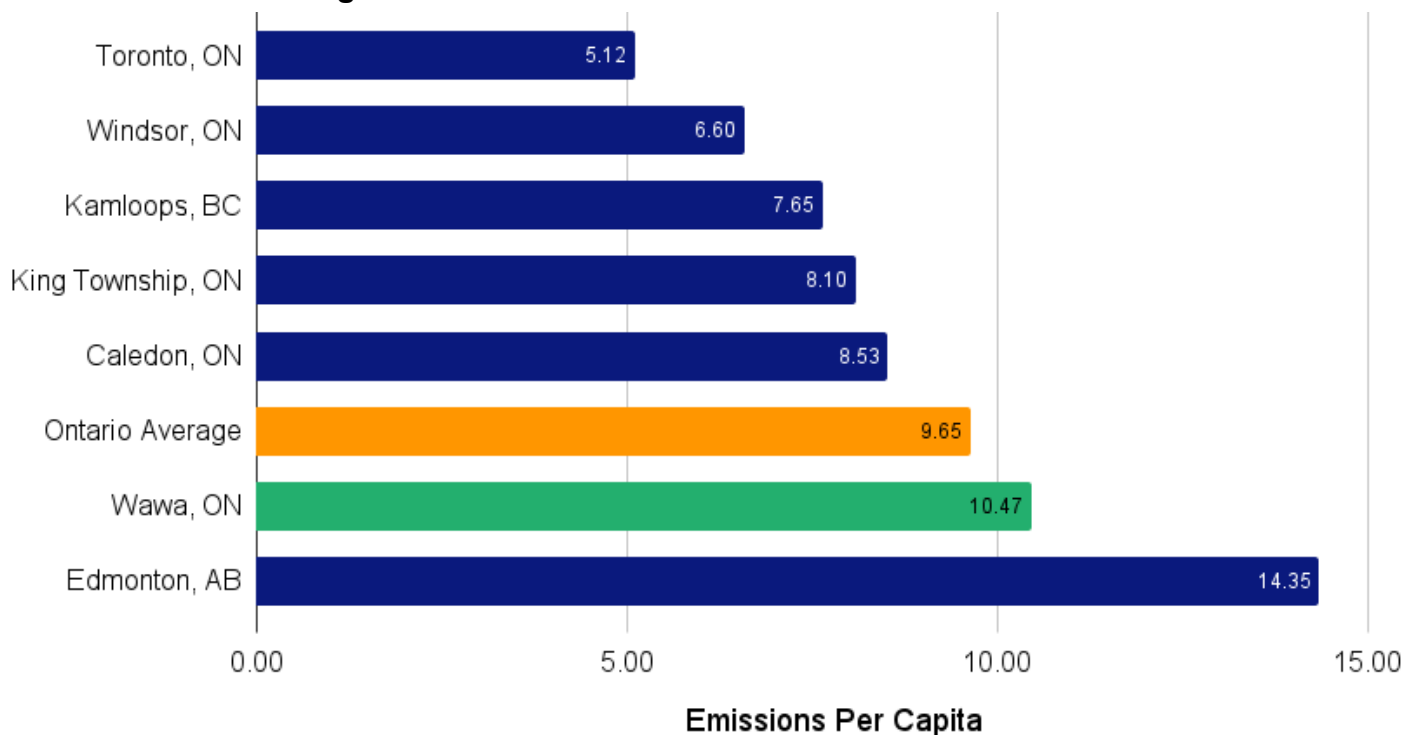
In 2023, an estimated total of 2705 tonnes of municipal solid waste was processed. The estimated average waste generated is 1000 kg per person based on data from the regional level. This is 41% above the Ontario average for waste disposal of 709 kg per person [5]. There is no curbside recycling or organics collection in Wawa which contributes to this high quantity of waste.

Benchmarking Baseline Results

The results of the baseline emissions inventory are used to determine the relative emissions performance of Wawa when compared to other municipalities within Ontario and across Canada.

In general, the amount of buildings, vehicles, and waste will increase when a community grows as additional houses, and services are added and enhanced to meet the growing population. The emissions results can be considered on a per capita basis to allow for comparisons to be made between communities of differing sizes. Population-weighted benchmarking data is displayed below.

Emissions Benchmarking



Wawa has higher emissions levels than the majority of communities included in the benchmarking set but this is expected given the significantly colder climate and associated increase in heating demand. Wawa has slightly higher emissions (8.5%) than the provincial average but when the biogenic emissions from wood are removed from the total, Wawa's levels are approximately equal to the average. This should be a point of pride for the community as it is significantly colder than the Ontario average, yet maintains comparable emissions. Wawa does not have a natural gas connection and as such approximately two-thirds of homes use propane or heating oil which has a higher emissions intensity. All communities in Canada have considerably higher levels than the global best practise of 1.3 TCO₂e achieved by Copenhagen, Denmark which is on track to achieve net-zero by 2030 [6].

There are significant opportunities for improvement which can move the community towards a net-zero pathway and these will be explored further in the Mitigation Action Development section of this report.

Future Emissions Projections 2023 - 2050

Business-As-Usual Forecast

With baseline emissions and energy levels established, an emissions forecast analysis can be conducted to determine the business-as-usual (BAU) scenario for the community. This business-as-usual scenario includes population dynamics as well as projected changes in energy supply and demand.

The BAU represents the “do nothing” scenario where no additional efforts are made by the community to enhance the environmental sustainability of Wawa. Under the BAU, emissions increase in response to growing population and electricity supply changes.

Population Growth

Wawa is poised for modest population growth for the 2023 - 2050 period. This will result in a forecasted slight increase in community emissions, as the buildings, vehicles and waste generation increases with the small increase in demand from new residents.

Based on the results from the 2021 Census, Wawa decreased in size slightly from 2,905 to 2,705 residents between 2016 and 2021. New job opportunities in the wood products and mining industries suggest that Wawa is poised for growth. To account for this new growth a modest population growth rate 0.5% is being applied for this analysis. This growth rate is well below the provincial average of 1.1%

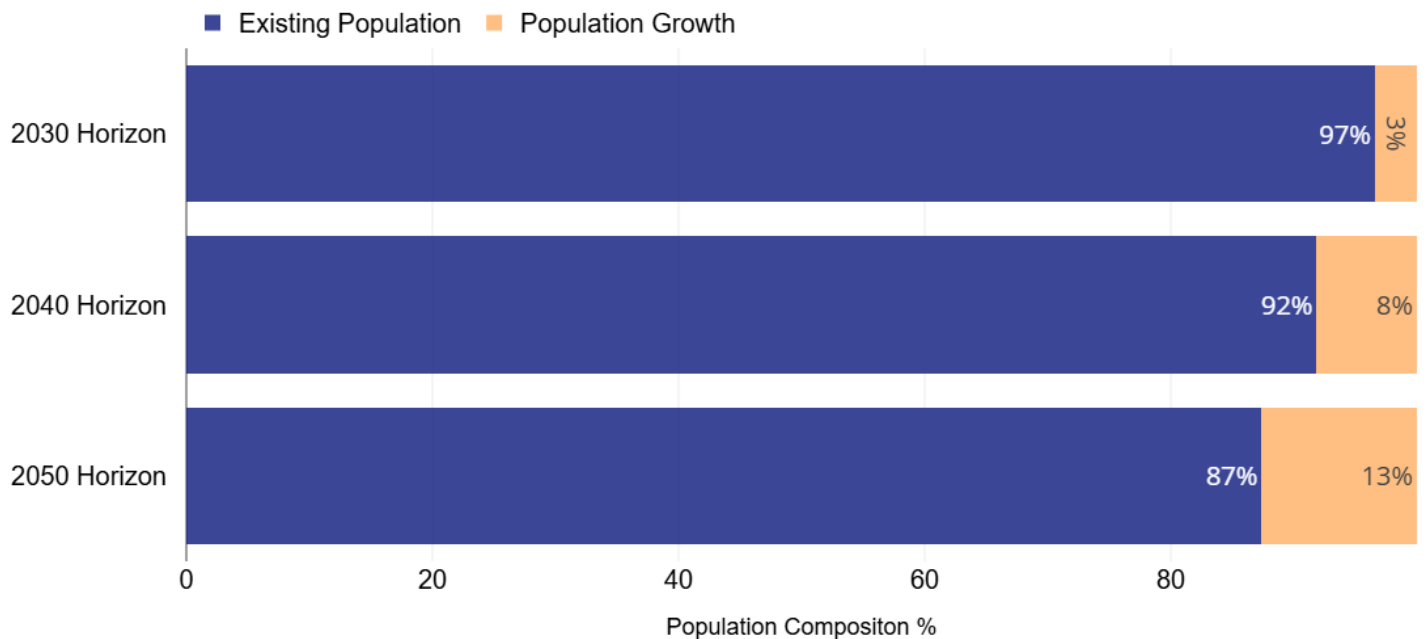
Using this annual average growth rate of 0.5%, the estimated projected populations can be determined for the planning horizons as outlined in the table below.

Milestone Year	Population
Baseline 2023	2,705
2030	2,801
2040	2,945
2050	3,096

Population Growth Proportions

The projected populations can be analyzed to determine the distribution between the population that currently lives in Wawa vs. population growth. This outlines the increased demand for services and amenities within the community. The figure below displays these population proportions. This highlights a key consideration for net-zero planning in that the majority of future emissions will depend upon the energy demand of those currently living in Wawa. This dynamic is unique to rural and remote communities with low population growth and stands contrary to considerations for high-growth towns and cities where future emissions levels are driven by energy demand from new members of the community.

Population Growth Proportion Bar Chart



Ontario Electricity Supply Mixture

The emissions forecast for the BAU scenario depends significantly on changes which will occur to the Ontario electricity grid as it responds to growing demand from provincial population growth. The emissions resulting from electricity consumption is dependent upon the supply generation mix between low-carbon (hydro, nuclear, wind and solar) and fossil-fuel (natural gas) based sources powering the electricity grid. Between 2005 and 2018, Ontario's emissions from electricity were reduced by 90% through the elimination of coal-powered generation.

The electricity grid can be considered as an independent variable in the projection modelling and it is to be recognised as outside the control of the municipality.

Ontario Grid Outlook

Ontario's grid operator, the Independent Energy System Operator (IESO), publishes annual reports outlining the generation / demand / and supply projections for future years [7]. Based on the recently published outlook reports, it is anticipated that emissions from electricity will increase as natural gas generation is further installed to meet increased peak and base load demands and offsets the generation provided by nuclear facilities scheduled for decommissioning.

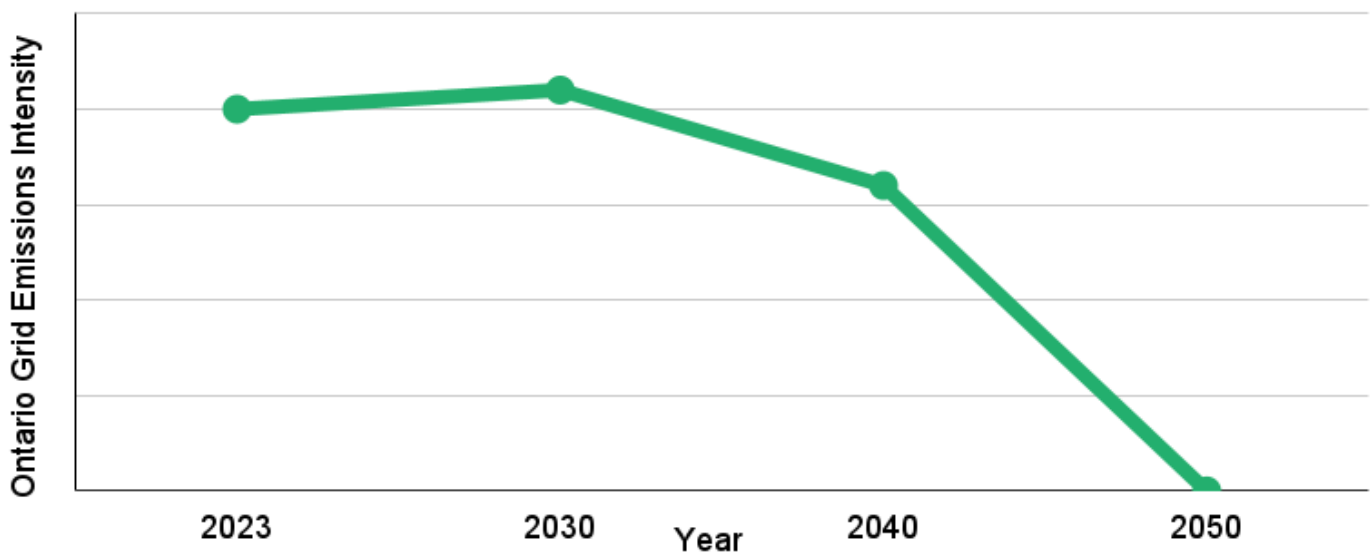
From a community energy planning perspective, there is a high level of uncertainty in predicting the most likely grid scenario and this modelling represents one possible outcome. By utilizing data from the baseline inventory analysis and isolating the impact on the grid from population dynamics, the impact of grid changes on future emissions are accounted for in the projections provided.

Powering Canada Forward

For the pathway modelling of this report, the development of the grid is consistent with the *Powering Canada Forward: Building a Clean, Affordable and Reliable Electricity System for every region of Canada* [8] plan published by Natural Resources Canada which outlines federal mandates and plans toward a net-zero electricity sector. The plan outlines how renewable resources will be further developed and integrated on each provincial grid, such to achieve this goal. The low-carbon trajectory for Ontario grid emissions is further supported by the Clean Electricity Regulations which were passed into law in late 2024 [9].

The BAU projection includes a 5% increase in grid emissions for 2030, a 20% decrease for 2040 and a 100% decrease by 2050 which represents a net-zero grid as depicted below. These projected changes are measured relative to the emissions intensity for the baseline year 2023. These are estimates and can be considered a best case scenario for the Ontario grid.

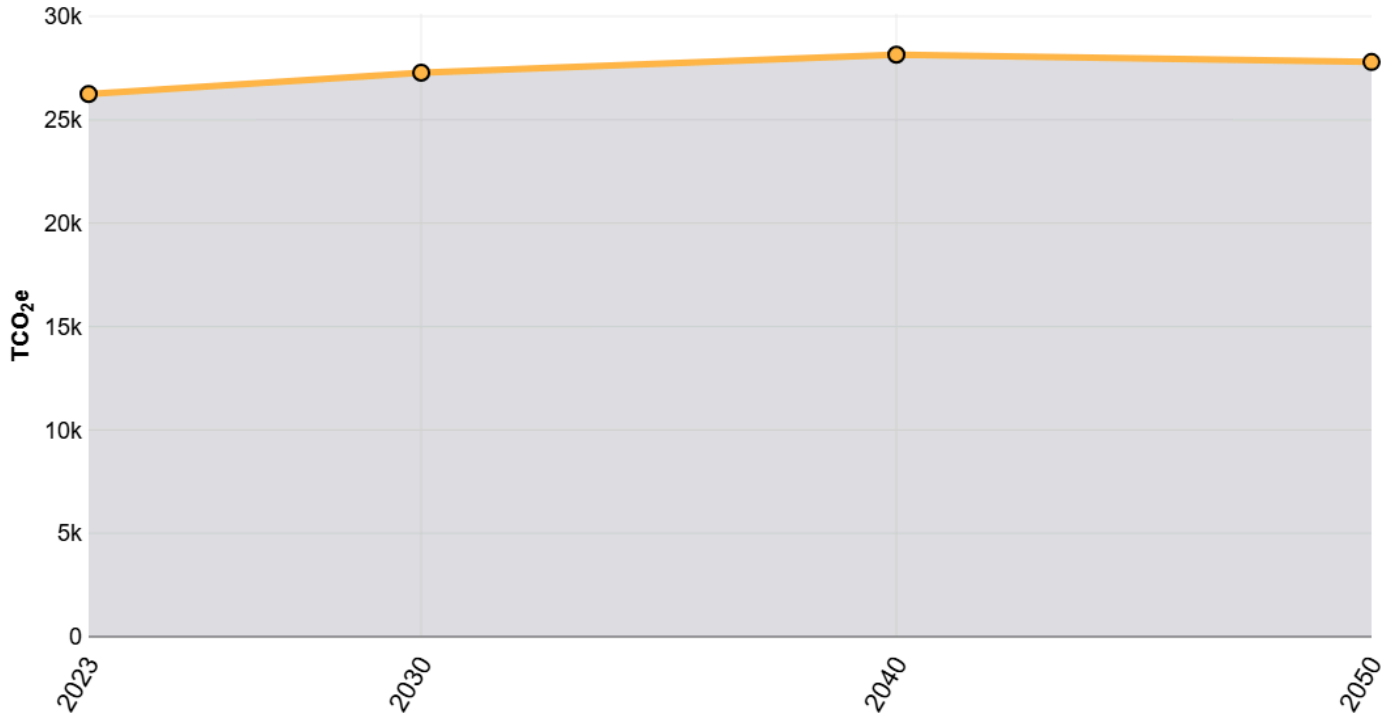
Projected Ontario Grid Emissions Intensity Changes 2023 - 2050



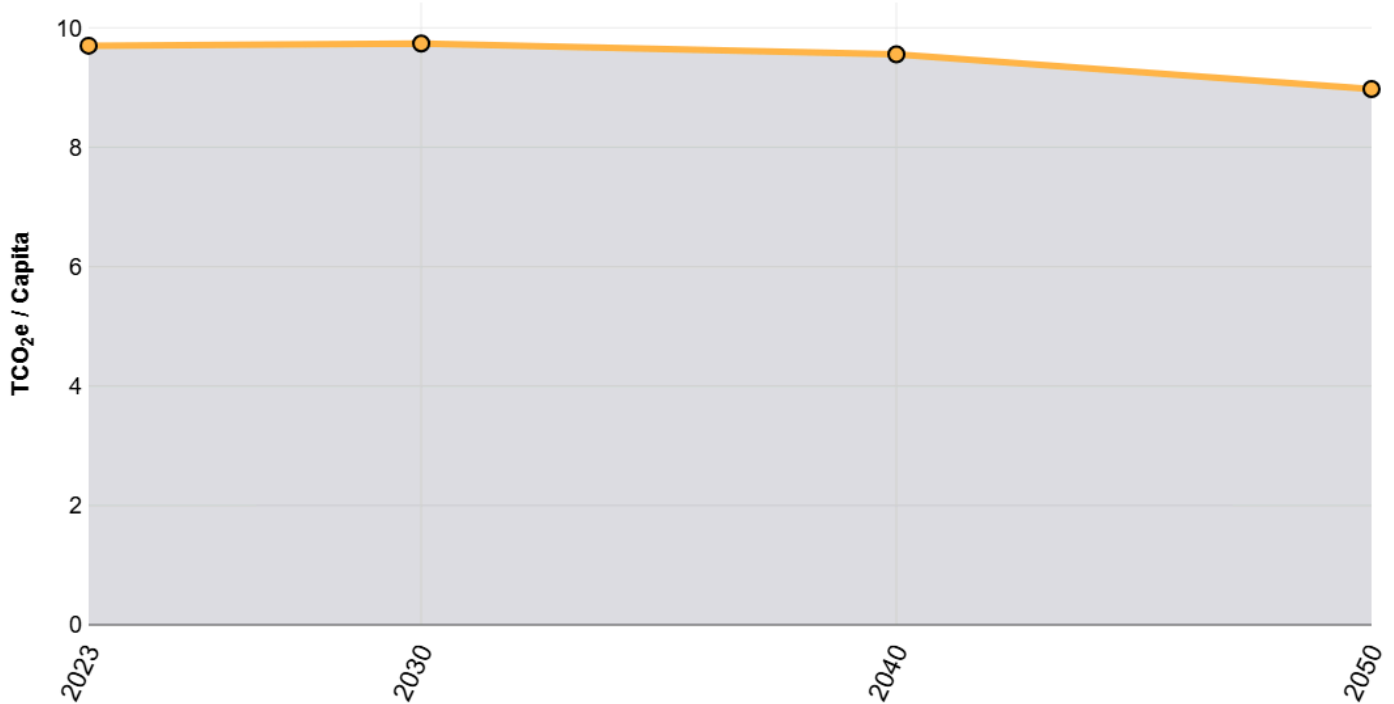
Emissions Projections Results

Using the population growth and grid impacts, the overall emissions and per capita emissions can be projected from the baseline year to 2050 as displayed below.

Wawa's Overall BAU Emissions Projection



Wawa's Per-Capita BAU Emissions Projection



Business-As-Usual Emissions Projection

Year	Population	BAU Emissions	Emissions Per Capita
2023 Baseline	2,705	26,247	9.70
2030	2,801	27,279	9.74
2040	2,945	28,147	9.56
2050	3,096	27,791	8.98

Projected Increases Over Baseline Levels

Year	Total Increase Over Baseline
2030	3.93%
2040	7.24%
2050	5.88%

The results of the emissions pathway projection indicate that without action overall community scope emissions from Wawa will increase slightly from the baseline level of approximately 26,247 tonnes to 27,791 tonnes by 2050 (5.88% increase). Projected population growth and the new buildings, vehicles and solid waste associated with this growth are driving this small increase.

On a per capita basis, the emissions are projected to increase minimally in the short term, however slight reductions in the long-term are included in the model as a result of improvements to the Ontario electricity grid per the *Powering Canada Forward* Plan discussed above.

Using this Business-As-Usual projection we can now investigate and apply mitigation measures to reduce emissions towards a net-zero goal.

Mitigation Action Development

Based upon community engagement and input (conducted by QUEST), 14 actions have been selected for reducing emissions and energy consumption for Wawa. These actions work together to inform the municipality's sustainable development from its baseline year of 2023 through to the 2030, 2040, and 2050 planning horizons.

The mitigation modelling conducted and actions discussed provide a roadmap for net-zero emissions by 2050. The intention is that this roadmap will help motivate and accelerate the community towards the net-zero goal.

Types of Mitigation Actions

The actions within this net-zero plan can be classified by four main types of emissions mitigation. These types are outlined below and are to be applied in the order presented.

Energy Conservation



Behavioural aspects relating to how assets are utilized and operated which can reduce the energy demand. Conservation is the most cost effective of mitigation actions.

Energy Efficiency



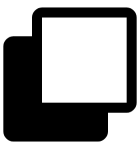
Investment in equipment which can more effectively convert source energy into usable energy in order to meet a given energy demand. For example LEDs bulbs convert electricity to usable light more efficiently than incandescent bulbs.

Fuel Switching



Changing the energy source used to meet a given energy demand with a lower emitting energy source. For example, switching an ICE vehicle to an EV.

Compensatory Mitigation



The reduction of accounted emissions by offsetting of emissions through carbon sequestration or the purchase of emissions offset credits. Compensatory mitigation was not included in this plan.

The goal of the modelling exercise is to outline a pathway to achieve a target of 90%+ reduction in emissions which is representative of net-zero. This is a “top-down” modelling approach. Emissions savings parameters for each action are set based on technical considerations relating to the action being applied. Participation rates are set based on what is required to achieve a net-zero trajectory and it is recommended that these are a point of future discussion with the community climate task force.

The small magnitude of remaining emissions are likely offset by carbon sequestered by trees located in Wawa.

Building Sector Actions

Energy Conservation

Reduction of energy consumption through behavioral aspects and basic building maintenance. Energy conservation is the lowest cost option for emissions reduction from the building sector.

Energy conservation activities include:

- Lowering the thermostat during winter
- Reducing air conditioning during summer
- Shutting off lights and electronics when not in use. Automated light sensors
- Installing and using Smart thermostats to better control heating and cooling
- Ensuring that doors and windows seal shut properly to avoid air leaks
- Framing around windows and doors is properly sealed to avoid air leaks
- Changing furnace filter at regular intervals to ensure it is operating properly
- Use blinds and curtains to reduce heat gain for south facing windows in the summer

Energy conservation has the co-benefits of reduced energy costs and improved home comfort.

Mitigation Type	Conservation
Emissions Reduction Potential	100% for energy that is conserved
Key Performance Indicators	Residential energy consumption, Commercial energy consumption
Participation	Average reductions achieved relative to baseline levels 15% by 2030, 20% by 2040, 25% by 2050 for residential dwellings. 20% by 2030, 25% by 2040, 35% by 2050 for commercial and industrial buildings.

Building Retrofits

These retrofits involve upgrading existing homes and businesses with energy-efficient technologies and practices, aiming to decrease energy consumption, lower greenhouse gas emissions, and enhance overall comfort and resilience. Municipalities recognize that a substantial portion of their carbon footprint stems from residential buildings, making energy retrofits a strategic focal point.

Key retrofitting actions include:

- Increased insulation for walls, basements, attics
- High efficiency windows and doors
- High efficiency heating systems
- Improved air sealing of building envelope

Municipalities can support building retrofits by leveraging funding streams provided by the Federal and Provincial governments.

Building retrofits have the co-benefits of reduced energy cost, improved home comfort and positive economic impacts. Comprehensive energy retrofits not only contribute to emissions reductions but also stimulate economic growth by creating green jobs and fostering a sustainable housing market. Moreover, these initiatives enhance the resilience of homes, making them more resilient to extreme weather events, which is crucial in the face of climate change.

Mitigation Type	Conservation and Efficiency
Emissions Reduction Potential	Reductions relative to baseline levels: 30% for 2030, 50% for 2040, 60% for 2050 for residential dwellings. 35% for 2030, 55% for 2040, 65% for 2050 for commercial buildings
Key Performance Indicators	Number of homes retrofitted, emissions per household, residential building emissions
Participation	30% of buildings by 2030, 55% by 2040, and 95% by 2050

Green Development Standards

As new buildings are constructed to meet population growth, the new buildings will be of increased efficiency compared to the existing building stock. This is due to the increases in minimum energy performance which have been introduced to the building code. This effect can be further enhanced with development standards established by the community which require higher levels of energy efficiency and performance relative to the building code minimum standards.

The difference in performance between existing buildings and new builds will be dependent on the age and composition of the existing building stock as well as the standards relevant at the time of construction.

Mitigation Type	Efficiency
Emissions Reduction Potential	45% for 2030, 55% for 2040, 65% for 2050 for residential dwellings 50% for 2030, 60% for 2040, 80% for 2050 for commercial buildings
Key Performance Indicators	Number of new buildings constructed to higher efficiency standards
Participation	Applies to all new builds

Fuel Switching for Buildings

Fuel switching from fossil fuel based heating source (propane, heating oil) to electric heating with a heat pump is a strategic and environmentally friendly choice for heating in residential or commercial buildings. This transition offers several benefits, including energy efficiency, reduced greenhouse gas emissions, and long-term cost savings.

Heat pumps utilize electricity in conjunction with the thermal energy of the air or ground to produce heating and cooling at a very high efficiency.

Utilizes the renewable energy of the sun which is transferred to the air or ground. The efficiency of a heat pump will depend greatly upon the outdoor temperature and efficiency drastically decreases at low temperatures below -20 degrees Celsius depending on the system specifications. Given the large proportion of propane used for heating, heat pumps represent an excellent low-emissions upgrade for when the propane systems are due for decommissioning.

For cold climates, such as Wawa, the heat pump system can be combined with an auxiliary heating source to provide heating on the coldest days when the heat pump is not adequate. In general, for net-zero planning the auxiliary heating can be supplied by renewable natural gas or sustainable biomass (wood).

The fuel switching mitigation action in the net-zero model also includes solar, and biomass discussed below.

Mitigation Type	Fuel Switching
Emissions Reduction Potential	Reductions will depend upon the Coefficient of Performance (COP) of the heat pump system as well as the emissions intensity of the electricity grid. For low emissions grids 90% to 100%. When operating on a net-zero grid, the emissions savings are 100%. 90% for 2030, 95% for 2040, 100% for 2050
Key Performance Indicators	Building emissions
Participation	35% for 2030, 65% for 2040, 90% for 2050 for residential dwellings 35% for 2030, 65% for 2040, 90% for 2050 for commercial and industrial buildings

Solar Energy

Residential solar systems can be applied to reduce emissions from electricity through solar photovoltaic (PV) systems and emissions from heating through solar thermal systems. Solar PV can be tied into the electricity grid which works to reduce the overall emissions intensity of grid electricity. They can also be applied in off-grid systems which supply electricity directly to the buildings. These standalone systems have particular benefits in remote communities where grid connection may be limited and can alleviate grid transmission capacity issues for growing rural communities.

For the interconnection of multiple buildings, microgrids can be applied. Microgrids are localized electricity systems which can operate independently of the grid integrating distributed generation resources such as solar energy and other renewable resources with battery storage.

Solar thermal systems reduce emissions by offsetting fossil fuel usage (natural gas, propane, heating oil) for water heating.

Mitigation Type	Fuel Switching
Emissions Reduction Potential	Contributes 100% reduction when offsetting energy previously supplied by fossil fuels. Works to lower grid emissions intensity for grid tied systems.
Key Performance Indicators	kW of local solar capacity

Sustainable Biomass (Wood) for Heating

The use of wood for space and water heating can represent a carbon-neutral energy supply where sustainable practices are applied in the harvest, acquisition and use of the wood fuel. Wood can be sourced from lands where sustainable forestry practices are in place or from waste wood sources, which would otherwise be disposed of through open burning or landfill.

The efficient use of wood for heating can be ensured through the utilization of high-efficiency wood stoves in conjunction with proper maintenance practices. For rural and remote communities biomass is an important component of energy supply and the environmental benefits can be enhanced through sustainable practices. Biomass can work in conjunction with heat pumps to meet auxiliary heating demands.

Mitigation Type	Fuel Switching
Emissions Reduction Potential	100% when displacing a fossil fuel
Key Performance Indicators	Building emissions

Transportation Sector Actions

Active Transportation

Active transportation refers to any human-powered mode of transportation, primarily walking and cycling, that relies on physical effort rather than motorized vehicles. It is an essential component of sustainable urban mobility and offers numerous benefits to individuals, communities, and the environment. Active transportation works to address upstream causes of emissions by reducing the amount of trips which are completed with a vehicle and therefore reducing energy demand.

Municipalities can support active transportation through cycling infrastructure, connected trail systems as well as ebike/escooter rental programs. For the purposes of mitigation modelling, public transit can also be considered a form of active transportation.

The active transportation action has been adjusted to reflect Wawa's cold climate, where active means of transportation can be more difficult compared to milder locations. Despite the challenges of winter cycling and walking, there are many examples of cold communities with a high modal split. Sweden has an average modal split of 30% despite having cold weather most of the year [10]. Wawa can look to best practices applied in nordic communities to develop its active transportation infrastructure.

Mitigation Type	Conservation
Emissions Reduction Potential	100% reduction for trips made through active means vs. ICE powered vehicle
Key Performance Indicators	Modal split
Participation	Increase in proportion of trips completed via active transportation methods relative to baseline levels: 5% for 2030, 8% for 2040, 10% for 2050

Vehicle Right-Sizing

Vehicle right-sizing is an emissions reduction strategy that focuses on matching the size and type of vehicles to the specific needs of users or organizations. This approach is gaining attention, especially in North America as a way to reduce greenhouse gas emissions, improve fuel efficiency, and optimize transportation resources.

The opportunities for emissions reduction through right-sizing are very significant in Ontario, where currently the majority of vehicles are light-duty trucks.

Mitigation Type	Conservation
Emissions Reduction Potential	Dependent on vehicle specific parameters. Replacing a pick-up truck or SUV with a car can result in 20% to 30% fuel consumption and emissions savings. 25% savings was used in the model
Key Performance Indicators	Number of cars vs. light duty trucks per household
Participation	15% for 2030, 20% for 2040, 40% for 2050

Electric Vehicles

Replacing existing internal combustion engine (ICE) powered, light-duty vehicles with electric vehicles results in significant emissions savings when coupled with a low-emitting electricity grid. By transitioning to electric vehicles, communities can effectively decrease their carbon footprint and improve local air quality, promoting a healthier and more sustainable environment for residents. EVs produce zero tailpipe emissions, eliminating harmful pollutants such as carbon dioxide, nitrogen oxides, and particulate matter that contribute to climate change and respiratory diseases.

EVs can lose a portion of their driving range when operated in cold weather. To combat this effect, many modern EVs offer optional heat pump cabin heating systems which reduce the range loss. Despite the cold-weather considerations, many countries with cold climates have achieved high EV uptake such as Norway where 79% of new vehicles sales were electric in 2022 [11].

Wawa currently has 8 EV charging stations across the municipality. It is anticipated that expanded charging access as well as EV incentive programs and EV mandates will improve the uptake of EV vehicles.

Mitigation Type	Fuel Switching
Emissions Reduction Potential	95% for 2030, 97% for 2040, 100% for 2050
Key Performance Indicators	Transportation emissions, number of local EV charging stations
Participation	20% for 2030, 50% for 2040, 75% for 2050

Biofuel Utilization

Biofuels are fuels derived from biological materials such as plants, agricultural crops, algae or organic waste instead of fossil fuel sources. The primary biofuels for the transportation sector include ethanol, biodiesel and renewable diesel. Biofuel blends are currently in use in many Canadian provinces with minimum required biofuel percentages established for gasoline and diesel. It is anticipated that these requirements will continue to increase over time in response to standards established provincially or federally.

The utilization of biofuels is useful for net-zero planning by addressing emissions for existing internal combustion vehicles and providing a carbon neutral alternative to EVs for trucks and equipment which may be difficult to electrify.

Mitigation Type	Fuel Switching
Emissions Reduction Potential	Average savings for biofuel blends 20% for 2030, 40% for 2040, 80% for 2050
Key Performance Indicators	Biofuel composition requirements, biofuel sales, transportation emissions
Participation	Applied to ICE vehicles 50% for 2030, 60% for 2040, 95% for 2050

Waste Sector Actions

Waste Reduction & Prevention

This action works to address the upstream causes of emissions within the waste sector through the reduction of the waste mass sent to the landfill. There are a variety of factors which can contribute to the reduction and prevention of waste. Canada's single use plastics ban contributes to reductions by preventing disposable plastics from being generated. Another Federal policy known as the "right to repair" legislation was passed in 2024 which enhances the repairability and reuse of electronics and appliances thereby reducing waste [12].

Consumer behavior also plays a large role whereby consumers can prioritize products with less packaging which in-turn will influence manufacturers and producers to adjust their packaging practices to meet this change in demand. Many municipalities across the country have reduced waste tonnage through "Pay-as-you-throw" policies which charge households based on waste generated therefore incentivizing waste minimization.

Mitigation Type	Conservation
Emissions Reduction Potential	100% reduction for waste mass reduced from baseline levels
Key Performance Indicators	Waste generated per capita
Participation	5% for 2030, 10% for 2040, 20% for 2050

Increased Recycling Rates

Increased recycling rates address the midstream impacts of waste by addressing the potential emissions of materials already in circulation. Of particular focus are paper and cardboard waste products which are organic in nature and will decompose into methane within a landfill environment, leading to significant climate impact.

Wawa currently has no curbside recycling collection and this represents a significant opportunity for improvement.

Mitigation Type	Conservation
Emissions Reduction Potential	100% reduction for waste mass reduced from baseline levels
Key Performance Indicators	Waste diversion rate
Participation	Increased recycling diversion over baseline levels 15% for 2030, 25% for 2040, 30% for 2050

Organics Management

Organic waste from plants and animals such as food scraps, bones, fats, oils and grease etc. represent an aspect of the waste stream that can be managed to reduce emissions. Municipal organics collection programs can prevent these materials from entering the landfill waste stream. The best practice for municipally collected waste is processing with an anaerobic digester system which breaks down waste in an oxygen-free environment and produces a biogas which can be used for heating, the generation of electricity or the creation of renewable natural gas.

For Wawa, an alternative to municipal organics collection is the utilization of at-home composting with a compost bin or foodcycler.

Mitigation Type	Conservation
Emissions Reduction Potential	100% reduction for waste mass reduced from baseline levels
Key Performance Indicators	Waste diversion rate
Participation	Increased organic waste diversion over baseline levels 10% for 2030, 25% for 2040, 35% for 2050

Landfill Improvements

The efficiency of landfill operations can be enhanced through the utilization or expansion of landfill gas capture systems which collect biogas from the landfill which can be used for heating, the generation of electricity or the creation of renewable natural gas. For Wawa there exists an opportunity for waste emissions reductions as the Municipality of Wawa Landfill, where waste is currently disposed of, does not have any landfill gas capture technology.

There also may be the opportunity to switch waste processing from a landfill to a waste-to-energy facility where the waste is incinerated for the generation of electricity.

Mitigation Type	Efficiency
Emissions Reduction Potential	100% reduction for waste emissions captured by landfill gas capture system
Key Performance Indicators	Landfill gas capture percentage
Participation	Increased organic waste diversion over baseline levels 25% for 2030, 35% for 2040, 85% for 2050

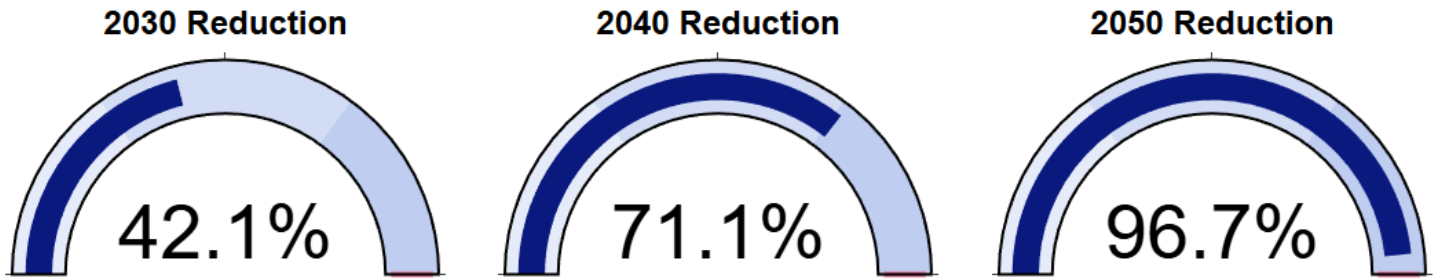
Mitigation Action Summary Table

Action	Sector	Type	KPIs
Energy Conservation	Buildings	Conservation	Energy consumption
Building Retrofits	Buildings (Residential and Commercial)	Efficiency	Number of homes retrofitted, emissions per household, residential building emissions, number of businesses retrofitted, commercial building emissions
Green Development Standards	Buildings (Residential and Commercial)	Efficiency	Number of new buildings constructed to higher efficiency standards, building energy consumption
Solar Energy	Buildings (Residential and Commercial)	Fuel Switching	kW of local solar capacity
Sustainable Biomass	Buildings (Residential)	Fuel Switching	Building emissions levels
Heat Pump Application	Buildings (Residential and Commercial)	Fuel Switching	Building emissions levels
Active Transportation	Transportation	Conservation	Modal split, transit ridership
Vehicle Right-Sizing	Transportation	Efficiency	Number of cars vs. light duty trucks per household
Electric Vehicles	Transportation	Fuel Switching	EV proportion of total vehicles, transportation emissions
Biofuels	Transportation	Fuel Switching	Biofuel composition requirements, biofuel sales, transportation emissions
Waste Reduction	Waste	Conservation	Waste generated per capita
Enhanced Recycling	Waste	Conservation	Diversion rate
Organics Management	Waste	Conservation	Waste emissions
Landfill Improvements	Waste	Efficiency	Waste emissions, percentage landfill gas capture

Mitigation Action Model Results

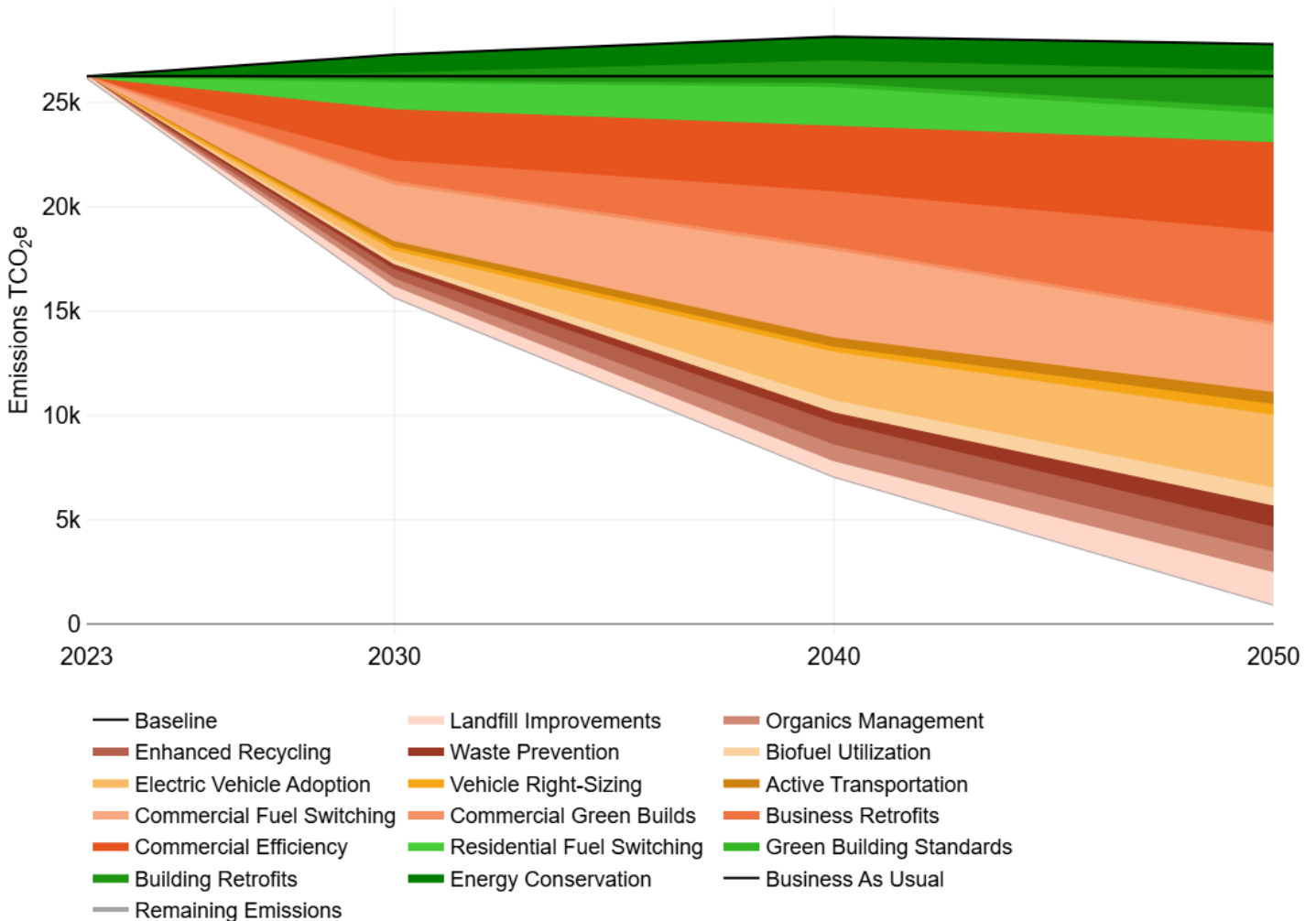
The mitigation actions are modelled within the software to determine the emissions reductions achievable on a per capita basis and these results are displayed below.

Population-Weighted Emissions Reductions



The emissions drawdown chart displays the net-zero trajectory for the community with each action displayed in a different color between the BAU pathway (the top line) and the net-zero pathway (the bottom line).

Emissions Drawdown Chart



By extrapolating the per capita emissions reductions by the forecast populations for 2030, 2040 and 2050, the overall emissions savings can be determined. The total annual emissions reductions from BAU are displayed below. Please see Appendix B for a list of emissions reductions for each action.

Emissions Savings Results



When these emissions reductions are applied to the BAU scenario, the overall reduction percentages can be determined as displayed below.

Overall Emissions Reductions



Overall Results Table

Parameter	2030	2040	2050
BAU Emissions	27280	28149	27796
Mitigation	11555	21023	26805
Resulting Emissions	15725	7125	991
Reduction from Baseline	10522	19122	25256
Reduction Percentage	40.09%	72.85%	96.22%

*Minor discrepancies may occur due to rounding.

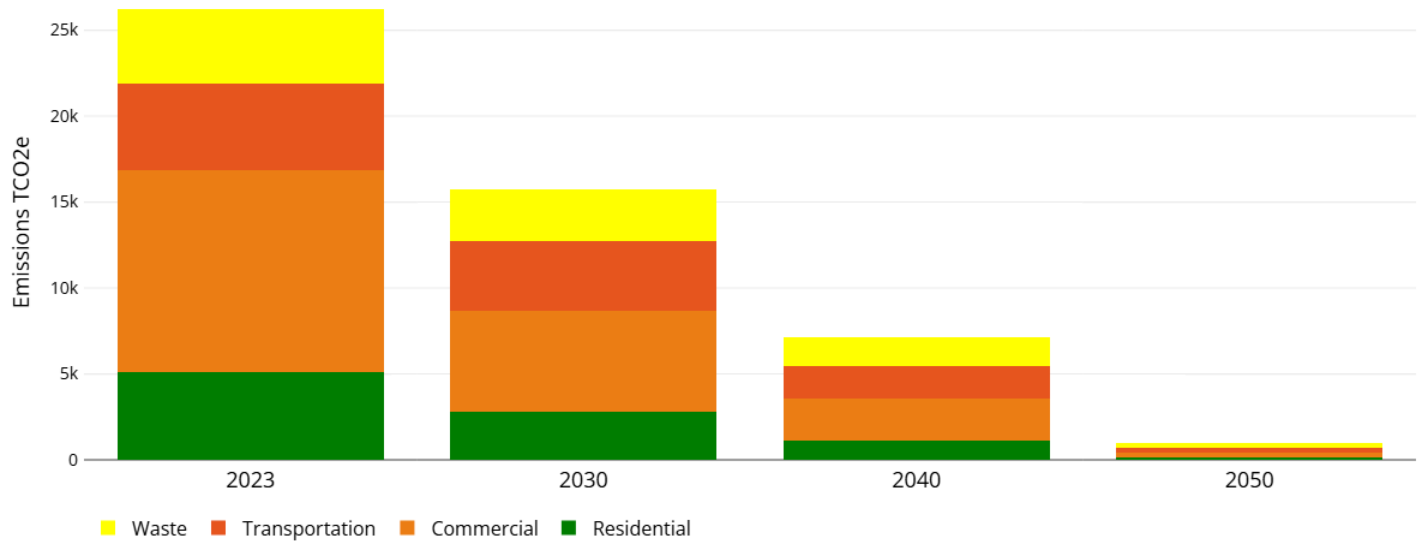
These results indicate that a net-zero emissions trajectory is possible for the municipality of Wawa when the identified actions are applied at the participation rates and emissions savings levels outlined.

Using the results of mitigation modelling the forecast emissions levels for the 2030, 2040 and 2050 planning horizons can be determined. These forecasts indicate that by 2050 a very minimal amount of emissions will remain - specifically in the waste and transportation sectors. Remaining emissions for waste are due to the upper limit for landfill gas capture efficiency. Remaining emissions for transportation relate to a small proportion of ICE powered vehicles which may be incompatible with biofuels.

Post - Mitigation Forecast Emissions



Emissions Forecast Comparisons



Given the very significant forest coverage in Wawa it can be inferred that the remaining 991 TCO₂e is likely to be absorbed and sequestered by the local forests, resulting in a complete net-zero level of sustainability. This could be further verified in the future by conducting a tree canopy study.

Conclusion

A GHG inventory assessment was conducted for the Municipality of Wawa for the year of 2023. The assessment determined the GHG emissions levels, energy consumptions metrics and energy cost for the community. This is the first GHG assessment which has been conducted for the community and represents an important step in the climate change mitigation process. The levels established can be considered as the baseline metrics for the community from which future targets and emissions reductions can be measured. Having a baseline emissions inventory should assist with grant applications.

The emissions were compared to other communities of various sizes in Ontario and Canada. Emissions in Wawa are above the Ontario average which can be expected for a northern cold climate community. Energy costs are high, which highlights the opportunities for savings through energy conservation and efficiency improvements.

Emissions projections for the 2030, 2040 and 2050 planning horizons were developed using the results of the GHG assessment. It was determined that under a BAU scenario, total emissions levels would rise significantly from baseline levels due to the projected increase in community population over the time periods of interest.

A net-zero mitigation model was created which combined mitigation actions and strategies for each sector. These actions took into account the feedback received from community engagement that was conducted as part of the MNZA project. Through the implementation of these mitigation actions significant reductions could be achieved on a per capita basis, specifically 49.1% by 2030, 72.9% by 2040 and 96.2% by 2050. Given Wawa's cold climate, successful mitigation projects in Nordic countries can be referred to for inspiration.

It is recommended that the data and information in this report be shared with community members as well as municipal and regional leadership in order to inspire and motivate the positive changes that will lead to enhanced environmental sustainability in Wawa.

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Appendix A - Inventory Data Tables and Notes

This Greenhouse Gas (GHG) Inventory Report was prepared by Climate Neutral for Wawa. The information and estimates are based on the best available data and standard methodologies at the time of preparation. While care has been taken to ensure accuracy, some values are based on assumptions or relevant national or provincial averages. This report is provided for informational and planning purposes only. Climate Neutral accepts no responsibility for any loss or consequence resulting from the use of this information.

Emissions Per Sector

Sector	Emissions	Emissions Per Capita	Percent of Total
Residential	7164	2.65	25.31 %
Commercial	11762	4.35	41.55 %
Transportation	5002	1.85	17.67 %
Waste	4382	1.62	15.48 %
Total	28,310	10.47	100 %

Emissions Per Source

Source	Emissions	Emissions Per Capita	Percent of Total
Electricity	1965	0.73	6.94
Wood	2063	0.76	7.29
Propane	2963	1.10	10.47
Heating Oil	1235	0.46	4.36
Gasoline	4566	1.69	16.13
Diesel	434	0.16	1.53
Other On-Road Sources	2	0.00	0.01
Landfill	4382	1.62	15.48

Energy Per Sector

Sector	Energy (GJ)	Energy Per Capita	Percent of Total
Residential	169952	62.83	34.53 %
Commercial	240658	88.97	48.90 %
Transportation	81582	30.16	16.58 %
Total	492191	181.96	100 %

Energy Per Source

Source	Emissions	Emissions Per Capita	Percent of Total
Electricity	131020	48.44	26.62
Wood	43901	16.23	8.92
Propane	49389	18.26	10.03
Heating Oil	16463	6.09	3.34
Gasoline	75046	27.74	15.25
Diesel	6536	2.42	1.33

Emissions and Energy Factors

Source	Emissions Factor	Energy Factor
Natural Gas	0.001932 TCO ₂ e/m ³	0.03921 GJ/m ³
Electricity	0.000054 TCO ₂ e/kWh	0.0036 GJ/kWh
Propane	0.060000 TCO ₂ e/GJ	1 GJ/GJ
Heating Oil	0.075000 TCO ₂ e/GJ	1 GJ/GJ
Wood	0.047000 TCO ₂ e/GJ	1 GJ/GJ
Gasoline	0.002081 TCO ₂ e/L	0.0342 GJ/L
Diesel	0.00264 TCO ₂ e/L	0.0398 GJ/L
Waste	1.62 TCO ₂ e/T	

Emissions factor based on 2025 National Inventory Report.

Emissions Scopes

Scope	Emissions	Percentage	Energy	Percentage
Scope 1 - Direct Emissions	26343.11 TCO ₂ e	93.05%	361170.96 GJ	73.38%
Scope 2 - Indirect Emissions	1965.30 TCO ₂ e	6.94%	131020.31 GJ	26.62%

Temperature Weighted Parameters

Parameter	Value
Heating Sources Emissions Per HDD	1.21 TCO ₂ e
Electrical Emissions Per CDD	54.59 TCO ₂ e

Heating sources include residential wood, propane and heating oil. Electrical emissions per CDD includes all electricity consumption.

Appendix B - Mitigation Model Tables

Emissions reduction levels are to be considered high-level estimates. Minor discrepancies may occur due to rounding.

Emissions Savings Per Action (TCO₂e)

Action	Mitigation 2030	Mitigation 2040	Mitigation 2050
Energy Conservation	799	1071	1201
Building Retrofits	394	1093	1795
Green Building Standards	74	193	294
Residential Fuel Switching	1279	1852	1364
Commercial Efficiency	2447	3144	4288
Business Retrofits	993	2645	4296
Commercial Green Builds	176	448	792
Commercial Fuel Switching	2715	3914	2587
Active Transportation	259	436	573
Vehicle Right-Sizing	185	251	515
Electric Vehicle Adoption	450	2308	3478
Biofuel Utilization	214	588	881
Waste Prevention	227	477	1003
Enhanced Recycling	431	1073	1204
Organics Management	388	805	983
Landfill Improvements	524	725	1552

Sector	2030 Mitigation	2040 Mitigation	2050 Mitigation
Residential	2547	4210	4653
Commercial	6331	10151	11963
Transportation	1108	3583	5447
Waste	1570	3080	4742
Planned Mitigation	11555	21023	26805

Appendix C - Glossary

Business-As-Usual - BAU

The normal operations and practices within a community, reflecting its standard procedures, routines, and energy consumption patterns without additional emissions mitigating actions.

Carbon emissions

Gases released into the atmosphere, primarily carbon dioxide, when burning fossil fuels or during industrial processes. These emissions are a significant factor in global warming and the enhanced greenhouse effect.

Climate change

Long-term shifts in temperatures and weather patterns.

Emissions intensity

The measure of greenhouse gas emissions produced relative to a specific activity or output. In the context of this report, it is a ratio of emissions per unit of energy produced and provides insight into how sustainably the energy demand is being met by the energy supply system.

Emissions reduction

A decrease in the release of greenhouse gases (GHGs) into the atmosphere.

Greenhouse gas - GHG

Gases in the earth's atmosphere that trap heat. During the day, high frequency radiation from the sun shines through the atmosphere, warming the earth's surface. The earth's surface warms and radiates low frequency thermal radiation (heat). A proportion of the low frequency radiation is trapped by the greenhouse gases in the atmosphere resulting in an increase in air temperature.

Internal Combustion Engine - ICE

Engines where fuel and air are burned inside the engine itself, creating high-pressure gases that then drive engine components to produce power. This process can be used to move vehicles, boats, ships, or other machinery.

Kilograms/Tonne Carbon Dioxide Equivalent - KgCO₂e/TCO₂e

Unit of measurement that quantifies the impact of different greenhouse gases on the environment, expressed as the equivalent mass of carbon dioxide.

Low-carbon

Causing or resulting in a relatively small net release of carbon dioxide into the atmosphere.

Mitigation actions

A recommended change to reduce and address an existing or potential vulnerability.

Modal Split

Distribution of transportation activities between active transportation such as walking, biking, transit and vehicles. For example when 10% of trips are completed with active transportation the modal split is 10%.

Net-Zero

A target of cutting carbon emissions to a small amount of residual emissions that can be absorbed and durably stored by nature and other carbon dioxide removal measures, leaving zero in the atmosphere. Global net-zero emissions will be reached when greenhouse gas emissions and removals due to human activities are in balance.

Renewable

Capable of being replaced by natural ecological cycles or sound management practices.

Spatial Intensity

The amount of emissions generated in a given geographical area.