COMMUNITY ENERGY AND GREENHOUSE GAS INVENTORY, 2015

Summary: March, 2018

Overview

This document offers an estimate of energy use and greenhouse gas emissions for the City of Charlottetown for the baseline year of 2015.

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Executive Summary

This document provides an estimate of energy use and greenhouse gas (GHG) emissions attributable to the entire City of Charlottetown. The population of Charlottetown is estimated at 37,200 as of mid-2015, just over 25% of Prince Edward Island's (PEI's) official population estimate at that time.

City GHGs in 2015 are estimated at 11.61 metric tonnes of carbon dioxide equivalent (tCO_2e) per capita, which is about 25% below PEI's GHGs of 15.53 tCO_2e per capita when including GHGs from *"stack emissions"* of imported electricity. Stack emissions from electricity imports are excluded in PEI's GHG Inventory, yet they are relevant to provincial energy policy, to address global warming, and are included in municipal GHG inventories across Canada and the world. This allows for a better *apples-to-apples* comparison.

Urban areas generally benefit from greater density in the built environment which reduces GHGs associated with space heating and transport, etc. Charlottetown's GHGs are lower partly due to a higher percentage of households that are apartments or condos (41.1%) compared to the provincial average (18.7%). While floor space in an apartment/condo averages *more than half* that of a typical single detached dwelling, the overall energy use in a typical apartment/condo is *less than half* compared to an average detached dwelling on PEI. The high proportion of commercial and institutional (C&I) space in the City per capita compared to the rest of PEI increases the City's per capita energy use and GHGs in the sector.

Tourist gasoline sales are excluded in the City's inventory per common protocol in GHG accounting for cities, as are fuel sales for shipping of commodities, cruise ships, tourist-related aviation and air passengers that do not live or travel by air for work purposes from within the Charlottetown area.

For GHGs from municipal solid waste (MSW), City emissions per capita appear less than those associated with the province. This is because much of the Capital Region's MSW is burnable waste which is sent to the District Energy System (DES), thus reducing the amount of MSW from the City that is landfilled and reducing landfill GHGs. Agriculture GHGs from within the City are estimated at less than 0.1%; 20.3% of PEI's GHGs in the inventory for 2015 as submitted to the UNFCCC in 2017 are attributed to agriculture.

Overall, GHGs for the City in 2015 are estimated to be 432,027 $tC0_2e$. This includes all GHGs, and a small amount of additional tCO_2e occurring from emissions in the upper atmosphere plus heat-radiating fossil soot particles, each due to commercial aviation attributable to Charlottetown. Though normally excluded in GHG inventories, these added emissions from aircraft are relevant to reducing warming so are included here.

The 100-year global warming potential ($GWP_{100\text{-}yr}$) of black carbon (BC) particles attributable to the City for all other fuels is estimated at about 24,000 tCO_2e. Usually BC warming is excluded in GHG inventories however it has been included here. The $GWP_{100\text{-}yr}$ of Charlottetown's GHGs plus BC particle emissions and warming attributed to emissions in the upper atmospheres from aircraft such as from contrails totals 456,027 tCO_2e in 2015; or 12.26 tCO_2e per capita.

Community energy expenditures are estimated at $176 million in 2015. Long-term global warming damages from the City's GHGs in 2015 are estimated at $146 million. Premature mortalities from air pollution in Charlottetown, attributable to current fuels in use by society, are estimated at 7 deaths per year with these economic damage costs estimated at $85 million/year. The energy, climate, and air pollution costs associated with energy use today are estimated at $407 million/year in 2015 (2017-CAD).

Overview

Tables 1 and 2 summarize energy use and greenhouse gas (GHG) emissions for the City of Charlottetown. Figure 1 shows the percentage shares of secondary energy use.

Table 1: City of Charlottetown Community Energy Use by Source, 2015

	Natural Units		*GJ*	*tCO_2e*
Electricity	370,172,517	kWh	1,332,622	141,881
District Energy	100,082	MWh	359,301	24,042
Fuel Oil	48,278,170	L	1,867,400	132,041
Gasoline	32,286,468	L	1,130,026	74,231
Diesel	9,667,312	L	370,258	26,338
Propane	3,695,275	L	93,527	5,706
Aviation Fuel	3,780,000	L	131,121	19,830
Wood	4,277,178	kg	54,723	812
Biogas	624,131	m^3	14,556	576
Total			5,353,533	432,027

Note – A gigajoule (GJ) is a unit of energy equivalent to about 277.778 kilowatt-hours (kWh) of energy. A kWh is a familiar unit of energy used by electric utilities for billing as a unit of energy consumption. In simple terms, 1,000 watts of power, which is similar to the full load drawn by some regular-sized microwaves, for a one hour period, results in 1 kWh of secondary energy consumption.

Figure 1: Charlottetown's Secondary Energy Use, 2015

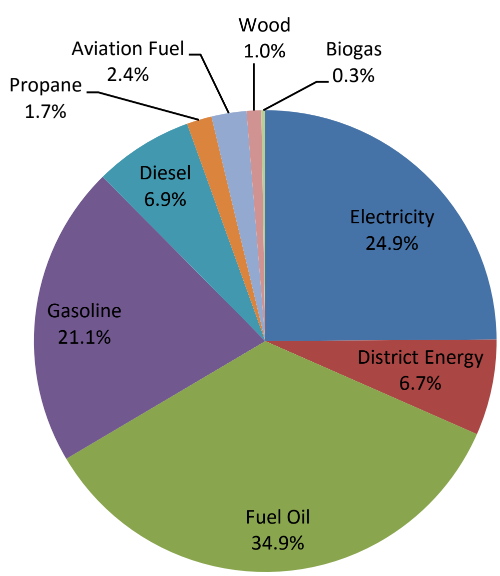


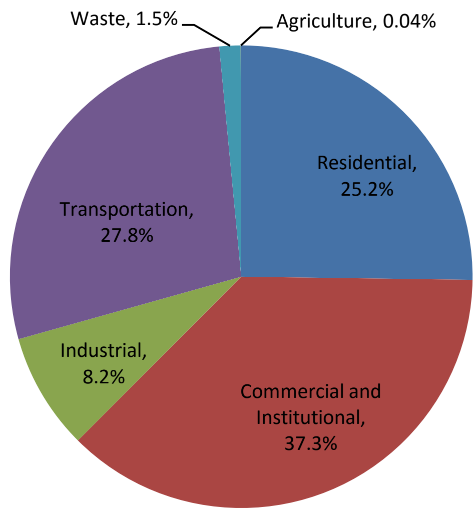
Table 2: City of Charlottetown Greenhouse Gas Inventory, 2015	
	Tonnes CO_2e
Residential	108,936
Commercial and Institutional	161,000
Industrial	35,286
Transportation	120,235
Onroad	*100,051*
Offroad	*71*
Marine	*283*
Aviation	*19,820*
Waste	6,400
Landfill	*5,400*
Compost	*1,000*
Agriculture	170
Enteric Fermentation	*140*
Manure Management	*30*
GHGs in tCO_2e	432,027
Per Capita tCO_2e from GHGs, Charlottetown	11.61
Per Capita tCO_2e from GHGs, PEI	15.53
Percentage Below PEI Average	25%
Factor for Inclusion	
Black Carbon (BC) Particles (tCO_2e)	24,000
Total tCO_2e	**456,027**
Excluded Factor (among others)	
Tourism-related gasoline	37,110
Per Capita Emissions for Charlottetown in 2015 including:	
GHGs + BC expressed in tCO_2e per capita	**12.26**
Incl. tourism-related gasoline, tCO_2e per capita	13.26

Global warming potentials (GWPs) of greenhouse gases (GHGs) and black carbon (BC) particles should be included in the community energy and GHG inventory as each result in warming. With GHG inventories typically 100-year GWP values ($GWP_{100\text{-}yr}$) are used and expressed in metric tonnes of carbon dioxide equivalent emissions (tCO_2e). Other timescales and metrics to account for climate change are relevant to inform decision-makers.

Tourism-related gasoline sales, shipping (commodities/cruise ships), tourism-related aviation, and so on, could remain excluded from the community energy and GHG inventory but are important to be aware of as these are causes of global warming from human activity that must be addressed.

Figure 2 shows a snapshot of the City of Charlottetown's GHG emissions estimates sector-by-sector for the year 2015.

Figure 2: Greenhouse Gas Emissions by Sector, 2015



Note – Figure 2 excludes effects of black carbon (BC) warming particles, with exception of aviation in the transport sector where BC is included. Warming effects of BC particles for all other fuels are shown separately in Table 2.

Estimates of energy expenditures for the City of Charlottetown are $176 million in 2015 (expressed in 2017-CAD). Energy expenditures by secondary energy source are shown in Table 3.

Table 3: City of Charlottetown Energy Expenditures, 2015

	$Millions Nominal 2015-CAD	*$Millions 2017-CAD*
Electricity	$62.3	$64.3
Oil	$42.6	$44.0
Gasoline	$34.6	$35.7
Diesel	$11.1	$11.4
District Energy	$11.6	$12.0
Aviation Fuel	$4.3	$4.5
Propane	$2.9	$3.0
Wood	$0.9	$1.0
Total Expenditures ($M)	$170.4	$176.0

Energy services offer society tremendous benefits. Yet these services have significant externalized social costs. The business costs, climate costs, and air pollution costs of the current energy infrastructure are shown in Table 4. There may be ways to minimize the social costs by increasing energy efficiency and incorporating clean energy in order to provide the same quality energy services we enjoy today at similar costs, but with far greater overall net benefits to our community and society.

Table 4: City of Charlottetown Energy, Climate, and Air Pollution Costs, 2015

	$M-2017-CAD
Energy Costs	$176
Climate Costs	$146
Air Pollution Costs	$85
Business Plus Social Costs of Energy	$407

In the following sections, community energy and GHG estimates by each sector are summarized. An estimate of the warming from black carbon particle emissions is given. The energy use, expenditures, and GHGs of the City's operations are given briefly.

Residential Sector

In Table 5 residential energy use and GHGs in the residential sector are summarized for the City. Figures 3 and 4 show GHG emissions by secondary energy source and energy use by end-use, respectively.

Table 5: Residential Energy Use and GHGs, 2015

	Natural Units		*GJ/Year*	*tCO_2e*
Electricity	109,449,454	kWh	394,018	41,950
Oil	21,591,754	L	835,169	59,053
District Heat	14,292.13	MWh-th	51,452	3,433
Propane	2,420,423	L	61,261	3,737
Wood	1,803,123	kg	32,456	762
Total			1,374,356	108,936

Figure 3: Residential Greenhouse Gas Emissions by Secondary Energy Source, 2015

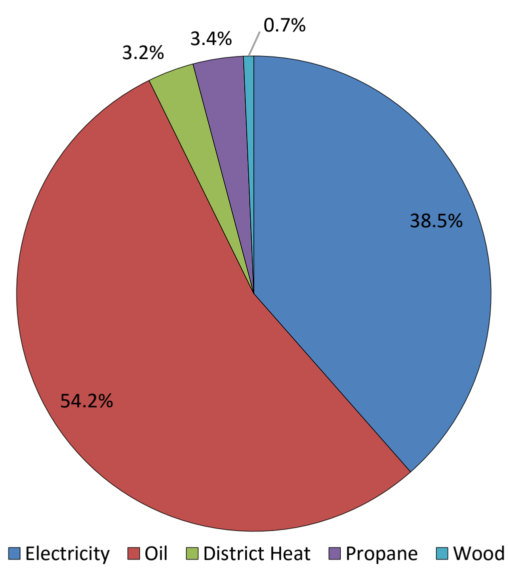
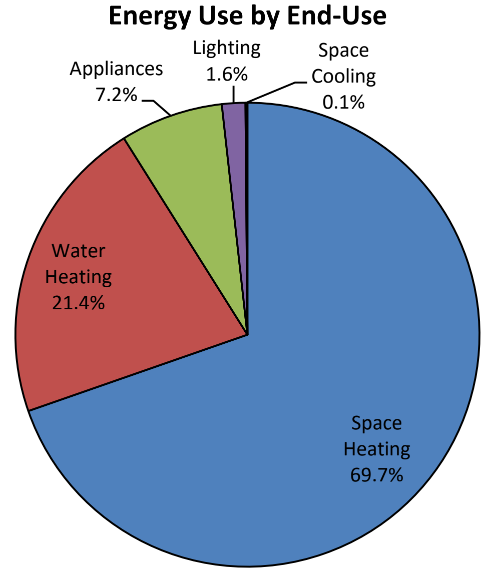


Figure 4: Residential Secondary Energy Use by End-Use



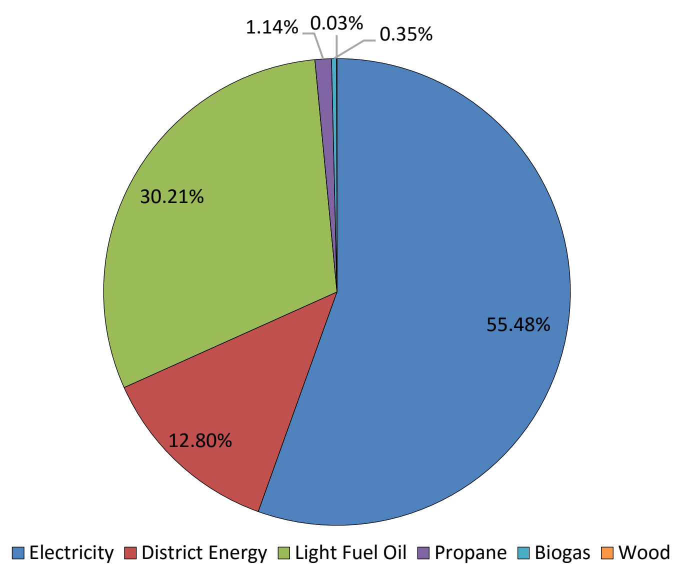
Commercial and Institutional Sector

Table 6 summarizes the City's commercial and institutional (C&I) sector energy use and GHGs. Figure 5 shows GHG emissions by secondary energy source.

Table 6: Commercial and Institutional Sector Energy Use and GHGs, 2015

	Natural Units		*GJ*	*tCO_2e*
Electricity	233,021,399	kWh	838,877	89,313
District Energy	85,790	MWh	308,845	20,609
Light Fuel Oil	17,779,799	L	687,723	48,628
Propane	1,185,302	L	30,000	1,830
Biogas	624,131	m^3	14,556	576
Wood	2,222,222	kg	20,000	45
Total			1,900,000	161,000

Figure 5: Commercial and Institutional Greenhouse Gas Emissions by Secondary Energy Source, 2015



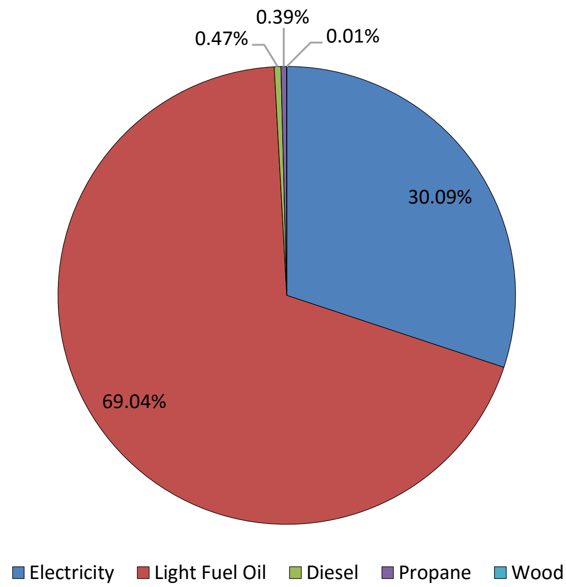
Industrial Sector

Table 7 provides estimates of the City's industrial sector energy use and GHGs. Figure 6 shows GHG emissions by secondary energy source.

Table 7: Industrial Sector Energy Use and GHGs, 2015

	Natural Units		*GJ*	*tCO_2e*
Electricity	27,701,664	kWh	99,726	10,618
Light Fuel Oil	8,906,618	L	344,508	24,360
Diesel	59,178	L	2,267	165
Propane	89,550	L	2,267	138
Wood	251,833	kg	2,267	5
Total			451,033	35,279

Figure 6: Industrial Greenhouse Gas Emissions by Secondary Energy Source, 2015



Transportation Sector

This section summarizes estimates of transportation sector energy use and GHGs from the onroad, offroad, marine, and aviation subsectors which are attributable to the City of Charlottetown.

Onroad Transport

Table 8 provides a summary of onroad transportation sector energy and GHGs. Figure 7 shows GHG emissions by secondary energy source.

Table 8: Onroad Transportation Energy Use and GHGs, 2015

	Natural Units		*GJ*	*tCO_2e*
Gasoline	32,211,738	L	1,127,411	74,055
Diesel	9,549,212	L	365,735	25,996
Total			1,493,146	100,051

Figure 7: Onroad Transport Greenhouse Gas Emissions by Secondary Energy Source, 2015

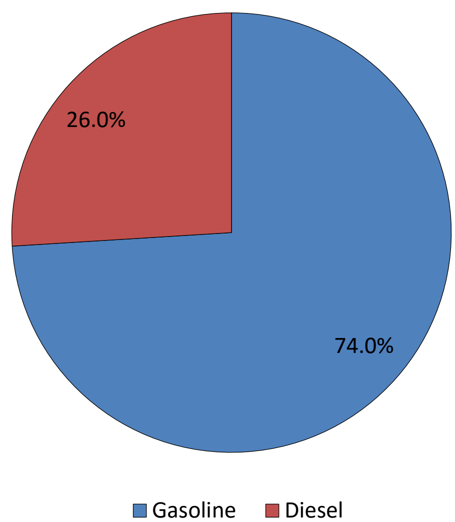


Table 9 shows details that are used as estimates of the number of onroad vehicles, vehicle kilometers traveled per vehicle, fuel consumption rates, quantities of fuels and GHGs by vehicle type.

Table 9: Charlottetown Onroad Transport, Fuel, and GHG Estimates, 2015

Total, all vehicles	Light-Duty Vehicles up to 4.5 tonnes	Medium-Duty Trucks 4.5 tonnes to 14.9 tonnes	Heavy-Duty Trucks 15 tonnes and over
Number of registered vehicles by type			
23,020	21,720	440	860
Average annual km traveled by vehicle type			
	15,090	8,390	14,450
Average annual fuel consumption rate in Litres (L)/100 km			
	10.9	30.1	39.1
Calculated fuel consumption (L), onroad registered vehicles			
	35,790,820	1,111,170	4,858,960
Calculated GHG emissions (tCO_2e), onroad registered vehicles			
	83,836	3,037	13,177

Assumes 90% of litres are motor gasoline for light-duty vehicles (LDVs) and 10% diesel for LDVs.
Uses fuel consumption rate multiplier of 1.05 for LDVs to account for urban city/highway fuel economy.
Assumes diesel used for medium and heavy trucks on PEI.
Data from Canadian Vehicle Survey (2009) is scaled by population growth and to Charlottetown for 2015.[1]
Number of MDVs and HDVs is conservatively increased by multiplier of 1.15 given provincial GHG data.
Excludes fuel and GHGs associated with tourism traffic.

Offroad Transport

Table 10 show energy and GHGs from offroad transport. For the City's inventory this subsector of transport includes estimates for all lawn mowing, golf carts, farm tractors, and snowmobiles, etc.

Table 10: Offroad Transportation Energy and GHGs, 2015

	Litres	*GJ*	*tCO_2e*
Gasoline	21,130	740	50
Diesel	6,883	264	21
Total		1,003	71

Marine Transport

For marine transport the main energy and GHGs occur in the City due to shipping of commodities and cruise ships. Each of these energy requirements and GHG sources are excluded from Charlottetown's inventory. Table 11 includes energy and GHGs from recreational watercraft attributable to Charlottetown's residents and primarily this includes sea-doos, small yachts or sportfishing boats, and auxiliary engines of sailboats.

Table 11: Marine Transport Energy and GHGs, 2015

	Litres	*GJ*	*tCO_2e*
Marine Diesel	52,040	1,993	156
Marine Gasoline	53,600	1,876	127
Total		3,869	283

Aviation

Over 310,000 air passengers were enplaned and deplaned at the Charlottetown Airport in 2015.[2] About half of all air passengers were Islanders.[3] This is scaled to the population of Charlottetown. Globally averaged air passenger distances traveled per flight is obtained for the year (nearly 1,900 km/flight). A multiplier of 1.33 is used since many times air travel by Islanders is not directly from initial departures to final destinations. This multiplier results in over 2500 km of air travel per air passenger enplaned and deplaned at the local airport, which may be conservative. A fuel consumption rate of 3.5 L/100 km traveled for air passengers is deemed representative of commercial aviation.[4] A modest multiplier of 1.1 is used to account for the fact that many public and private employees on PEI either work in the City or are residents themselves that use air travel for work purposes.

At common cruise altitudes of 10-12 km when air is often supersaturated with H_20 contrails form and persist for many hours, increasing radiative forcing or warming.[5] A radiative forcing index (RFI) factor is applied to determine CO_2e of emissions in upper atmospheres.[6] For black carbon (BC) emissions of fossil soot in the fuel, a 100-yr surface temperature response (STRE) per unit emission function for BC and primary organic matter (POM) is used.[7]

Table 12 shows energy and tCO_2e in aviation including GHGs, the RFI factor, and the 100-yr STRE for BC and POM in fossil soot. Best practices would include each these sources of global warming from human activity, instead of excluding their warming effects.

Table 12: Aviation Energy and GHGs, 2015			*GHGs*	*RFI**	*100Yr-STRE**	*Total*
	Liters	*GJ*	*tCO2e*	*tCO2e*	*tCO2e*	*tCO2e*
Aviation Gasoline	37,800	1,267	94	94	3	191
Jet Fuel (A-1)	3,742,200	129,854	9,662	9,662	314	19,639
Total	3,780,000	131,121	9,756	9,756	317	19,830

* RFI - Radiative forcing index factor for total aircraft.

* Refers to 100-year surface temperature response (STRE) of BC and POM per unit emission function in fossil soot of jet fuel, somewhat different than 100-yr GWP of BC used for all other fuels in this inventory.

Waste

Table 13 summarizes the GHGs associated with municipal solid waste and compost. The GHGs associated with waste are significantly higher at the provincial level. Municipal solid waste (MSW) from the capital region is often fed into the PEI Energy Systems energy-from-waste facility, reducing tonnage to landfills.

The Island Waste Management Corporation (IWMC) offered detailed data, and analysis with the disposal manager of IWMC helped the City to better estimate the composition of the various materials being landfilled, including those in the MSW stream that cannot received by PEI Energy Systems waste-to-energy facility (due to system downtimes, etc.) Using this information, Partners for Climate Protection (PCP) software is used to quantify resultant GHG emissions given the MSW stream tonnages and composition of materials. For compost, the provincial value of three kilotonnes of CO_2e for the year of 2015 is scaled down by a factor of one third.

Table13: Waste GHGs

	tCO_2e
Municipal Solid Waste	5,400
Compost	1,000
Total	6,400

Agriculture

There is some agricultural land within the City of Charlottetown. To estimate GHGs associated with the agricultural sector, GHGs associated with agricultural soils and other possible trace sources were excluded. Estimates of GHGs from enteric fermentation in ruminants such as cattle, and manure management, were provided for 2015. Tables 14 and 15 respectively show estimates of GHGs from enteric fermentation and manure management.

Table 14: Enteric Fermentation GHGs, 2015

100 Year GWP biogenic-methane (CH_4)
34

	Head	*kg CH_4 per head per year*[8]	*tCO_2e*
Dairy Cattle	30	118	120
Beef Cattle	10	47	16
Total	40		136

Table 15: Manure Management GHGs, 2015

100 Year GWP of Nitrous Oxide (N_20)

298

kg N excretion per head per year	*EF kg N_20 per kg N excreted*	*EF kg CH_4 per head*	*kg CH_4*	*CH_4 related tCO_2e*	*kg N_20*	*N_20 related tCO_2e*
100	0.02	6	180	6.12	60	17.88
70	0.02	1	10	0.34	14	4.17
Total				6.46		22.05

Note - Methodology for GHG quantification, including parameters used in columns 1-3, are available in reference.[9]

Black Carbon Particles

BC is about one million times more potent at warming the Earth in terms of radiative forcing than CO_2, per unit mass emitted, but BC has a very short lifetime in the atmosphere compared to CO_2. In terms of radiative forcing, black carbon may be the second-leading cause of observed global warming to date, after CO_2, and roughly tied with CH_4. As such, removing black carbon emissions is among the fastest ways of slowing global warming, although all emissions must be addressed simultaneously.

To estimate the global warming potential (GWP) of emissions of black carbon (BC) particles, two approaches are used. As discussed, a 100-year STRE for BC in fossil soot from aviation fuel is used as a proxy for the GWP in that sector. A small fraction of aviation fuel is assumed to have a BC emissions factor (EF) associated with aircrafts climbing and the rest is assigned a lesser BC EF for cruising altitudes. The emissions that resulted directly from GHGs released from the aviation fuel burned, expressed in tCO_2e, plus a radiative forcing index factor for emissions occurring in the upper atmosphere, and BC emissions as stated, are encapsulated within the GHG inventory CO_2e value under aviation in Table 2.

For all other fuel sources, in terms of BC emissions, it is necessary to approximate these based on available literature. One paper offers a way to estimate BC EFs for various fuels.[10] This process results in an estimate of roughly 26 tonnes of BC emitted in 2015.

The globally averaged 100-year GWP of BC, which is 900 times greater in terms of warming as CO_2 per unit mass emitted, is adjusted for the Canadian region using specific forcing pulse (SFP) values, as these are proportional to GWP; thus the $GWP_{100\text{-yr}}$ of BC is calculated as 931 times greater than CO_2 per tonne emitted.[11,12] Multiplying the BC emissions estimated for 2015 of about 26 tonnes, by BC's $GWP_{100\text{-yr}}$ for the Canadian region results in about 24,000 tCO_2e.

Air Pollution

Air monitoring data of fine particles ($PM_{2.5}$) and ground level ozone (O_3) is obtained from the air monitoring station in the City for the years 2011-2013. A health effects equation is used to estimate premature mortalities from air pollution exposure in the City. Premature mortality due to air pollution in Charlottetown is estimated at 7 (2-14) deaths annually. The economic damage costs of air pollution for Charlottetown are estimated at $85 million/year ($24-$170 million/year).

A main aspect of the social costs of air pollution is the value of the lives lost prematurely. The U.S. Environmental Protection Agency's (EPA's) statistical value of life established in 2010 of $9.1 million

(2009-USD) is used and adjusted for inflation.[13] A 1:1 relationship between USD and CAD is assumed, similar to the period from early 2009 to late 2014.

For non-mortality costs, such as morbidity costs that do not result in death, U.S. EPA values were recently estimated at 7% of mortality costs.[14] However, other studies in the economics literature indicate considerably higher non-mortality costs. A comprehensive analysis of air pollution damages at every air quality monitor in the U.S found that the morbidity cost of air pollution (mainly chronic illness from exposure to particulate matter) might be as high as 25% to 30% of the mortality costs.[15] A central estimate for non-mortality costs of about 16% is obtained by averaging the 7% and 25% values. Mortality plus non-mortality costs are thus calculated as approximately $12.14 million per premature death due to air pollution.

To put our modeled air pollution mortality estimates into context, in 2008 the Canadian Medical Association (CMA) estimated that exposure to $PM_{2.5}$ and O_3 air pollution was responsible 21,000 premature deaths each year in Canada, including about 80 chronic premature deaths on PEI, with annual illness costs in 2008 on PEI of $28.2 million (2006 CAD).[16] Encapsulated in this, according to the study, were about 10 annual acute deaths on PEI. CMA projected annual chronic mortality attributable to air pollution from $PM_{2.5}$ and O_3 exposure would be 105 deaths for PEI in 2017. No value was assigned to any chronic premature deaths and the value of life assigned for acute deaths was only $2.4 million (2006 CAD). CMA authors stated (footnote 17, pg. 20 of 113):

> "These economic damages are based on acute premature mortality cases. Given the high economic value assigned to avoiding premature mortality, the corresponding economic damages for chronic premature mortality would be much higher."

Other recent studies have had mid-range estimates of air pollution mortality rates of about 7,800-14,400 premature deaths/year in Canada.[17,18] When scaled to the population of Charlottetown, our estimate of air pollution mortalities is low compared to the CMA and these other two studies.

The main contributor to air pollution mortality is $PM_{2.5}$. One study shows of 7,790 annual air pollution deaths estimated in Canada with 7,100 deaths attributable to $PM_{2.5}$. Population-weighted ambient concentrations of $PM_{2.5}$ in Canada were found to be 7 micrograms per cubic meter ($\mu g/m^3$) in that study. This compares to concentrations of $PM_{2.5}$ measured in Charlottetown which averaged $6.3 \mu g/m^3$ over the three years of data. So, the City's mid-range estimates of mortalities are reasonable and conservative.

The City of Charlottetown has cleaner air than many places worldwide. Newcomers to Charlottetown from highly polluted places such as China often place an extremely high value and comment on the superior air quality and environmental conditions found here, even compared to larger urban centres in Canada. While the air is cleaner in Charlottetown, our findings suggest air pollution is still a health concern. Evidence suggests there is no safe threshold to $PM_{2.5}$. Concentrations of $PM_{2.5}$ of only a few $\mu g/m^3$ have been shown deleterious to human health. One highly cited study recently found for every 5 $\mu g/m^3$ of $PM_{2.5}$ there was an increased risk of lung cancer by 18%.[19] This alone suggests the results obtained here may be conservative.

City Operations: Energy Use, Expenditures and GHGs, 2013-2016

Corporate greenhouse gas (GHG) emissions across the City of Charlottetown's operations are estimated at 7,420 tonnes of carbon dioxide equivalent in 2016 (tCO_2e/year), 3.8% below 2015 GHGs. Expenditures in the inventory for 2016 were roughly $3.5 million. Figure 8 shows corporate GHGs by sector and source in 2016.

Figure 8: Corporate GHG Emissions by Sector and Source, 2016

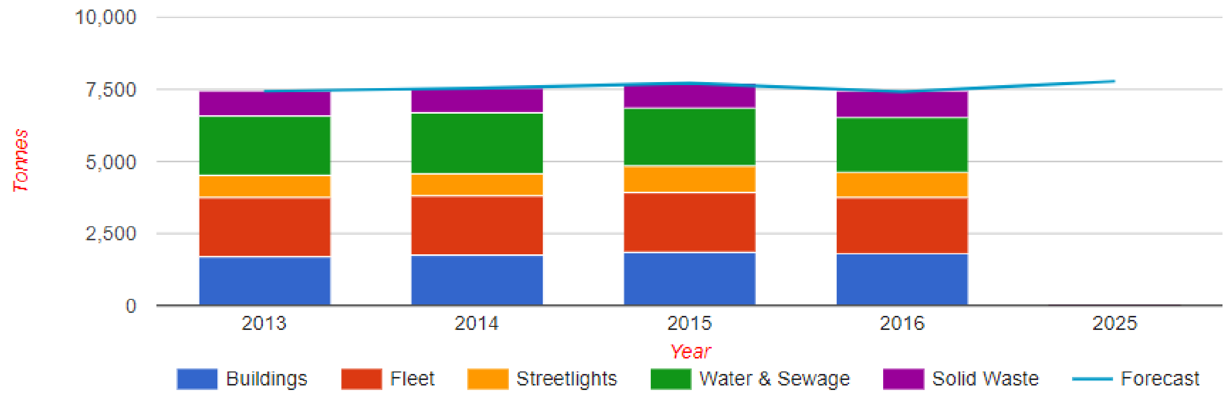
Note: Electricity is estimated to have amounted to 48.8% of GHGs in 2016.
Electrical energy accounted for 52.1% of all energy consumption.

Given software limitations, the City's corporate operations inventory uses a somewhat lower GHG intensity for electricity sector of (280 grams of CO_2e/kWh) than the community inventory uses. For the corporate energy, expenditures, and GHG estimates the City uses software such that there is no way to account for biogas energy used, nor methane leakage from digesters, and in future there is no way to properly account for onsite solar energy generation, etc. This skews information a bit.

It is notable that the community energy and GHG inventory encapsulates the energy and emissions from City operations, so the quantities from both the community and corporate operations should not be added together.

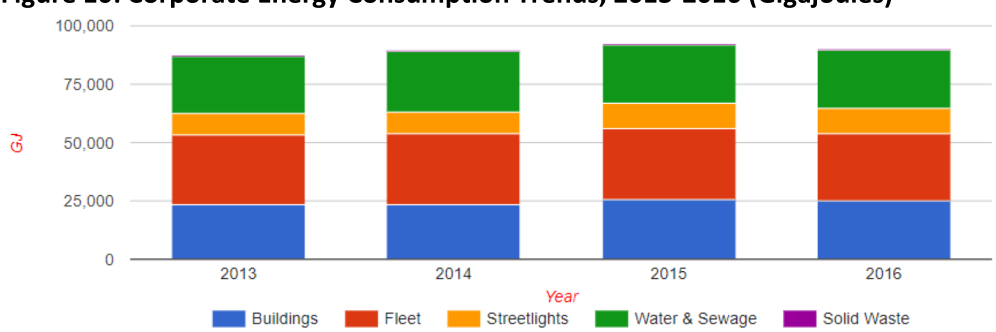
Figure 9 summarizes corporate GHG emission trends from 2013 to 2016, with a business-as-usual projection to 2025 developed in earlier modeling. Figures 10 and 11 respectively summarize trends in a) energy consumption, and b) expenditures related to both energy and solid waste for the period 2013-2016. Please note our corporate GHG inventory remains a work in progress.

Figure 9: Corporate GHG Emissions Trends, 2013-2016 and Business-As-Usual GHG Projection in 2025 (tCO_2e/year)



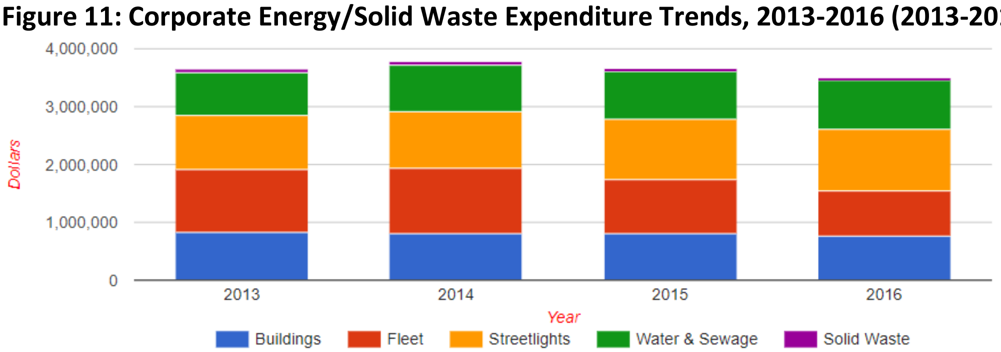
Note: In the business-as-usual projection, a) water and sewage growth assumes a neighboring municipality connects to our sewage infrastructure, increasing consumption by about 10%; and b) building growth includes the possibility of a new fire station. This could eliminate a current fire station. The new building would be better constructed with more efficient technologies but would be larger than the existing station. For this reason, a projected growth of 5% is allocated over the next 10 years; c) fleet growth considers the possibility of a 5-car expansion in the police fleet (5%); d) streetlights forecast is set at 0% due to the adoption of LED lighting systems; and e) solid waste increase is set at 0.1% per year based on the impact of a 1% population increase on our public park waste stream. The forecast does not include the possibility of reduced carbon intensity from the electricity grid through municipal solar photovoltaic generation, etc. GHG emissions may also increase as City population increases may necessitate additional services, etc.

Figure 10: Corporate Energy Consumption Trends, 2013-2016 (Gigajoules)



Note: 2015 energy consumption spike due partly to higher heating degree days (colder winter), increased snow clearing, and water & sewage demand from more snow melt flowing into sanitary sewer. 1 GJ = 277.8 kWh

Figure 11: Corporate Energy/Solid Waste Expenditure Trends, 2013-2016 (2013-2016 Nominal CAD)



Note: Recent petroleum products have been low price in comparison to historic levels.

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Supplemental Information

A supplementary information section provides additional descriptions and data for sections in the main document.[20] Topics covered in that document include the following:

SI.1) Population Projections;

SI.2) Energy and Emissions Methodology;

SI.3) Exclusions;

SI.4) Business-As-Usual Projection;

SI.5) Energy Expenditures;

SI.6) Social Cost of Carbon; and

SI.7) Social Costs of Air Pollution

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