2018 Community Energy Use & Greenhouse Gas Emissions Inventory

October 2019

london.ca

COMPACT of MAYORS COMMITTED 2015

London CANADA

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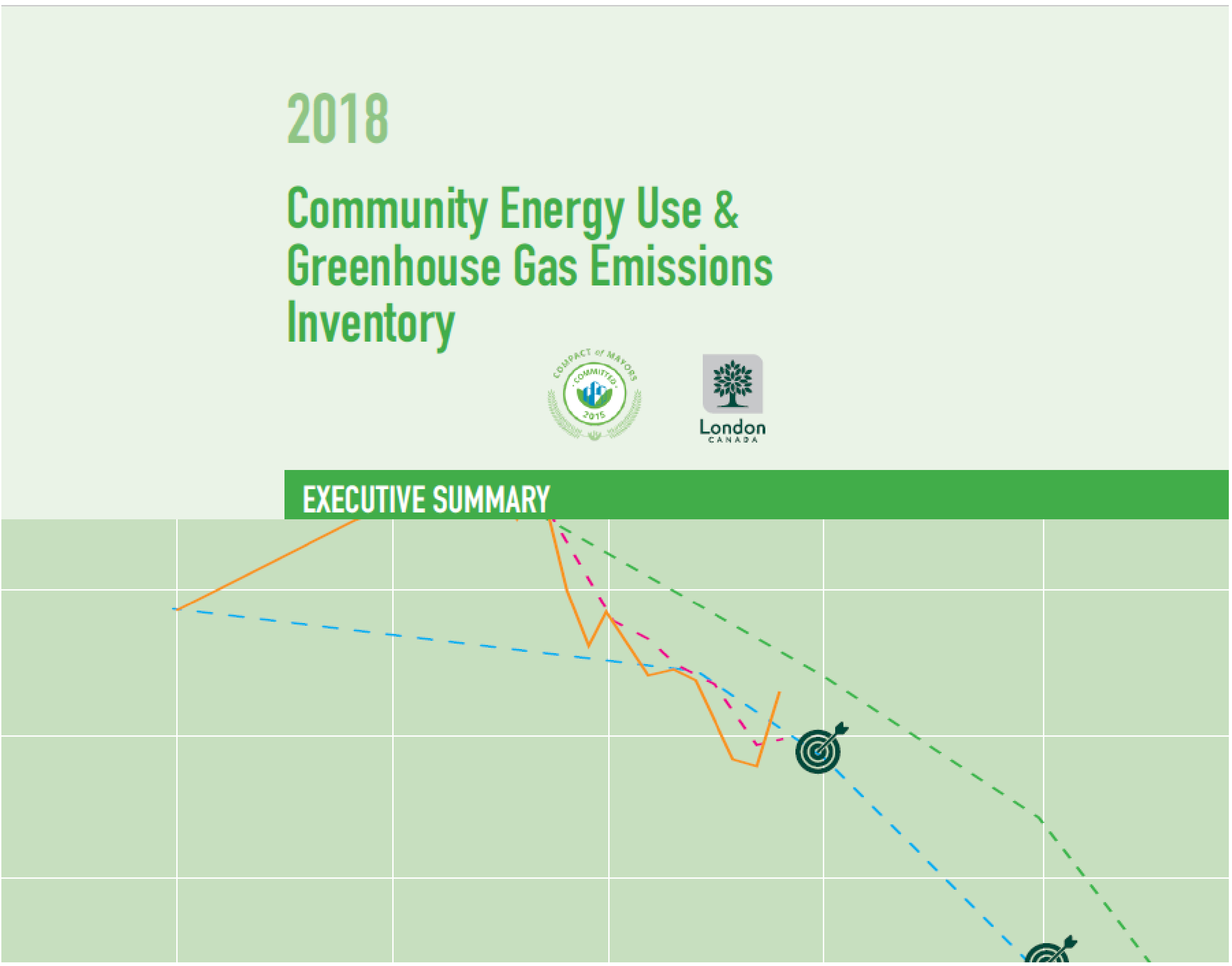
EXECUTIVE SUMMARY

The Executive Summary for the 2018 Community Energy Use & Greenhouse Gas Emissions Inventory is now a stand-alone document that can be found on the Community Energy Use & GHG Emissions section of the City of London's website, or by clicking on the image below if reading this document on-line.



1 PURPOSE OF THIS DOCUMENT

The purpose of this document is to provide an overview of:

- energy consumption in London (a high level inventory of energy use) during the period 1990 to 2018;
- associated greenhouse gas (GHG) emissions; and
- energy expenditures in London.

On April 23, 2019, the following was approved by Municipal Council with respect to climate change:

> *Therefore, a climate emergency be declared by the City of London for the purposes of naming, framing, and deepening our commitment to protecting our economy, our eco systems, and our community from climate change.*

This document is the measurement tool to highlight London's progress towards meeting its community energy reduction and GHG emission reduction targets along with other targets and directions.

Energy efficiency and conservation provides important opportunities to reduce costs. The majority of money spent on energy leaves London, but money spent on energy efficiency and conservation stays in London. It supports local businesses offering these products and services, while the resulting money saved from energy efficiency and conservation can then be used for more productive uses.

Many people benefit from the use of energy efficiency, renewable energy, and energy conservation products and services:

- Households can help the environment and typically save more money in the long run.

- Business owners and managers can reduce operating costs, become role models for corporate social responsibility, and position themselves with a competitive advantage.

- Students and teachers can benefit from learning about our current, unsustainable demand for energy and how energy conservation, energy efficiency and renewable energy technologies can help our environment and replace fossil fuels that are being depleted.

- Innovators can create new energy-efficient and renewable energy products and services, and become architects of change.

Many of these inventory reports have a similar look and feel by design. The data may change annually, but the rationale and dialogue remains similar. A complete listing of reports is found in Section 3.

The City of London also reports this information on an annual basis to CDP Cities (formerly the Climate Disclosure Project) and the Global Covenant of Mayors for Climate & Energy.

2 BACKGROUND

The City of London does not have direct control over how much energy is used in London, but it does have influence. The control over energy use in London rests primarily with citizens, visitors, employers and employees. Individual and collective action with respect to sustainable energy use, energy management, and energy conservation is critical for our future.

London's 2014-2018 Community Energy Action Plan (CEAP) was approved by Council in July 2014. Within the 2014-2018 CEAP, listed under the subsection titled Reporting and Education about the Economic and Environmental Considerations of Energy Use, the highest priority actions for the City of London were to:

1. Provide Londoners with annual information on community energy use and GHG emissions.

2. Develop and report new energy-related performance indicators that highlight the total cost of energy and total money saved/generated from community energy actions.

3. Develop new tools to raise awareness on progress being made in London.

There are many factors that influence how much energy a city uses to function and thrive:

Land use and urban development – planning city growth sets the framework for how much energy is needed for a city to function. Mixed density balances the energy-efficiency of higher-density and social demand for living space. Mixed land use reduces the distance people and goods need to travel.

Urban design – urban design can either negate or enhance the energy efficiency benefits of good functional planning (mixed land use and mixed density). This includes design factors such as connectivity between city blocks, streetscape design, and street orientation.

Transportation – transportation planning has to account for the movement of people and goods. In an ideal world, you would minimize the interactions between the two. However, the reality is that a city's transportation network often has to serve both needs at the same time. An energy-efficient transportation system is one that provides a number of competitive choices for the movement of people and goods.

Buildings – The design, construction, and maintenance of all building types (homes, office buildings, industrial buildings) has a significant impact on the energy consumed by that building. New buildings can be designed that approach net-zero energy use, but the vast majority of London's buildings are old, inefficient designs that often have unseen problems with their insulation and draft-proofing. Building type can also affect energy use and associated emissions. Building energy modelling done for the London Energy Efficiency Partnership (LEEP) Project indicates the following:

- Single-family residential buildings (detached, semi-detached and row housing) require more energy for winter space heating than for summer space cooling;

- Conversely, commercial office buildings require more energy for summer space cooling than for winter space heating; and

- Multi-unit residential buildings generally have a balance between annual space heating and space cooling energy demand.

Personal choices and actions – Design and technology has its limits. For example, a programmable thermostat has no energy conservation benefit if its user does not program it. Social norms are a powerful influence on people's behaviour.

Local economy – the nature of the economic base will influence how much energy it will use. For some businesses, energy use is a minor cost. For others, energy bills can make the difference between profit and loss. For many local employers, there are opportunities for energy conservation, energy-efficiency, and renewable energy generation waiting to be developed.

Leadership – the words spoken, commitments made, and actions taken by leaders in the business, institutional, government and non-government sectors with respect to energy conservation, sustainable energy, reducing the use of fossil fuels, reducing GHG emissions and adapting to climate change.

Seasonal weather variations can affect energy use and associated emissions. London's climate is one that is dominated by the heating demand during cold weather months. On average, the heating season starts in late September and ends in May. With climate change, the energy demands for heating are expected to fall.

The energy demand for space cooling (i.e., air conditioning) in London is relatively small compared to space heating. However, on a hot summer day, a typical household's electricity demand will be three times greater than a cool summer day. This short term "peak demand" places strain on Ontario's electricity generation and supply system. With climate change, the demand for air conditioning is expected to increase.

3 PREVIOUS INVENTORY REPORTS

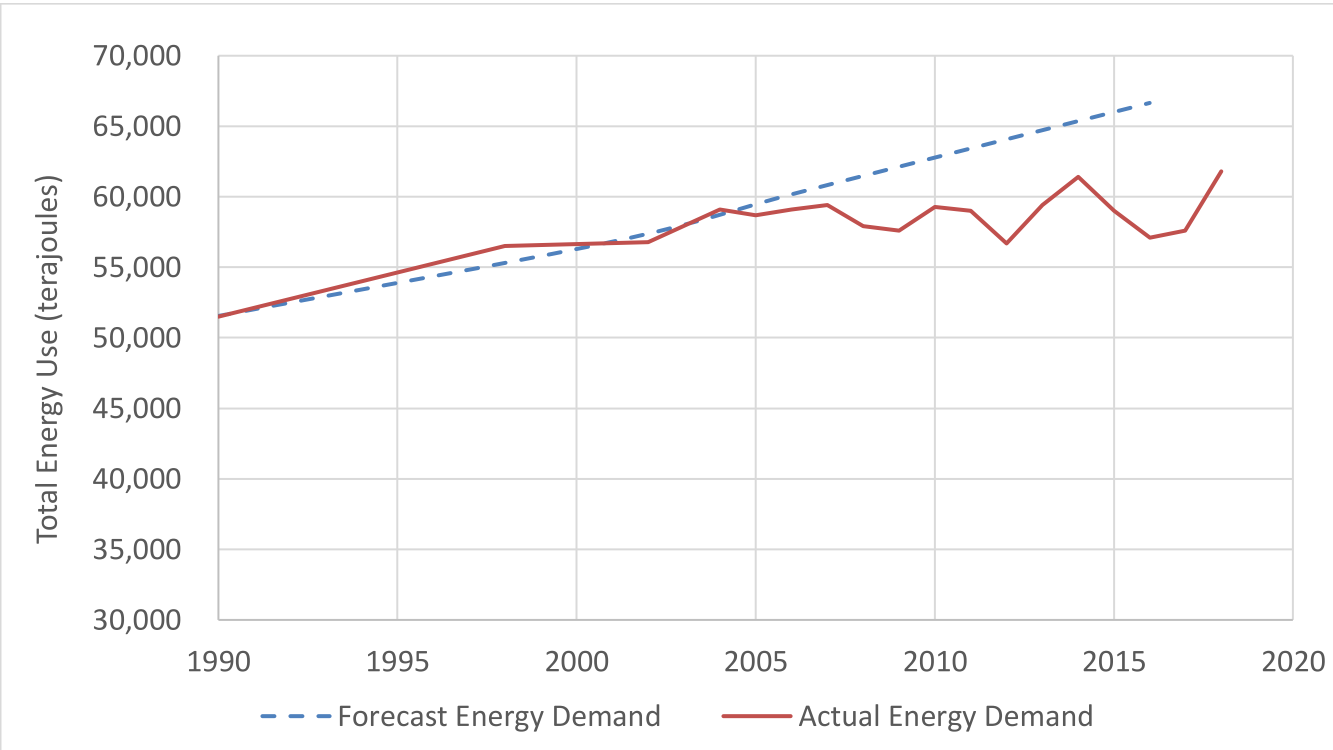
The following is a list of the previous energy inventory reports that have been prepared for London:

- *2017 Community Energy & Greenhouse Gas Inventory,* prepared by the City of London for the Civic Works Committee in August 2018.
- *2016 Community Energy & Greenhouse Gas Inventory,* prepared by the City of London for the Civic Works Committee in August 2017.
- *2015 Community Energy & Greenhouse Gas Inventory,* prepared by the City of London for the Civic Works Committee in June 2016.
- *2014 Community Energy & Greenhouse Gas Inventory,* prepared by the City of London for the Civic Works Committee in May 2015.
- *2013 Community Energy & Greenhouse Gas Inventory,* prepared by the City of London for the Civic Works Committee in July 2014.
- *2012 Community Energy & Greenhouse Gas Inventory: Challenges & Opportunities,* prepared by the City of London for the Civic Works Committee in October 2013.
- 2011 data was highlighted in the *Environmental Programs Update,* prepared for the Civic Works Committee meeting on May 2012.
- *2008 Energy Use Inventory Report,* prepared by the City of London for the Environment and Transportation Committee in July 2010.
- *2007 Energy Use Inventory Report,* prepared by the City of London for the Environment and Transportation Committee in May 2008.
- *2006 Energy Use Inventory Report,* prepared by the City of London for the Mayor's Sustainable Energy Council in November 2007.
- *1998 Air Emissions and Energy Use in the City of London*, prepared for the London Energy/Air Emissions Reduction Strategy Task Force in March 2000.
- *1990 City of London Air Emissions Study*, prepared by SENES Consultants in association with Proctor and Redfern Limited and Torrie Smith Associates for Vision '96 in September 1995.

4 COMMUNITY ENERGY USE INVENTORY

Total energy use in London in 2018 was 61,800 terajoules[1], 20 percent above 1990 levels, and four percent above 2007 levels. As seen from Figure 1, London's total energy use has dropped below the forecasted "business as usual" track forecasted in the 1990s. This illustrates the impact that recent energy conservation activities have had decoupling energy use from growth.

Figure 1 - Comparison of Forecast vs. Actual Energy Demand for London



Colder weather in the winter and spring seasons of 2018, compared to 2017, resulted in an increased demand for natural gas for space heating. This colder weather, combined with hotter summer temperatures in 2018 compared to 2017, also resulted in increased demand for electricity for heating, ventilation, and air conditioning.

London's industrial, commercial, and institutional buildings and facilities accounted for 42 percent of all energy used in London. London Hydro and Enbrdige (formerly Union Gas) include multi-unit residential buildings (apartment buildings and condominiums) under the category of commercial buildings. Transportation accounted for 34 percent of all energy used in London, most of which is associated with personal vehicle use. Single family residential homes accounted for 24 percent of all the energy used in London.

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[1] a terajoule (or, one trillion joules) is a metric unit for measuring energy, and is approximately equivalent to the energy provided by burning 26,000 litres of gasoline (roughly the amount of gasoline in 500 cars)

Table 1 – 1990-2018 Community Energy Use by Sector

Sector	Total Energy Use (Terajoules/year) and Share of Total Energy Demand		
	1990	**2007**	**2018**
Transportation	18,200 (35%)	20,000 (34%)	21,300 (34%)
Residential	13,100 (25%)	14,400 (24%)	14,800 (24%)
Industrial, Commercial & Institutional (IC&I)	20,200 (40%)	25,100 (42%)	25,600 (42%)
Total	**51,500**	**59,400**	**61,800**

NOTE: due to rounding of numbers, individual numbers may not add up to the total

The community energy model developed by the Canadian Urban Institute for the Integrated Energy Mapping for Ontario Communities project, combined with provincial Broader Public Sector (BPS) energy data, was used to estimate a more-detailed breakdown of energy use by building type, as shown in Table 2.

Table 2 – 2018 Estimated Breakdown of Energy Use by Subsector

Sector	Sub-sector	Total Energy Use (terajoules/year)
Transportation	Fuel sold at gas stations	15,000
	Road freight transport	3,800
	Corporate fleets	800
	London Transit	300
	Railway freight transport	500
	Domestic aviation	900
Residential	Low-density homes	12,400
	Medium-density homes (e.g., townhomes)	2,500
Industrial, Commercial & Institutional (IC&I)	High-density residential buildings	1,600
	Commercial – office buildings	3,400
	Commercial – retail buildings (e.g., malls)	5,800
	Industrial	10,500
	Institutional - schools	500
	Institutional - hospitals	1,100
	Institutional - colleges & universities	2,000
	Institutional - municipal buildings & water	400
	Other	200

Over the 1990-2018 time period, London's population has increased by 31 percent. Energy use per person in London was 154 gigajoules (GJ) per year in 2018, down eight percent from 2007 and the 1990 baseline level as well (Table 3).

Table 3 – 1990-2018 per Person Energy Use by Sector

Sector	Per person Energy Use (GJ/person)			
	1990 (Pop. 307,000)	2007 (Pop. 355,000)	2018 (Pop. 401,000)	Change from 1990
Transportation	59	56	53	-10%
Residential	43	40	37	-13%
Industrial, Commercial & Institutional (IC&I)	66	71	64	-3%
Total	**168**	**167**	**154**	**-8%**

NOTE: due to rounding of numbers, individual numbers may not add up to the total

Figure 2 – Change in Energy Use in London, Per Person by Sector Since 1990

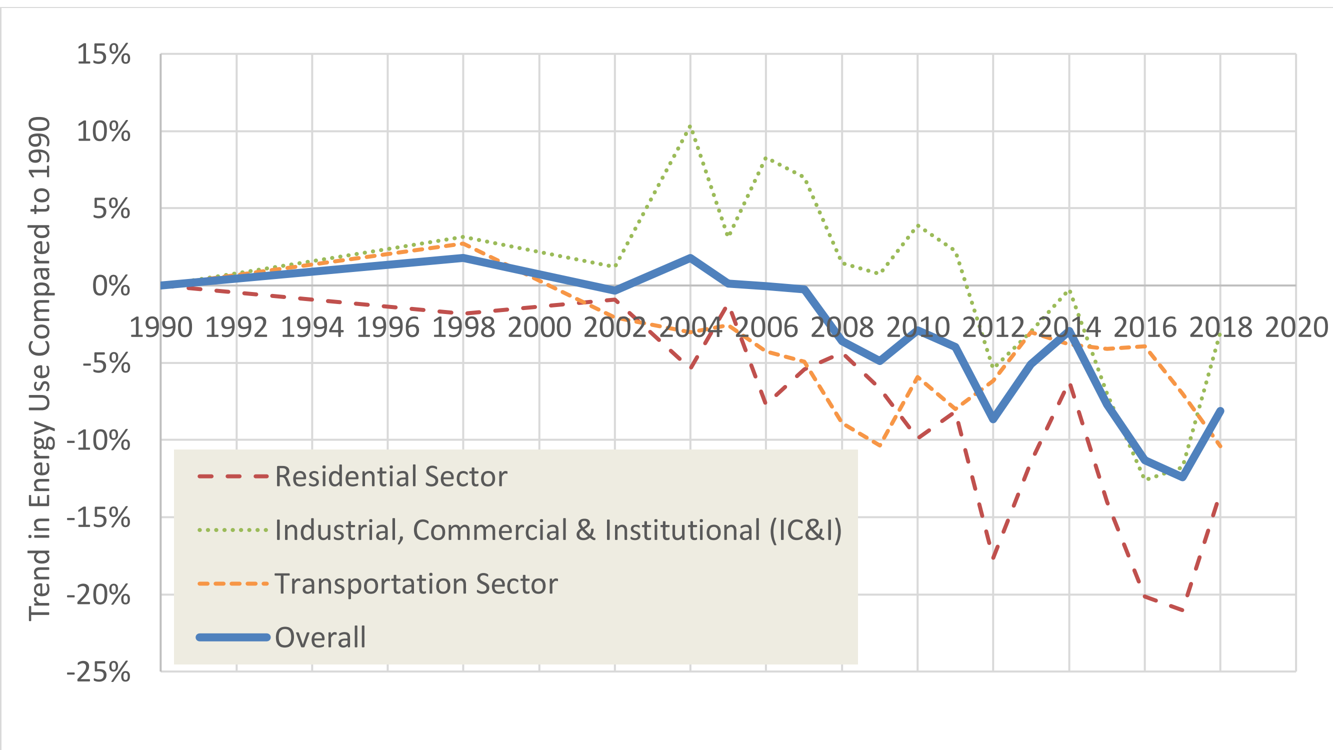


Figure 2 illustrates the change in energy consumption in London by sector on a per person basis, using 1990 as the baseline year. The weather-related impacts of the "Polar Vortex" of 2014 (very cold winter), the "Winter that Wasn't" of 2012 (very warm winter), and the combination of a colder winter and warmer summer in 2018 compared to 2017 can be seen clearly, especially for the residential sector. However, residential energy efficiency has still seen improvements that may be attributed to improvements in the energy efficiency of consumer appliances, space heating and cooling systems, home retrofits and new home construction (e.g., ENERGY STAR® New Homes).

4.1 TRANSPORTATION ENERGY USE

The one sector that had been lagging behind a couple of years ago was transportation. The volume of fuel sold in London had been increasing year-over-year between 2011 and 2016, but this trend stopped in 2017 and continued on in to 2018. Transportation fuel use per person decreased by four percent between 2017 and 2018, with transportation energy use per person in 2018 now 10 percent lower than 1990.

One possible explanation for this decrease is that the average fuel prices at the pumps increased by an additional 13 cents per litre between 2017 and 2018. In comparison, back in 2016, fuel prices at the pumps were 28 cents per litre lower compared to last year.

Vehicle ownership in London has grown by 36 percent since 2011, or over four percent per year on average. As of December 2018, there were over 286,000 light-duty vehicles registered in London – an increase of almost 75,000 since 2011. When compared to Census data on Londoners between the age of 20 and 84, vehicle registration increased from 0.77 per person in 2011 to an estimated 0.94 per person in 2018.

Vehicle choice is also showing a mix of trends. Compact cars remain the most-popular vehicle segment and number of hybrid and/or electric vehicles in London are 3.5 times higher in 2018 compared to 2011. However, sport utility vehicles and large pick-ups are becoming more popular as the relative number of minivans and mid-sized sedans decline.

On a positive note, the average annual fuel use per registered vehicle in London was 19 percent lower in 2018 compared to 2011. Additional detail is provided in Table 4 below.

Table 4 – Vehicle Ownership Statistics for London

	2011	2018	Change
Total registered vehicles	210,700	286,200	36%
No. of adults 20-84 years old	274,000	303,000 (estimate)	11%
Vehicles per adult	0.77	0.94	22%
Hybrid gas-electric vehicles (excluding plug-in hybrids)	930	2,580	250%
Electric vehicles	0	700	
Fuel use per vehicle (GJ/year)	65	52	-19%
Average vehicle age	n/a	7.5 years (2011-12 models)	
Top five vehicle segments (share of vehicle registrations)	Compact car (22%) Mid-sized car (14%) Minivan (10%) Compact SUV 10%) Full-sized car (7%)	Compact car (24%) Compact SUV (19%) Mid-sized car (13%) Large Pickup (9%) Intermediate SUV (8%)	

This highlights the importance of city-led transportation initiatives such as rapid transit and the Cycling Master Plan. According to London's *Smart Moves 2030 Transportation Master Plan*, around 84 percent of all personal trips made in London during the weekday afternoon peak period are made in personal vehicles, and most of these only have one occupant – the driver.

4.2 Energy Use and the Local Economy

Energy use per person related to the industrial, commercial, and institutional sector in 2018 was three percent lower than 1990 and nine percent lower than 2007. London Hydro and Enbridge (formerly Union Gas) have also been increasing efforts to promote energy conservation and demand management with their business client base.

Another way to measure improvements in energy efficiency of the local economy is to compare it to Gross Domestic Product (GDP). According to statistics from the London Economic Development Corporation (LEDC) and the Conference Board of Canada, London's GDP (in constant 2007 dollars – i.e., excluding inflation) has grown by 71 percent between 1990 and 2018.

Based on GDP estimates for 1990, London's energy productivity - GDP generated per unit energy used in London's employment sector - has improved by 35 percent. Table 5 illustrates this in more detail. This means that local businesses are producing products and services more efficiently and/or moving towards producing products and services of higher value for the same amount of energy used.

Table 5 – 1990-2018 Energy Productivity of London's Employment (IC&I) Sector

	1990	1998	2007	2018
Gross Domestic Product ($ millions GDP[1])	$9,600[2]	$11,600[2]	$15,400	$16,400
Energy Used by IC&I Sector (TJ)	20,200	22,500	25,100	25,600
Energy Productivity ($GDP per GJ) [3]	$474	$515	$615	$639
Improvement in Productivity Since 1990		9%	30%	35%
Average Annual Productivity Improvement		1.0%	2.0%	1.0%

NOTE: due to rounding of numbers, individual numbers may not add up to the total

1 – GDP data based on the London Census Metropolitan Area (includes St. Thomas & Strathroy), prorated by 77% based on population of London, and adjusted to constant 2007 dollars based on the Consumers Price Index (CPI) for Ontario

2 – Extrapolated from 2007 GDP data for London CMA based on changes to Ontario's real GDP for 1990 and 1998

3 – London's GDP divided by energy used in IC&I sector

A number of London's major employers have taken a leadership position on energy management, but there are still many opportunities to reduce energy use in the employment sector, particularly amongst small-to-medium sized enterprises who may not have the human, financial, and/or technical resources to manage their energy use effectively.

4.3 Energy Commodities Used in London

The breakdown of energy use and GHG emissions by commodity is outlined in Table 6.

Natural gas is the largest source of energy used in London, accounting for 45 percent of all energy used in London in 2018. Colder weather in the winter and spring seasons of 2018, compared to 2017, resulted in an increased demand for natural gas for space heating, with natural gas use in residential, commercial, and institutional buildings increasing by 15 percent in 2018 compared to 2017. The use of natural gas for local industrial customers increased by 25 percent.

Gasoline was the second largest source of energy, accounting for 24 percent of London's energy use. Gasoline use decreased by two percent in 2018. For transportation fuels, at least 90 percent of all of the gasoline sold in gas stations in London was ethanol blended gasoline (10% ethanol) according to Kent Marketing.

Electricity accounted for 19 percent of all of the energy used in London. The colder weather noted above, combined with hotter summer temperatures in 2018 compared to 2017, also resulted in increased demand for electricity for heating, ventilation, and air conditioning. Residential electricity use increased by nine percent. Electricity use for local industrial, commercial, and institutional customers only increased by two percent.

For electricity, it is important to note that over 90 percent of the electricity generated in Ontario comes from emissions-free sources. In 2018, as reported by the Independent Electricity System Operator (IESO), 61 percent of Ontario's grid electricity was supplied by nuclear generating stations, while hydroelectric generating stations supplied 25 percent and other renewable sources of electricity (wind, biomass, solar) provided eight percent of our electricity needs. Natural gas-fired generating stations provided seven percent of Ontario's supply.

Table 6 – 2018 Community Energy Use by Energy Commodity

Energy Commodity	Total Used	Energy (Terajoules)	Energy (%)
Natural Gas	743,300,000 m^3	27,700	45%
Gasoline[1]	423,400,000 L	14,700	24%
Electricity	3,298,000 MWh	11,900	19%
Diesel[1]	110,200,000 L	4,300	7%
Propane[1]	39,300,000 L	1,000	1.6%
Aviation fuel	24,000,000 L	900	1.5%
Ethanol (in ethanol-blended gasoline)	38,400,000 L	700	1.2%
Fuel Oil[1]	16,000,000 L	600	1.0%
	Total	**61,800**	

NOTE: due to rounding of numbers, individual numbers may not add up to the total

1 – includes some data prorated from Ontario consumption data provided by Statistics Canada; 2016 data

However, one important concept that needs to be understood is thermal efficiency. Whenever any fuel is burned in an engine to create mechanical energy, or used to make steam to spin a turbine to generate electricity, only a small portion of thermal energy ends up being converted to mechanical or electrical energy. The rest of the energy often ends up being lost as "waste heat". For example, the amount of thermal energy converted into power by steam-driven turbines in electricity generating stations is usually about 33 percent, or in other words you need to use three units of heat energy to make one unit of electrical energy. The conversion rate is higher for combined cycle gas-fired power plants, which can reach about 50 percent conversion of heat energy into electricity.

This is the same for internal combustion engines used in vehicles, which are about 35 percent efficient when running in highway driving, and about 20 percent efficient overall when you take into account the fuel wasted in city driving associated with waiting at stop lights and other situations where the engine idles. Replacing internal combustion vehicles with battery-powered electric vehicles is more efficient overall, even more so when sources like hydroelectricity are used.

When the thermal efficiency of converting heat into power in electricity generating stations is taken into account, a different picture of energy needs emerges, as seen in Table 7.

Table 7 – 2018 Energy Use in Electricity Generation Accounting for Thermal Efficiency

Source of Energy[1]	Energy (Terajoules)	Energy (%)
Uranium[2]	22,000	80%
Hydroelectric	2,900	11%
Natural Gas[3]	1,500	6%
Wind	860	3%
Solar[4]	50	0.2%
Biofuels[2]	100	0.4%
Total	**27,400**	

NOTE: due to rounding of numbers, individual numbers may not add up to the total

1 – Based on IESO 2018 annual electricity generation data from transmission-connected sources

2 – Assumed 33% thermal efficiency for generating electricity

3 – Assumed 50% thermal efficiency for generating electricity

4 – IESO data for solar only includes large transmission-connected solar farms. The Ontario Energy Board estimates that solar PV accounts for over 2% of power generation when smaller, local embedded generation is included

Table 7 helps illustrate the fact that electricity is not an energy resource, but the conversion of one form of energy (e.g., thermal energy in the case of nuclear, natural gas or coal) into electrical energy. In most cases, the remaining heat from large electricity generation plants is wasted. For London's electricity needs in 2018, around 27,400 terajoules of energy resources were consumed to provide London with 11,900 terajoules of electricity – the remaining 15,500 terajoules of energy was waste heat that was not utilized. However, this table helps to illustrate that greater use of cogeneration (or combined heat and power) and non-fuel renewables (hydro, wind, solar) will help to reduce this waste. Note that there are other “losses” that occur in energy distribution, such as line losses from power transmission, which have not been quantified.

Table 8 outlines the trend in per person energy commodity use since 1990. As noted earlier, colder weather in 2018 resulted in higher natural gas use.

Table 8 – 1990-2018 per Person Energy Use by Energy Commodity

Energy Commodity	**Total Energy Use Per Person (Gigajoules/person)**			
	1990	**2007**	**2018**	**Change from 1990**
Natural Gas	67	70	69	3%
Gasoline (including ethanol-blended gasoline)	41	40	38	-6%
Electricity	34	36	30	-14%
Diesel	13	12	11	-18%
Fuel Oil	7.2	5.3	1.5	-79%
Aviation fuel	3.2	2.4	2.2	-29%
Propane	2.4	2.1	2.5	3%
Total	**168**	**167**	**154**	**-8%**

NOTE: due to rounding of numbers, individual numbers may not add up to the total

5 ENERGY EXPENDITURES AND ENERGY GENERATION

5.1 ENERGY EXPENDITURES IN LONDON

Using information on utility billing rates and fuel price data from Kent Marketing, the total cost of energy use can be estimated. Note that these costs also include costs for the distribution and delivery of the energy commodity, as well as taxes on these commodities. A full description of the methodology is outlined in Appendix A (Section A.3).

Energy use and associated expenditures on energy are a significant operating cost for many businesses. In addition, for many Londoners, the rising costs of gasoline and electricity have put pressure on day-to-day household expenses, often requiring households to cut back on discretionary purchasing.

Understanding how much is collectively spent on energy, and the opportunities arising from energy conservation, is important for London. Table 9 outlines the total estimated costs associated with the energy commodities used in London.

Table 9 – Total Estimated Cost by Energy Commodity in 2018

Energy Commodity[1]	Estimated Energy Cost			
	Cost ($ million)	Share (%)	Energy (terajoules)	Price per gigajoule
Gasoline (including ethanol-blended gasoline)	$ 584	37 %	15,400	$ 38
Electricity	$ 518	33 %	11,900	$ 44
Natural Gas	$ 288	18 %	27,700	$ 10
Diesel[1]	$ 121	8 %	3,800	$ 28
Propane	$ 31	2 %	1,000	$ 31
Fuel Oil	$ 20	1 %	600	$ 33
Total	**$ 1,560**		**61,800**	**$ 25**

NOTE: due to rounding of numbers, individual numbers may not add up to the total
1 – excludes diesel for railway freight transportation and aviation fuels

It is estimated that Londoners spent almost $1.6 billion on energy in 2018, an increase of 11 percent from 2017.

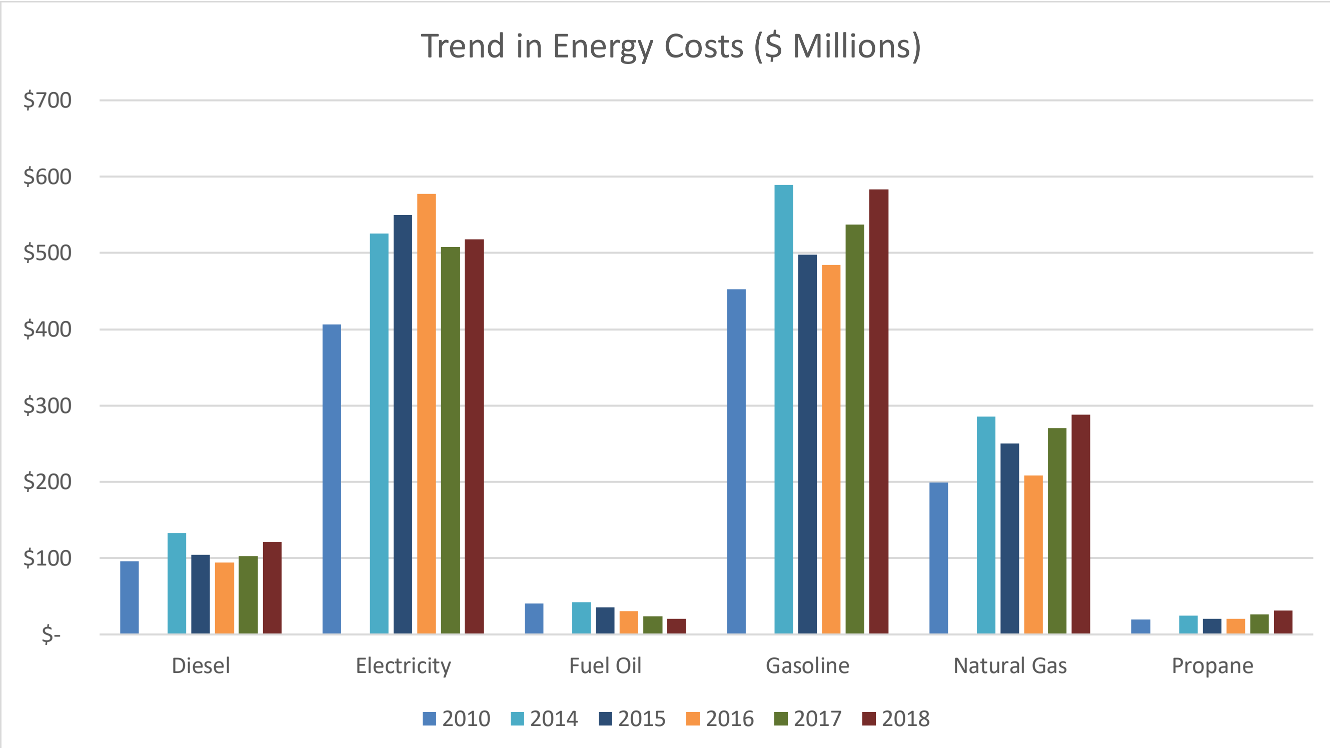
Gasoline is now the largest energy expenditure in London, accounting for 36 percent of city-wide energy costs. Electricity accounts for 35 percent of energy costs. Natural gas use accounts for only 19 percent of energy costs, even though it is the largest source of energy we use.

Gasoline costs increased by nine percent, due primarily to crude oil price increases and higher refinery operating margins resulting in an overall increase of almost 13 cents per litre, even with the cancellation of carbon pricing through Ontario's former Cap and Trade program for fuel distributors.

Electricity costs increased by two percent due primarily to increased demand as noted earlier, offset by a six percent decrease in electricity prices.

Natural gas costs increased by seven percent due primarily to increased demand which was offset by a 12 percent reduction in the natural gas commodity price as well as the cancellation of carbon pricing through Ontario's former Cap and Trade program for fuel distributors.

Figure 4 – Trend for Total Energy Commodity Costs (Millions) by Commodity in London



However, it is important to note that costs could have been higher. If 2010 is used as a baseline year in terms of energy use per capita, as noted in Figure 5, recent improvements in energy efficiency have created ongoing savings. In 2018, it is estimated that $160 million in energy costs were avoided through energy efficiency. Added up year-over-year, London has avoided over $730 million in energy costs due to improved efficiency since 2010.

Every percentage that Londoners reduce their energy use results in around $13 million staying in London.

Information from utility billing rates and fuel price data can also be used to provide a reasonable estimate where the money is spent by Londoners on energy, as illustrated in Table 10. Out of the almost $1.6 billion spent on energy in 2018, it is estimated that 14 percent of this money stayed in London, most of which goes towards London Hydro's and Enbridge - Union Gas' local operations. The rest leaves London.

With the drop in global oil commodity prices earlier this decade, Western Canada's share of our energy dollars has dropped significantly. In 2014, Londoners and London businesses sent about $440 million of their energy dollars to Western Canada compared to about $200 million in 2016 and $320 million in 2018.

About $390 million of our energy dollars also goes to electricity generators in Ontario like Bruce Power and Ontario Power Generation, as well as Ontario's electricity transmitter, Hydro One.

Figure 5 – Trend for Total Energy Costs Compared to 2010 Energy Efficiency Baseline

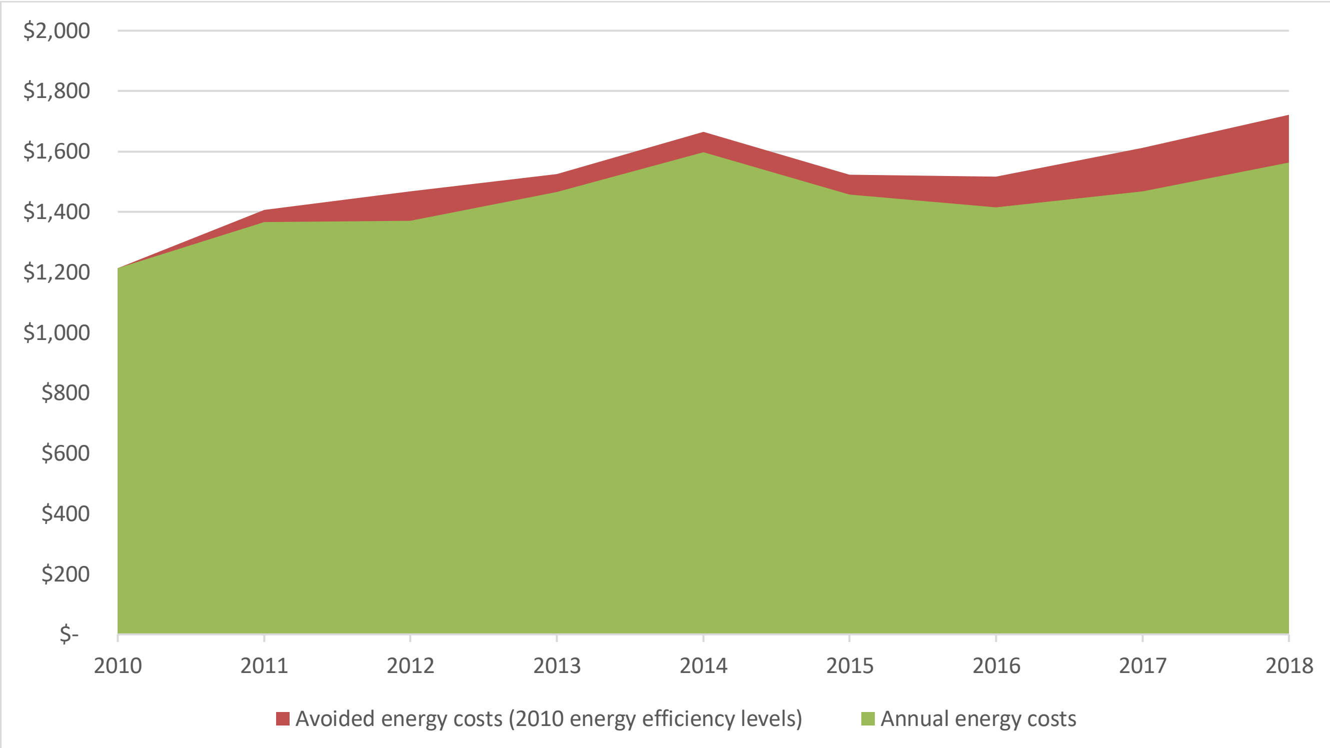


Table 10 – Estimated Share of Energy Revenue (2018)

Commodity	Where the Money Goes (% share)					
	London Region	**Ontario - Business**	**Ontario - Government**	**Western Canada**	**Canada - Government**	**United States**
Diesel	<1%	2%	1%	3%	1%	-
Electricity	4%	25%	3%	-	1%	-
Fuel Oil	<1%	<1%	<1%	<1%	<1%	-
Gasoline	3%	9%	7%	14%	5%	-
Natural Gas	5%	3%	3%	3%	1%	4%
Propane	1%	1%	<1%	-	<1%	-
Total	**14%**	**40%**	**14%**	**20%**	**7%**	**4%**

NOTE: due to rounding of numbers, individual numbers may not add up to the total

A portion of the money collected from federal and provincial taxes and other utility bill fees does help pay for other government services in London. For example, the City of London gets a portion of the gasoline tax to help pay for improvements to local transportation, other infrastructure and environmental projects. Also, energy conservation incentives offered by utility companies are also funded through utility bills, as it is usually more economical to invest in conserving energy rather than it is to build new power plants.

5.2 Energy Generation in London

London has almost 68 megawatts (MW) of local electricity generation capacity installed to date, an increase of 4.0 megawatts from 2018. In 2018, there was 48.4 megawatts of gas-fired generation, 16.1 megawatts of solar photovoltaic (PV), 2.85 megawatts of biogas, and 0.675 megawatts of hydro-electric power generation in operation in London.

Most of London's local generating capacity is associated with natural gas combined heat and power cogeneration plants, used in four different applications:

- **District energy** - London District Energy (18.8 MW) is a "merchant plant" that sells the power to the Independent Electricity System Operator and the thermal energy (steam for heating, chilled water for cooling) to buildings in central London.

- **Industrial** - Ingredion (14.1 MW) and Labatt Brewery (4.2 MW) generate steam as well as electricity "behind-the-meter" for use in their operations.

- **Campus** – the London Health Sciences Centre (9.6 MW) Victoria Hospital campus generates both steam and electricity for hospital buildings, including the ability to keep the heat and power in the event of an emergency.

- **Micro-scale** – small scale combined heat and power systems (under 100 kilowatts) are in use at the Canada Games Aquatic Centre and H.B. Beal Secondary School for pool heating as well as electricity "behind-the-meter" for use in their operations.

Between 2008 and 2018, embedded electricity generation purchases (i.e., locally produced electricity sold to the grid) have increased from 0.2 percent to 1.3 percent of London's electricity needs. This is below the 2.0 percent level reached in 2015. For London District Energy, generating power is dependent upon the Hourly Ontario Energy Price, which itself is driven by province-wide electricity demand.

6 TRANSLATING ENERGY USE INTO GREENHOUSE GAS IMPACT

6.1 GREENHOUSE GAS EMISSIONS FOR 2018

Energy use in London was responsible for almost 3.0 million tonnes of greenhouse gas (GHG) emissions (expressed in terms of equivalent carbon dioxide, or CO_2e) in 2018. Table 11 provides additional information on GHG emissions associated with the various sources of energy used in London.

Table 11 – 2018 GHG Emissions by Energy Commodity

Energy Commodity	Energy (Terajoules - TJ)	GHG Emissions (kilotonnes CO_2e)	GHG (%)	GHG Intensity (tonnes/TJ)
Natural Gas	27,700	1,410	48%	51
Gasoline (including ethanol)	15,400	980	37%	64
Diesel	4,300	300	10%	70
Electricity	11,900	100	3%	8
Aviation Fuel	900	60	2%	68
Propane	1,000	60	2%	60
Fuel Oil	600	40	1%	70
Total	**61,800**	**2,960**		

NOTE: due to rounding of numbers, individual numbers may not add up to the total

Energy use is responsible for 94 percent of all GHG emissions from human activity in London. Not only does burning fossil fuels such as gasoline, diesel, and natural gas produce carbon dioxide – the most common GHG associated with human activity – but the use of electricity also contributes to GHG emissions.

Over 90 percent of Ontario's electricity was generated from emissions-free sources in 2018, such as nuclear and hydro-electric generating stations as well as renewable sources (wind and solar). However, as reported by the Independent Electricity System Operator, Ontario still relies on fossil fuels such as natural gas to generate almost seven percent of the electricity we use. In 2018, it is estimated that every 1,000 kilowatt-hours of electricity generated in Ontario produced about 30 kilograms of carbon dioxide emissions. This is an order-of-magnitude better than it was 15 years ago (2003), when electricity generated in Ontario produced around 300 kilograms of carbon dioxide emissions.

The remaining six percent of GHG emissions are methane emissions from the anaerobic decomposition of organic materials in the active and closed landfills located in London as well as commercial sector waste disposed in landfills outside London, and nitrous oxide emissions from sewage sludge incineration.

London’s 2014-2018 Community Energy Action Plan has the following GHG reduction targets:

- a 6% reduction from 1990 levels by 2014,
- a 15% reduction from 1990 levels by 2020,
- a 37% reduction from 1990 levels by 2030, and
- an 80% reduction from 1990 levels by 2050.

Total GHG emissions in 2018 were over 3.1 million tonnes of equivalent carbon dioxide, or nine percent lower than the 1990 level, which is above the trend line for the first time for meeting the 2020 goal. There were three primary reasons for the increase (i.e., “spike”) in emissions in 2018, of which the first two applied to many cities in eastern North America:

- Colder weather in the winter and spring seasons of 2018, compared to 2017, resulted in an increased demand for natural gas for space heating;

- Hotter summer temperatures in 2018, compared to 2017, increased demand for electricity for air conditioning. This increased demand was met by Ontario’s natural gas fuelled power plants, which resulted in higher emissions associated with electricity use; and

- Landfill gas emissions from the City of London’s W12A Landfill were also higher in 2018 due to operational challenges with the W12A Landfill’s gas flare system.

Seasonal weather variations can affect energy use and associated emissions significantly. In 2016, as was also the case in 2012, the unusually warm winter reduced energy needs for heating buildings. Contrast that to 2014 and 2018, when the colder winter weather increased the need for natural gas. Overall, over the last ten years, winter average temperatures and most summer average temperatures have been warmer than normal (as defined by Environment Canada’s 1971-2000 climate data for London - see Appendix B).

Using a three-year rolling average smooths out the impact of annual variations in weather in order to determine trend directions. One year spikes in GHG emissions have occurred in previous years in London. Although total GHG emissions for 2018 were above the trend line for meeting the 2020 target, the three-year rolling average total GHG emissions for the 2016-2018 period was 13 percent below 1990 levels, below the trend line for meeting the 2020 target.

Figure 6 illustrate the total GHG emission trend since 1990. The increase in GHG emissions began to stabilize around 2002 after a continued climb from 1990. Since 2005 there has been a downward trend.

Figure 6 - Targets vs. Actual GHG Emissions from London

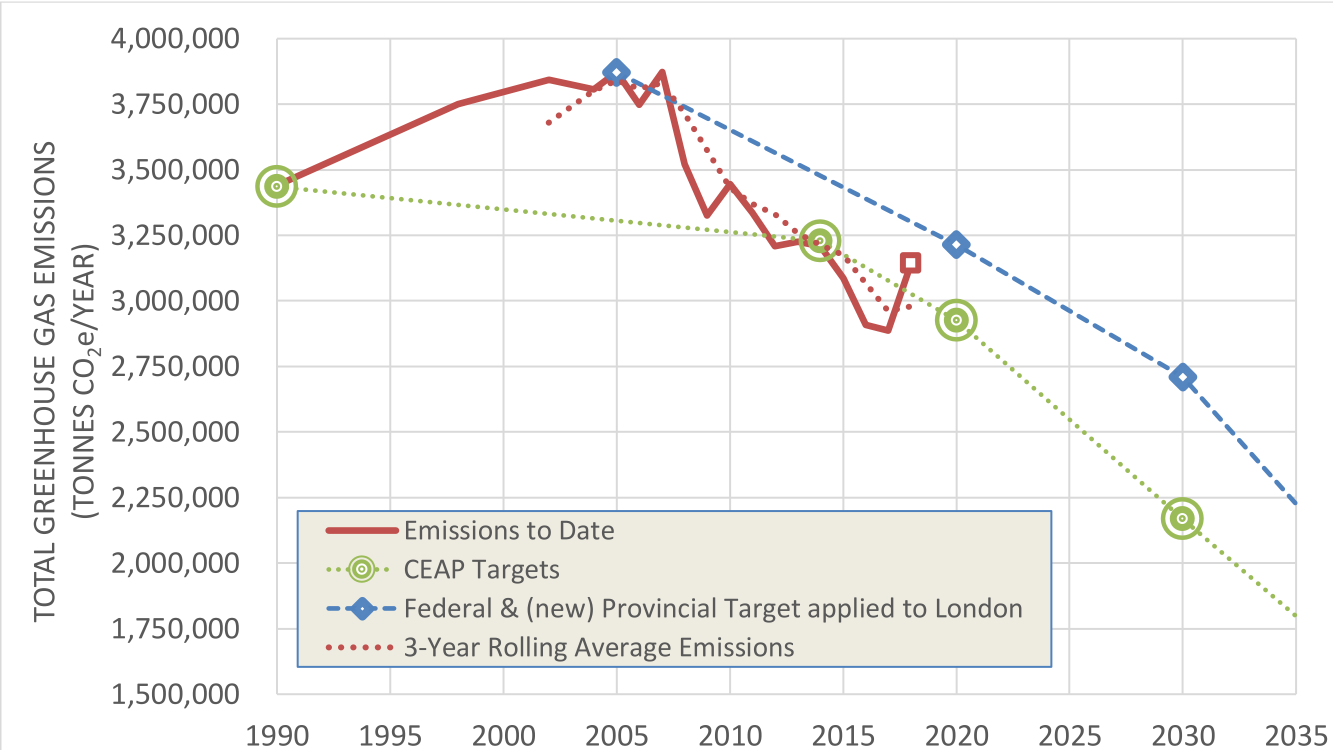


Table 12 illustrates the GHG emission trends by sector, including landfill gas emissions. As seen in Table 12, transportation and the industrial, commercial, and institutional sectors have the greatest contribution.

Table 12 – 1990-2018 Community GHG Inventory in London

Sector	GHG Emissions (kilotonnes/year)		
	1990	**2007**	**2018**
Transportation	1,290	1,370	1,380
Residential	730	820	590
Industrial, Commercial & Institutional	1,120	1,430	990
Landfill Gas Emissions & Sewage Incineration	300	260	190
Total	**3,440**	**3,870**	**3,140**

NOTE: due to rounding of numbers, individual numbers may not add up to the total

The community energy model developed by the Canadian Urban Institute for the Integrated Energy Mapping for Ontario Communities project, combined with provincial Broader Public Sector (BPS) energy data, was used to estimate a more-detailed breakdown of GHG emissions by building type, as shown in Table 13.

Table 13 – 2018 Breakdown of GHG Emissions by Subsector

Sector	Sub-sector	GHG Emissions (kilotonnes/year)
Transportation	Fuel sold at gas stations	960
	Road freight transport	260
	Corporate fleets	50
	London Transit	20
	Railway freight transport	40
	Domestic aviation	60
Residential	Low-density homes	500
	Medium-density homes (e.g., townhomes)	80
Industrial, Commercial & Institutional	High-density residential buildings	40
	Commercial – office buildings	140
	Commercial – retail buildings (e.g., malls)	220
	Industrial	430
	Institutional - schools	20
	Institutional - hospitals	40
	Institutional - colleges & universities	80
	Institutional - municipal energy use	10
Landfill Gas Emissions & Sewage Incineration	W12A Landfill	120
	Closed landfills	40
	IC&I waste disposed outside of London	10
	Sewage sludge incineration	10

In terms of per person emissions, as illustrated in Table 14 and Figure 7, emissions today are 30 percent lower than they were back in 1990 (11.2 tonnes per person in 1990 versus 7.8 tonnes per person in 2018).

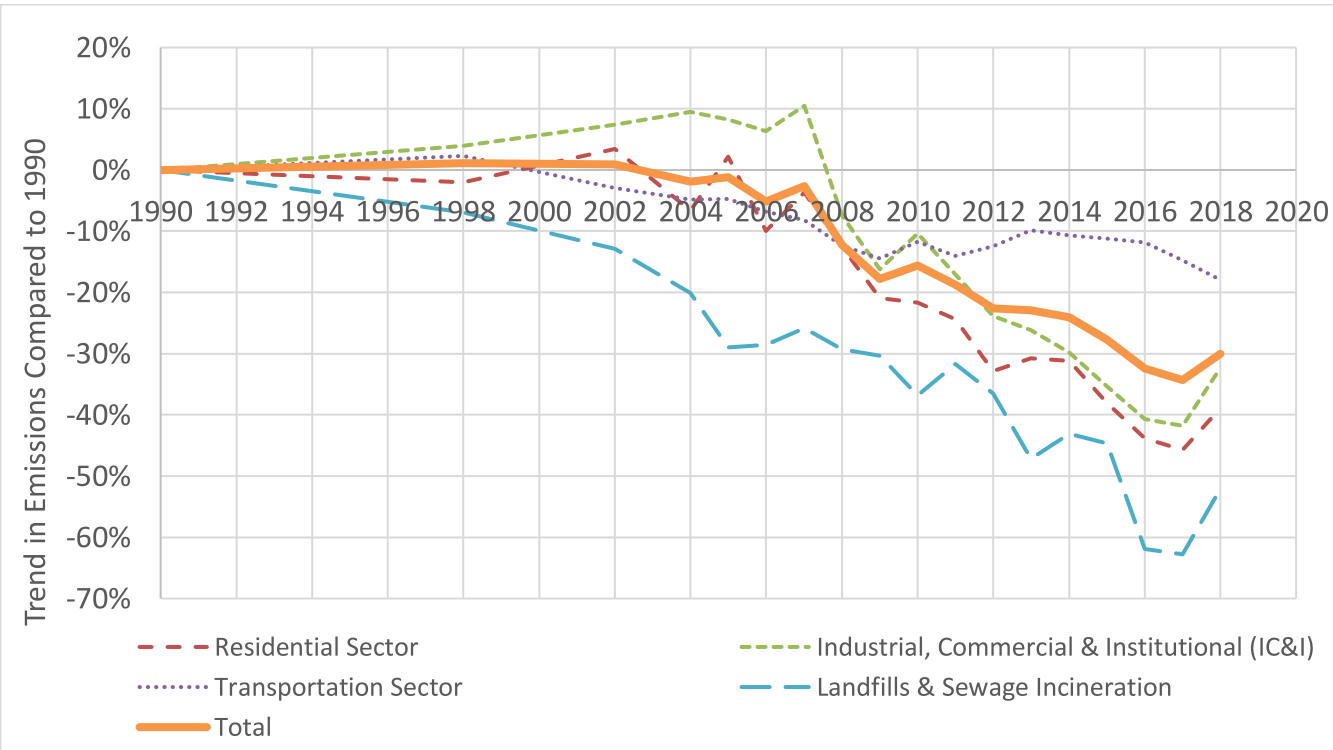
As discussed before, this reduction in GHG emissions has been created by a reduced GHG intensity for Ontario's electricity grid, improved home energy efficiency, reduced energy use in the business sector, and the City of London landfill gas collection and flaring system at the W12A Landfill. Transportation emissions are also lower due to improved fuel efficiency, the use of ethanol-blended gasoline (10% ethanol by volume) as well as vehicle tailpipe emission controls that have reduced emissions of nitrous oxide.

Table 14 – 1990-2018 per Person GHG Inventory in London

Sector	GHG Emissions (tonnes/person)			
	1990 (Pop. 307,000)	2007 (Pop. 355,000)	2018 (Pop. 401,000)	Change from 1990
Transportation	4.2	3.9	3.4	-18%
Residential	2.4	2.3	1.5	-39%
Industrial, Commercial & Institutional	3.6	4.0	2.5	-32%
Landfill Gas Emissions & Sewage Incineration	1.0	0.7	0.5	-52%
Total	**11.2**	**10.9**	**7.8**	**-30%**

NOTE: due to rounding of numbers, individual numbers may not add up to the total

Figure 7 – Change in GHG Emissions in London, Per Person by Sector, Since 1990



It is important to note these GHG emission estimates do not include emissions (indirect emissions) associated with the extraction, production, and transportation of materials, fuels, food, and consumer products (e.g., emissions from produce grown and transported from California, consumer products made and transported from China.) This is consistent with the approach taken by other Canadian cities reporting GHG emissions through the Partners for Climate Protection program. However, it is important to recognize the fact that the production and transportation of the consumer goods we purchase do have an environmental impact, and that some types of goods (e.g., meat and dairy products) do have a larger impact than others.

6.2 Publicly-Reported Local Emitters

In 2018, the provincial government required facilities that emit more than 25,000 tonnes of greenhouse gases to report their emissions on an annual basis. In London, there are eight facilities that have reported their emissions, as shown in Table 15. Note that these are direct emissions only, and do not include emissions associated with electricity use or vehicle fuel use.

The district heating steam plant at Western University provides heat for buildings on the Western University campus as well as the neighbouring London Health Sciences Centre University Hospital. In the case of London District Energy, these emissions are associated with providing steam heating and chilled water to buildings, as well as generating electricity. Many building owners served by London District Energy, including the City of London and St. Joseph's Health Care, include their share of these emissions within their energy and GHG reporting.

It is important to note that these "large emitters" only accounted for 12 percent of London's total GHG emissions.

Table 15 – Facilities Meeting Federal or Provincial GHG Reporting Requirements in London

	Annual GHG Emissions (tonnes CO_2e)		
Reporting Facility (based on fuel combustion)	**2010**	**2013**	**2017**
Fanshawe College of Applied Arts and Technology	3,143	2,924	2,857
Ingredion Canada Incorporated	124,320	115,988	122,352
Labatt Breweries of Canada LP	26,594	27,503	28,716
London Health Sciences Centre (Victoria Campus CHP)	37,108	41,707	41,847
Western University (steam plant)	51,364	47,322	49,687
London District Energy	39,844	44,622	31,610
Great Lakes Copper	N/A	N/A	13,027
Kaiser Aluminum	N/A	N/A	18,036
W12A Landfill – Corporation of the City of London	160,430	106,349	68,925
Greenway Pollution Control Centre – Corporation of the City of London	N/A	N/A	20,190
Total	**442,803**	**386,415**	**397,247**
Percentage of total emissions from London	**13%**	**12%**	**13%**

The institutional sector – municipal government, colleges and universities, schools, hospitals – is also required to report its energy use and associated GHG emissions to the Province of Ontario through Ontario Regulation 397/11. These emissions will be for the organization as a whole, not just one specific facility or building. Table 16 summarizes the data reported for 2016, the most recent information available from the provincial government. Note that this information will include emissions from electricity use, but does not include emissions from vehicle fuels. Also, in the case of the City of London, the province’s reporting requirements do not require electricity use for street lighting and sports field lighting to be reported.

Table 16 – Ontario Regulation 397/11 Reporting Organizations in London

Reporting Organization (based on building electricity and fuel use)	Annual GHG Emissions 2016 (tonnes CO_2e)
University of Western Ontario	54,357
London Health Sciences Centre	44,950
Thames Valley District School Board	12,410
St. Joseph's Health Care London	11,551
City of London	10,297
Fanshawe College	4,626
London District Catholic School Board	4,126
Conseil scolaire de district des écoles catholiques du Sud-Ouest	416
County of Middlesex (buildings in London)	316
Conseil scolaire de district du Viamonde	217
Municipality of Thames Centre (building in London)	9
Boreal College	5
total	**143,280**
Percentage of industrial, commercial, and institutional emissions	**17%**
Percentage of total emissions from London	**5%**

7 HOUSEHOLD ENERGY USE AND EMISSIONS

Estimating energy use and associated emissions at the household scale can be useful to help Londoners understand what they are using energy for and how they compare to other Londoners. These estimates can be made using the following assumptions:

- For electricity and natural gas, divide the total residential customer energy use by the number of customers
- For gasoline, divide the total retail sales of gasoline by the number of households in London
- For propane, divide the estimated total residential use of propane by the number of households in London

Electricity and natural gas use can be broken down further based on provincial data on typical energy use breakdown in Ontario homes.

Greenhouse gas emissions from organic waste in curbside waste can be estimated by dividing the annual GHG emissions from the W12A Landfill by the number of households in London.

Note that these estimates best reflect those Londoners who live in single-family homes.

Table 17 – Estimated Average Household Energy Use and Emissions in London for 2018

Household Activity	**Average Monthly Use over the Year**	**Average Monthly Cost over the Year**	**Average Annual GHG Emissions (tonnes CO_2e)**
Gasoline use (vehicles)	208 litres	$263	5.3
Natural gas use	190 cubic metres	$78	4.3
Home heating		*$60*	*3.3*
Hot water heating		*$18*	*1.0*
Electricity use	670 kilowatt-hours	$100	0.16
Air conditioning		*$13*	*0.02*
Appliance & plug load		*$32*	*0.05*
Lighting		*$10*	*0.02*
HVAC fan motor		*$45*	*0.07*
Propane use	6 litres	$15	0.1
Organic waste in garbage		not applicable	0.9
Total		**$455**	**10.8**

NOTE: due to rounding of numbers, individual numbers may not add up to the total

8 SUMMARY AND CONCLUSIONS

8.1 ENERGY USE

Since 2005, London has seen its total energy use remain relatively unchanged as London continues to grow.

Residential (single family home) energy efficiency has seen improvement, driven by energy conservation programs such as the former federal and provincial home energy audit and retrofit programs, along with utility conservation and demand management programs. New home construction in London has seen energy efficiency improvements driven by voluntary participation in efficiency programs such as Energy Star New Homes, as well as the 2012 Ontario Building Code.

Over the last ten years, energy efficiency for London's industrial, commercial, and institutional sector has been improving. London has many examples of local employers who have taken action on energy efficiency and conservation.

Transportation fuel use, particularly retail sales of gasoline, is the only sector where energy use has increased over the last ten years.

In summary, specific highlights of recent community energy use progress and longer-term trends, include:

- The total amount of energy used in London in 2018 was 61,800 terajoules. This is a 7% increase over 2017. The combination of a colder winter and a hotter summer in 2018 (compared to 2017) increased the demand for natural gas and electricity.

- Londoners are using energy more efficiently – on a per person basis, Londoners and London businesses used 8% less energy overall in 2018 than used in 2007, the year that energy use reached its peak in London.

- London is producing more good and services for every unit of energy used – on a dollar gross domestic product (GDP adjusted for inflation) per unit energy basis, London's industrial, commercial, and institutional sector improved the value of goods and services produced per unit of energy used by 35% between 1990 and 2018.

- Almost $1.6 billion was spent by Londoners and London businesses on energy in 2018. This is an 11% increase over 2017.

    - Almost 90% of this money leaves London.
    - Gasoline costs increased by 9%, due to an increase in crude oil prices in 2018.
    - Electricity costs increased by 2%, due to higher electricity consumption.
    - Natural gas costs increased by 7% overall, where decreases in natural gas prices were offset by increases in natural gas consumption.

- London is spending less money on energy – improvements in energy efficiency compared to 2010 levels of efficiency (on a per person basis and applied to activity in 2018) avoided $160 million in energy costs had there been no improvements (i.e., Londoners and businesses would have spent $160 million more in 2018 on energy).

In addition, since 1990:

- The total amount of energy used in London in 2018 was 61,800 terajoules, 20% above 1990 levels. This increase is due to London's growing population along with our growing economy, partially offset by the improved energy efficiencies noted below.

- On an energy used per person basis:
  - Transportation fuel use has decreased by 10%;
  - Energy use to heat and power single-family residential homes has decreased by 13%; and
  - Energy use to heat and power industrial, commercial, and institutional buildings decreased by 3%.

The one sector that had been lagging behind a couple of years ago was transportation. The volume of fuel sold in London had been increasing year-over-year between 2011 and 2016, but this trend stopped in 2017 and continued on in to 2018. Transportation fuel use per person decreased by four percent between 2017 and 2018, with transportation energy use per person in 2018 now 10 percent lower than 1990.

Vehicle ownership in London has grown by 36 percent since 2011, or almost five percent per year on average. As of December 2018, there were over 286,000 light-duty vehicles registered in London – an increase of about 75,000 since 2011. When compared to Census data on Londoners between the age of 20 and 84, vehicle registration increased from 0.77 per person in 2011 to 0.94 per person in 2018. However, on a positive note, the average annual fuel use per registered vehicle in London was 19 percent lower in 2018 compared to 2011.

8.2 Opportunities for London

Out of the almost $1.6 billion spent on energy in 2018, it is estimated that about 14 percent of this money stayed in London. London would benefit from keeping more of its money in London. Every percentage that Londoners reduce their energy use results in approximately $13 million staying in London.

For example, the average household in London, living in a single-family home, spent over $450 every month on energy. Over half of this, about $260, was spent on gasoline. Electricity accounted for about $100 per month, while natural gas was under $80 per month.

Money saved through energy efficiency and conservation can be used for other purposes, whether that's paying down debts faster or purchasing other goods and services. Also, investing in energy saving retrofits, local sustainable energy projects and local energy production creates local jobs.

8.3 Greenhouse Gas Emissions

From a GHG reduction perspective, credit should be given to the Government of Ontario for following through in its plans to replace coal-fired power generation plants with cleaner sources, such as nuclear, hydroelectric, natural gas, and renewables, as well as encouraging electricity conservation. GHG emissions from the province's electricity grid are now 90 percent lower than they were ten years ago. The reductions in energy use noted above are also a contributor to London's significant reductions in GHG emissions. Federal vehicle emission standards and provincial ethanol in gasoline requirements have also helped to reduce transportation GHG emissions. Finally, the City of London's landfill gas collection and flaring system represents the largest source of GHG emissions reduction directly under municipal government control.

In summary: the use of energy in London has had the following GHG impacts:

- Total GHG emissions in 2018 were over 3.1 million tonnes of equivalent carbon dioxide – the top three sources in 2018 were personal vehicles (30%), single-family homes (19%), and local industry (14%).

- London's total GHG emissions in 2018 were 9% below 1990 levels – the colder winter and a hotter summer increased the use of natural gas for heating and electricity generation, which resulted in higher GHG emissions. In comparison, GHG emissions in 2017 were the lowest to date at 17% below 1990 levels.

- London's 3-year rolling average for total GHG emissions in 2018 were 13% below 1990 levels – the rolling average is determined by averaging the last three years (2016, 2017 and 2018). London's CEAP goal is to reach 15% reduction from 1990 levels by 2020.

- Londoners' per-person GHG emissions are significantly lower – on a per person basis, Londoners and London businesses released 30% fewer GHG emissions in 2018 than they did in 1990.

Whether emissions continue to decrease depends upon the impact of energy and fuel conservation efforts, provincial and federal climate change policies, climate trends, economic growth, and consumer choices. It is also important to note that these actions also contribute to reductions in air pollution emissions (e.g., nitrogen oxides, volatile organic compounds) from fossil fuel use.

In terms of household GHG emissions, the average household emitted 10.8 tonnes per year. As with cost, about half (49%) of this came from burning gasoline. Natural gas used for space heating and water heating accounted for 40 percent of emissions. Organic waste in the landfill accounted for about eight percent. Given Ontario's clean electricity grid, electricity use in the home only accounts for under two percent of household GHG emissions.

APPENDIX A - METHODOLOGY

This document builds upon two foundational energy use and GHG emissions inventories that have been developed for London and related data, specifically:

- The 1995 *City of London Air Emissions Study*, prepared by SENES Consultants in association with Proctor & Redfern Limited and Torrie Smith Associates. It provided the baseline inventory for the community (1990) and municipal operations (1992).
- The London Energy/Air Emissions Reduction Strategy Task Force report in March 2000 titled *Air Emissions and Energy Use in the City of London.* This report revised the baseline 1990 community inventory and provided an update to the community inventory using 1998 data. It also provided an emissions and energy use business-as-usual forecast for 2001, 2006, 2012, and 2016.

Since 2003, City of London (Environmental Programs) staff has maintained and updated the community energy use and GHG emissions inventory on an annual basis.

The methodology employed is consistent with the GHG emission inventory protocol provided by ICLEI Canada for participants in the Federation of Canadian Municipalities' Partners for Climate Protection (PCP) program. The *2012 Community Energy & Greenhouse Gas Inventory: Challenges & Opportunities* report was reviewed by ICLEI and FCM staff as part of the City of London's Milestone 5 recognition for the PCP program.

The GHG inventory includes Scope 1 and Scope 2 emission sources, plus those Scope 3 emission sources required by the Compact of Mayors:

- Scope 1 - GHG emissions from fuel use and landfills within the boundary of the city
- Scope 2 - Indirect GHG emissions that occur outside of the city boundary as a result of electricity consumption within the city
- Scope 3 - Other indirect emissions that occur outside of the city boundary as a result of activity within the city:
  - solid waste disposal (IC&I waste disposed in landfills outside London)
  - domestic aviation
  - railways

The remaining Scope 3 emissions, other indirect emissions and embodied emissions that occur outside of the city boundary as a result of activities of the city, are not included in the inventory, such as:

- marine
- embodied emissions upstream of power plants
- embodied emissions in fuels
- embodied emissions in imported construction materials
- embodied emissions in imported goods
- embodied emissions in imported food

A.1. COMMUNITY INVENTORY DATA COLLECTION

Data for the community inventory is available for 1990, 1998, 2002, and 2004-2018 unless otherwise noted below. The inventory information used for the residential sector is based on the following:

- Annual electricity use data was provided by London Hydro. Note that this excludes multi-unit residential buildings, which are considered to be commercial accounts by London Hydro.
- Annual natural gas use data was provided by Union Gas. Note that this excludes multi-unit residential buildings, which are considered to be commercial accounts by Union Gas.
- Other home heating fuel data (e.g., propane, fuel oil) was obtained from Statistics Canada end-use energy data for Ontario prorated by population to estimate use within London. Note that the latest information is from 2017.

The inventory information used for the business and institutional sector is based on the following:

- Annual electricity use was provided by London Hydro. Note that this includes General Service < 50 kW , General Service > 50 kW , Large Users > 5000 kW, Users with Embedded Services (e.g., co-generation plants), sentinel lights, and street lighting.
- Annual natural gas use was provided by Union Gas. Note that this includes industrial, commercial, and institutional accounts.
- Other fuel data (e.g., fuel oil, kerosene) developed from Statistics Canada end-use data for Ontario prorated by population to estimate use within London. Note that the latest information is from 2017.

The inventory information used for the transportation sector is based on the following:

- Annual retail transportation fuel sales data for gasoline, ethanol-blended gasoline (E10) and diesel was provided by Kent Marketing. Given that London is a self-contained urban area, it is assumed that all transportation fuel used by London residents and businesses are purchased within London. This information has the benefit of being current (2018 data).
- Diesel use for public transit was provided by London Transit.
- Community non-retail (i.e., road transport, commercial and other institutional) transportation fuel data developed from Statistics Canada end-use energy data for Ontario prorated by population to estimate use within London. Propane and diesel identified as being used in the commercial and industrial sector is assumed to be used as transportation fuel only. Note that the latest information is from 2017.

The inventory information used for landfills is based on the following:

- Annual waste quantities placed within the landfills for each calendar year.

- For the W12A landfill, the emission reductions associated with the landfill gas collection and flaring system are based on continuously measured landfill gas flow rate and methane concentration at the landfill flare.

- The global warming potential of methane of 25, as per the Intergovernmental Panel on Climate Change's *Fourth Assessment Report* and used by the federal government in its GHG emissions reporting.

As a result of London having joined the Compact of Mayors in 2015, new information needs to be included within London's energy and GHG emissions inventory as per the Global Protocol for Community-Scale GHG Emission Inventories (GPC):

- Fuel used by aviation
- Fuel used by railways
- Waste generated in London and disposed outside of London

The inventory information used for aviation is based on the following:

- From the National Inventory Report, 1990-2017 - Greenhouse Gas Sources and Sinks in Canada, GHG emissions data for domestic aviation in Ontario was prorated by population to estimate Londoner's share of aviation emissions. Note that the latest information is from 2017.

- To estimate energy use, it was assumed that the domestic aviation GHG emissions is derived from the use of aviation jet fuel, and the GHG emission factor for jet fuel was used to back-calculate estimated volumes of jet fuel.

The inventory information used for railways was developed from Statistics Canada energy end-use data for Ontario prorated by population to estimate use within London. Note that the latest information is from 2017.

The inventory information used for waste generated in London and disposed outside of London is based on the following:

- For 2018, GHG emissions were estimated by taking the reported GHG emissions from the Twin Creek Landfill and Ridge Landfill for 2016, and dividing it by London's share of the annual fill rate at these landfills. City of London Solid Waste Management staff estimated the volume of London's industrial, commercial, and institutional (IC&I) sector solid waste disposed outside of London to be around 83,000 tonnes – 45,000 tonnes to the Twin Creek Landfill and 8,000 tonnes to landfills in Michigan.

- For the 1990 to 2016 period, the amount of IC&I waste per capita was assumed to be the same as reported last year, namely 0.31 tonnes per person. GHG emissions were estimated based on the Ontario Waste Management Association' Cap & Trade Research spreadsheet model for Ontario waste sector; based on the model's estimated 0.75 tonnes CO_2e emitted per tonne waste disposed at large landfills. It was assumed 50% landfill gas capture from 2002 to 2018, only 25% landfill gas capture for 1998, and no landfill gas capture for 1990.

As a result of London having joined the Compact of Mayors in 2015, it is recommended that nitrous oxide emissions from sewage treatment be included within London's energy and GHG emissions inventory as per the Global Protocol for Community-Scale GHG Emission Inventories (GPC). Nitrous oxide is a combustion by-product from the incineration of sewage sludge and its formation is influenced by incinerator operating conditions (i.e., combustion temperature).

Since 2008, annual stack testing at the Greenway Wastewater Treatment Plant sludge incinerator has included the measurement to nitrous oxide alongside other air pollutants. Table A-1 summarizes the nitrous oxide stack test results.

Table A-1: Summary of 2008 – 2018 Stack Test Results for N_2O Emissions from the Greenway WWTP Sewage Sludge Incinerator

Year	N_2O emissions			
	Measured average emissions g/s	Measured average emissions kg/h	Estimated annual emissions tonnes/y	Estimated annual CO_2e tonnes/y
2008	0.1	0.4	3	1,000
2009	1.1	3.9	28	8,800
2010	1.1	3.9	28	8,700
2011	1.2	4.4	32	9,900
2012	1.0	3.5	26	7,900
2013	0.2	0.6	4	1,400
2014	1.1	4.1	29	9,100
2015	1.0	3.7	26	8,200
2016	0.3	1.1	7	2,300
2017	2.4	8.6	65	20,000
2018	1.7	6.0	43	13,000

As can be seen from the table above, measured emissions of nitrous oxides can vary from year to year. As Environment and Climate Change Canada reduces the reporting threshold for facility emissions to 10,000 tonnes per year of carbon dioxide equivalent emissions for the 2018 reporting year, the Greenway Wastewater Treatment Plant may be required to report its emissions.

A.3. Greenhouse Gas Emission Factors for Energy Commodities

Greenhouse gas emissions associated with energy use were calculated based on the emission factors provided by *Canada's National Inventory Report 1990-2017*, except for the 2018 grid-average emission factors for Ontario, which have been estimated based on the 2018 electricity supply mix for Ontario reported by the IESO, combined with the data from *Canada's National Inventory Report 1990-2017*. A summary of emission factors has been provided in Table A-1.

All GHG emissions are expressed in terms of equivalent carbon dioxide (CO_2e), based on the global warming potentials (GWP) of the various GHG emissions provided by *Canada's National Inventory Report 1990-2017.*

Table A-2 – Greenhouse Gas Emission Factors and Energy Conversions

Source of Emission	Emission Factor (CO_2e)	Information Source
Electricity - Ontario 2018	0.03 kg/kWh	Estimated based on IESO information for 2018
Electricity - Ontario 2017	0.02 kg/kWh	National Inventory Report, 1990-2017 - Greenhouse Gas Sources and Sinks in Canada ANNEX 11: ELECTRICITY IN CANADA: SUMMARY AND INTENSITY TABLES
Electricity - Ontario 2016	0.04 kg/kWh	
Electricity - Ontario 2015	0.04 kg/kWh	
Electricity - Ontario 2014	0.04 kg/kWh	
Electricity - Ontario 2013	0.08 kg/kWh	
Electricity - Ontario 2012	0.11 kg/kWh	
Electricity - Ontario 2011	0.11 kg/kWh	
Electricity - Ontario 2010	0.14 kg/kWh	
Electricity - Ontario 2009	0.12 kg/kWh	
Electricity - Ontario 2008	0.17 kg/kWh	
Electricity - Ontario 2007	0.24 kg/kWh	
Electricity - Ontario 2006	0.21 kg/kWh	
Electricity - Ontario 2005	0.25 kg/kWh	
Electricity - Ontario 2004	0.22 kg/kWh	
Electricity - Ontario 2002	0.29 kg/kWh	
Electricity - Ontario 1998	0.23 kg/kWh	
Electricity - Ontario 1990	0.22 kg/kWh	
natural gas	1.90 kg/m^3	National Inventory Report, 1990-2017 - Greenhouse Gas Sources and Sinks in Canada ANNEX 6: EMISSION FACTORS
fuel oil	2.73 kg/L	
propane	1.54 kg/L	
gasoline	2.34 kg/L	
diesel	2.71 kg/L	
gasoline (E-10)	2.09 kg/L	
Source of Energy	**Energy Content**	**Information Source**
electricity	0.0036 GJ/kWh	Natural Resources Canada CO_2 Calculator
natural gas	0.0372 GJ/m^3	
fuel oil	0.0388 GJ/L	
propane	0.0253 GJ/L	
gasoline	0.0347 GJ/L	
diesel	0.0387 GJ/L	
gasoline (E-10)	0.0332 GJ/L	TSA's Canadian Cities GHG Emissions Strategy Software

A.4. Cost Estimates for Community Energy Use

Information on the cost of using petroleum products is based on information available from Kent Marketing Services, specifically:

- Annual retail prices (including tax) and wholesale prices for regular-grade gasoline, mid-grade gasoline, premium-grade gasoline, diesel, and furnace oil;
- Crude oil price component associated with retail fuels, allocated to Western Canada (Alberta and Saskatchewan) which is the source of oil for refineries in Sarnia;
- The refiners operating margin, which is the difference between annual crude oil prices and wholesale prices, allocated to Ontario (refineries in Sarnia);
- The Harmonized (Federal and Provincial) Sales Tax and Federal Fuel Excise Tax; and
- The marketing operating margin, which is the difference between annual retail prices the wholesale prices and federal and provincial taxes, allocated to London (gas stations).

This allocation method was reviewed and accepted as being reasonable in 2013 by Kent Marketing.

Information on the cost of using electricity is based on customer rate structure information available on London Hydro's website, specifically:

- The Rate Component ($/kWh), the Loss Adjustment Factor, and (where applicable) the Global Adjustment, which is allocated to Ontario reflect the cost to generate electricity in Ontario;
- Delivery-related costs (Distribution Variable Charge, Network Charge, Connection Charge, Rate Rider for Tax Change, and Rate Rider for Variance Account), which is allocated to London to reflect London Hydro's operations;
- Transmission-related costs, which is allocated to Ontario to reflect Hydro One's operations; and
- Regulatory-related and Government-related charges (e.g., Ontario Hydro Debt Retirement, HST).

This allocation method was reviewed and accepted as being reasonable in 2013 by Wattsworth Analysis, the City of London's energy procurement advisor.

Information on the cost of using natural gas is based on customer rate structure information available on Union Gas's website, specifically:

- The Gas Commodity Rate, the Gas Price Adjustment, and Transportation, which is allocated to a mix of Western Canada (conventional gas wells) and United States (shale gas) to reflect the sources of natural gas supply and transporting this gas to Ontario ;
- Storage-related costs, which is allocated to Ontario to reflect Union Gas's regional and Ontario-wide storage and distribution operations;

- Delivery-related costs, which is allocated to London to reflect Union gas's local operations to supply natural gas to customers in London; and
- The HST.

This allocation method was reviewed and accepted as being reasonable by Wattsworth Analysis.

APPENDIX B - 2003-2018 HEATING & COOLING DEGREE DAYS FOR LONDON

Heating degree day (HDD) is a measurement tool used to estimate energy demand needed to heat a home or business. A similar measurement, cooling degree day (CDD), reflects the amount of energy used to cool a home or business.

It is based on the average outdoor air temperature over an entire day. The heating needs for a home or a building are generally directly proportional to the number of HDD at that location. Heating degree days are defined relative to a base temperature; the outside temperature above which a building needs no heating. For homes, a daily average temperature of 18 °C is used as this base. Therefore, if the average temperature for a day was 8 °C, then the HDD would be 10 for that day. Similarly, if the average temperature for a day was -2 °C, then the HDD would be 20 for that day. A typical winter month would have about 700 HDDs in London.

Environment Canada produces Climate Normal data ranges over a historic 30 year period. Over the last 10 years, most winters and summers have been warmer than they were over the 1971-2000 period.

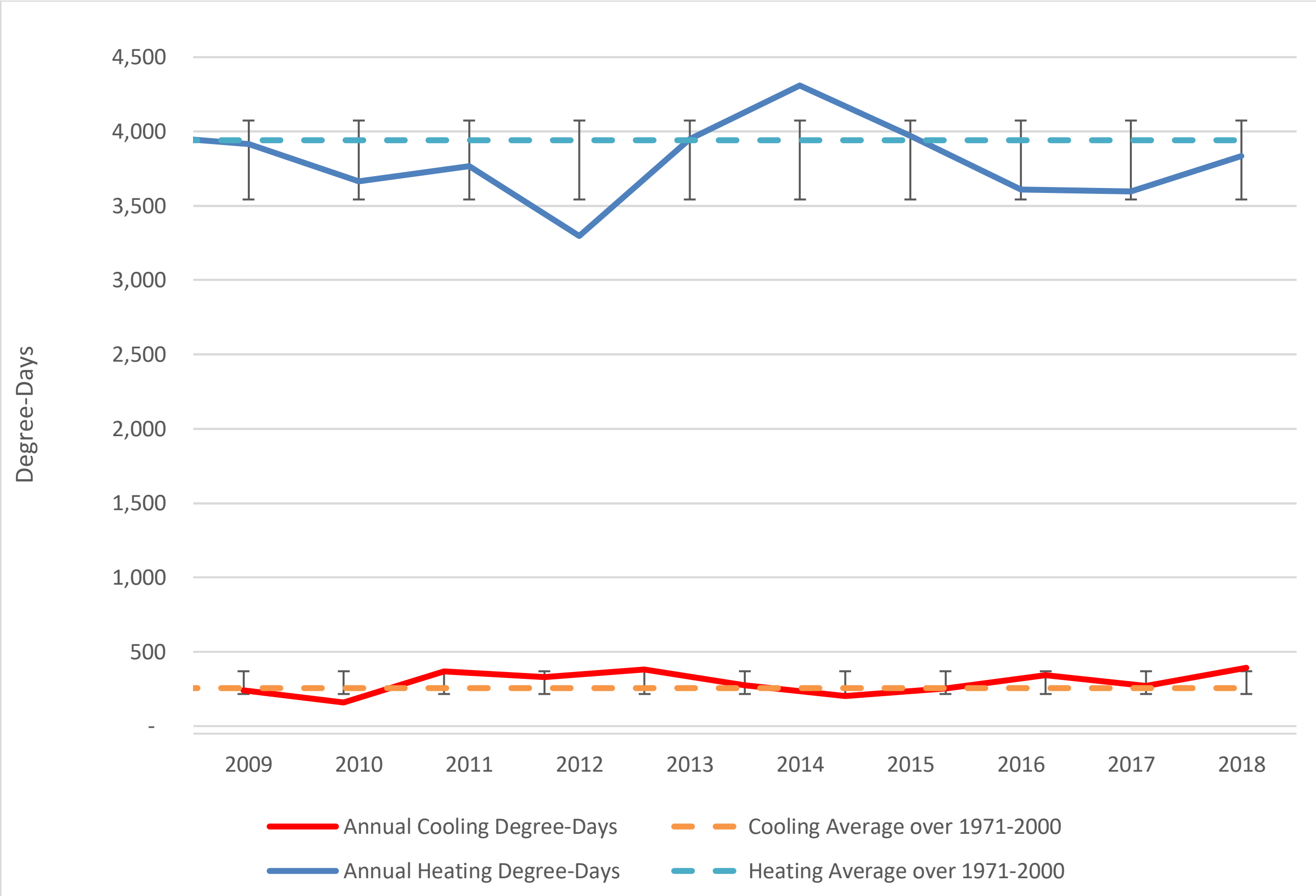
Table A-3 – Annual Residential Heating and Cooling Degree-Days for London

	Degree-Days		Difference from 30 Year Average	
Year	**Heating**	**Cooling**	**Heating**	**Cooling**
2009	3,914	159	-1%	-38%
2010	3,664	369	-7%	44%
2011	3,766	330	-4%	29%
2012	3,297	381	-16%	49%
2013	3,951	276	0%	8%
2014	4,309	201	9%	-21%
2015	3,971	254	1%	-1%
2016	3,615	343	-8%	34%
2017	3,597	271	-9%	6%
2018	3,836	392	-3%	53%
Average for 2009-2018 period	**3,791**	**298**	**-4%**	**16%**
30 year average (1971-2000)	**4,058**	**236**		

Notes:
1. Climate Normal data based on the 1971-2000 period
2. Heating and cooling degree-days based on the daily average difference from 18°C

Using this data, it can be assumed that, over the last 10 years, building heating needs were about four percent lower than they would have been back in the 1971-2000 period, and that air conditioning needs were about 16 percent higher.

Figure A-1 – Annual Residential Heating and Cooling Degree-Days for London



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