2016 Community Energy & Greenhouse Gas Emissions Inventory

August 2017

london.ca

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EXECUTIVE SUMMARY

The purpose of this document is to provide an overview on energy consumption in London and associated greenhouse gas emissions during the period from 1990 to 2016. The details in the document provide a useful source of information to strengthen existing projects/programs, or to help identify new business and academic opportunities for energy efficient products and technologies, energy conservation and demand management products and services, biofuels, and renewable energy generation.

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

- Land use and development
- Urban design
- Transportation
- Buildings
- Personal choices and actions
- Local climate & economy

COMMUNITY ENERGY USE INVENTORY

The three most common benchmark dates being used for reporting on overall progress are:

- 1990 – the baseline year used for the Province of Ontario's greenhouse gas (GHG) reduction targets
- 2007 – the year energy use and greenhouse gas emissions reached their peak in London
- 2010 – the first year for which total energy cost data has been determined in London

Total community energy use in London in 2016 was 57,600 terajoules, 12 percent above 1990 levels, and three percent below the peak in 2007.

Energy use by sector in London in 2016 was as follows:

- 40 percent from the industrial, commercial, and institutional buildings and facilities;
- 37 percent from transportation, most of which is associated with personal vehicle use; and
- 24 percent from single-family residential homes

In 2016, energy use per person in London was 11 percent below 1990 levels.

The biggest improvements came from residential energy use per person, which was 20 percent lower than 1990. This may be attributed to improvements in the energy efficiency of consumer appliances, space heating and cooling systems, home retrofits, and new home construction. In addition, warmer-than-average temperatures reduced the demand for natural gas for space heating.

Energy use per person related to the local economy in 2016 was 12 percent lower than 1990. However, London's energy productivity – dollars of real gross domestic product generated per unit energy used by London's employment sector – improved by 57 percent between 1990 and 2016.

TRANSPORTATION FUEL USE IS INCREASING

The one sector that now seems to be lagging behind is transportation. Transportation energy use per person in 2016 was only two percent lower than 1990. The volume of fuel sold in London has been increasing over the last five years, and is now 15 percent higher than 2011.

London's improving local economy may be generating more car-based commuting trips. The dramatic drop in fuel prices at the pumps, which were 29 cents per litre lower in 2016 compared to 2014, may also be encouraging more trips to be made by car.

Vehicle ownership in London has also grown by 25 percent since 2011, or about four percent per year on average. As of July 2016, there were over 264,000 light-duty vehicles registred in London – an increase of almost 54,000 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 0.91 per person in 2016.

However, on a positive note, the average annual fuel use per registered vehicle in London was eight percent lower in 2016 compared to 2011.

SOURCES OF ENERGY USED IN LONDON

In terms of sources of energy, natural gas is the largest source of energy used in London, accounting for 39 percent of all energy used in London in 2016. Gasoline was the second largest source of energy, accounting for 29 percent of London's energy use. Electricity accounted for 21 percent of all of the energy used in London.

TRANSLATING ENERGY USE INTO ECONOMIC AND BUSINESS DEVELOPMENT OPPORTUNITIES

It is estimated that Londoners spent over $1.4 billion on energy in 2016, a decrease of thee percent from 2015. Most of this was driven by warmer-than-average temperatures reduced the demand for natural gas for space heating. Natural gas costs were down 17 percent as a result.

Electricity costs increased by five percent, with rising electricity prices being offset by a drop in total electricity consumption.

Electricity and gasoline remain the most prominent costs, accounting for 41 and 34 percent respectively of the total cost. Natural gas use accounts for only 15 percent of energy costs, even though it is the largest source of energy we use.

The improvements in energy efficiency seen since 2010 are estimated to have saved London about $102 million in avoided energy costs in 2016.

Every percentage that Londoners reduce their energy use results in around $12 million staying in London.

Investing in energy efficiency measures also creates demand for local energy-related product and service providers.

ELECTRICITY GENERATION IN LONDON

London has almost 65 megawatts (MW) of local electricity generation capacity installed to date, an increase of 5 megawatts from last year due to new solar power projects. As of April 2017, there was 14.1 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 this local capacity is associated with combined heat and power cogeneration plants at London District Energy, Ingredion, London Health Sciences Centre, and Labatt Brewery.

Between 2008 and 2016, embedded electricity generation purchases (i.e., locally produced electricity sold to the grid) have increased from 0.2 percent to 1.6 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.

TRANSLATING ENERGY USE TO GREENHOUSE GAS IMPACT

The total energy-based greenhouse gas emissions in London for 2016 were 2.8 million tonnes, expressed in terms of equivalent carbon dioxide (CO_2e). This represents 95 percent of the total human activity based greenhouse gas emissions from London (over 2.9 million tonnes) in 2016.

The remaining five percent of greenhouse gas emissions are produced by 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.

Greenhouse gases are created by burning fossil fuels such as natural gas, gasoline, and diesel. Although greenhouse gas emissions associated with electricity were significantly lower in 2016 (about 90 percent lower) than at their peak in 2003, its use still contributes to GHG emissions when natural gas power plants are in operation. In summary, energy-related GHG emissions are:

- 41 percent from natural gas
- 38 percent from gasoline
- 11 percent from diesel
- 4 percent from electricity
- 6 percent from other fuels

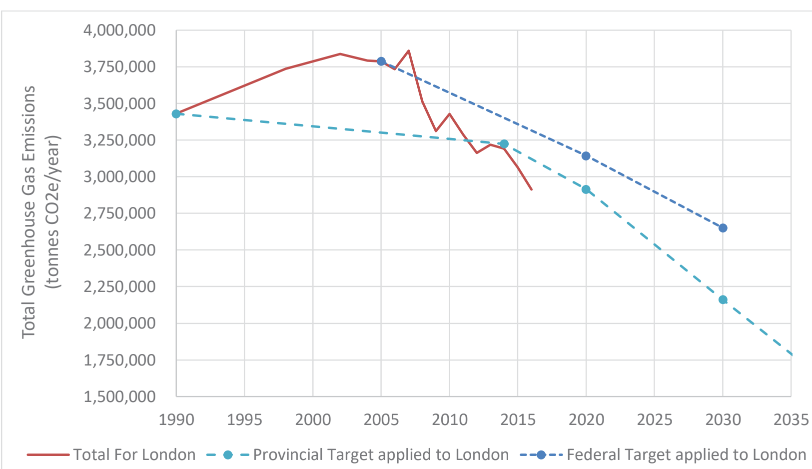
Total greenhouse gas emissions from London have decreased compared to the "peak" in 2007, as seen in Figure i. In 2016, greenhouse gas emissions were 24 percent lower than 2007. In fact, London's emissions in 2016 were 15 percent lower than the 1990 level used to benchmark emission reduction efforts.

On a per-person basis, London's emissions in 2016 were 32 percent lower than 1990.

London's Community Energy Action Plan has adopted the greenhouse gas emission reduction goals of the Province of Ontario, namely a 15 percent reduction from 1990 levels by 2020, a 37 percent reduction by 2030, and an 80 percent reduction by 2050.

Total greenhouse gas emissions in 2016 were close to achieving the 2020 reduction goal four years early. Whether emissions continue to decrease depends upon the impact of energy and fuel conservation efforts, Ontario's upcoming Climate Change Action Plan, climate trends, economic growth, and consumer choices.

Figure i – London's Greenhouse Gas Emission Trend versus Federal and Provincial Reduction Targets



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 2016;
- associated greenhouse gas emissions; and
- energy expenditures in London.

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.

2 BACKGROUND

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.

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.

Ontario currently relies heavily on petroleum fuels and natural gas to meet most of its energy needs. Fossil fuels are non-renewable, finite resources that will eventually be depleted. However, national and international energy boards and agencies do not report any immediate concerns about the ability to supply oil and other key energy commodities for the next 20 years. However, they do assume that oil and other energy commodities will become more expensive over time. In contrast, renewable energy resources — such as wind and biomass energy — which have been expensive to utilize, are starting to become competitive with conventional energy.

3 PREVIOUS INVENTORY REPORTS

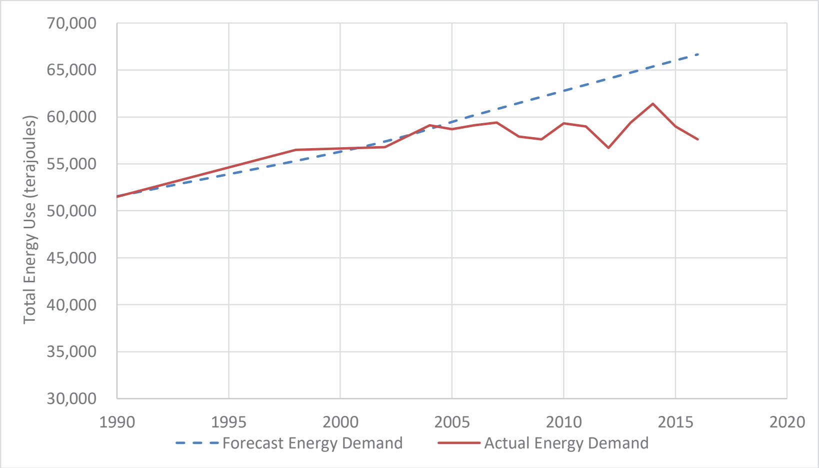
The following is a list of the previous energy inventory reports that have been prepared for London:

- *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 2016 was 57,600 terajoules, 12 percent above 1990 levels, and two percent below 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.

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



Transportation accounted for 39 percent of all energy used in London, most of which is associated with personal vehicle use. London's industrial, commercial, and institutional buildings and facilities accounted for 39 percent of all energy used in London. London Hydro and Union Gas include multi-unit residential buildings (apartment buildings and condominiums) under the category of commercial buildings. Single family residential homes accounted for 23 percent of all the energy used in London.

It is important to note that 2016 was the first year that transportation has been the largest energy-using sector in London.

Table 1 – 1990-2016 Community Energy Use by Sector

Sector	Total Energy Use (Terajoules/year) and Share of Total Energy Demand		
	1990	2007	2016
Transportation	18,200 (35%)	20,000 (34%)	22,300 (39%)
Residential	13,100 (25%)	14,400 (24%)	13,100 (23%)
Industrial, Commercial & Institutional (IC&I)	20,200 (40%)	25,100 (42%)	22,300 (39%)
Total	**51,500**	**59,400**	**57,600**

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 – 2016 Estimated Breakdown of Energy Use by Subsector

Sector	Sub-sector	Total Energy Use (terajoules/year)
Transportation	Fuel sold at gas stations	15,700
	Road freight transport	4,400
	Corporate fleets	500
	London Transit	300
	Railway freight transport	500
	Domestic aviation	900
Residential	Low-density homes	11,000
	Medium-density homes (e.g., townhomes)	2,200
Industrial, Commercial & Institutional (IC&I)	High-density residential buildings	1,500
	Commercial – office buildings	2,800
	Commercial – retail buildings (e.g., malls)	5,000
	Industrial	8,200
	Institutional - schools	600
	Institutional - hospitals	1,300
	Institutional - colleges & universities	2,200
	Institutional - municipal buildings & water	500
	Other	200

Over the 1990-2016 time period, London's population has increased by about 25 percent. Energy use per person in London was 150 gigajoules (GJ) per year in 2016, down 10 percent from 2007 and 11 percent from the 1990 baseline level (Table 3).

Table 3 – 1990-2016 Per Person Energy Use by Sector

Sector	Per person Energy Use (GJ/person)			
	1990 (Pop. 307,000)	2007 (Pop. 355,000)	2016 (Pop. 383,800)	Change from 1990
Transportation	59	56	58	-2%
Residential	43	40	34	-20%
Industrial, Commercial & Institutional (IC&I)	66	71	58	-12%
Total	**168**	**167**	**150**	**-11%**

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

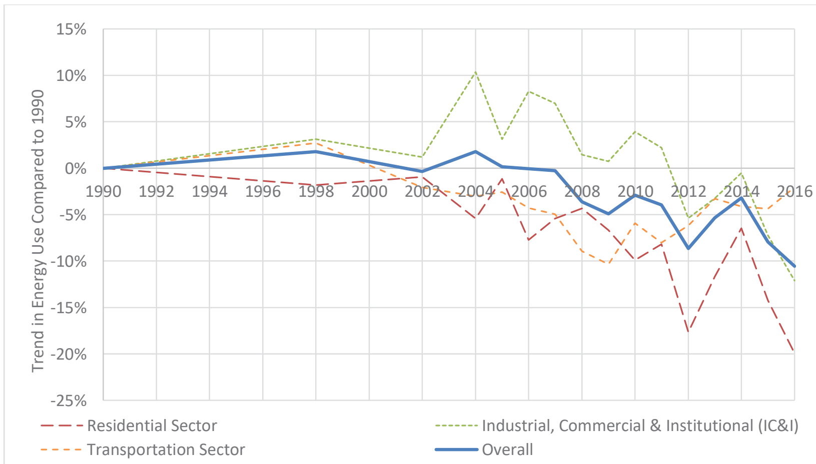


Figure 2 illustrates the change in energy consumption in London by sector on a per person basis, using 1990 as the baseline year. The impact of both the "Polar Vortex" of 2014 (very cold winter) and the "Winter that Wasn't" of 2012 (very warm winter) can be seen clearly, especially for the residential 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 is lagging behind is transportation. Transportation energy use per person in 2016 was only two percent lower than 1990. The volume of fuel sold in London has been increasing steadily over the last five years, and is now 15 percent higher than 2011. London's improving local economy may be generating more car-based commuting trips. The dramatic drop in fuel prices at the pumps, which were 29 cents per litre lower in 2016 compared to 2014, may also be encouraging more trips to be made by car.

Vehicle ownership in London has also grown by 25 percent since 2011, or about four percent per year on average. As of July 2016, there were over 264,000 light-duty vehicles registred in London – an increase of almost 54,000 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 0.91 per person in 2016.

Vehicle choice is also showing a mix of trends. On a positive note, the share of relatively fuel-efficient compact and mid-sized cars has increased and the number of hybrid and/or electric vehicles has more than doubled between 2011 and 2016. However, sport-utility vehicles and large pick-ups are becoming more popular as well.

Overall, the average annual fuel use per registered vehicle in London was eight percent lower in 2016 compared to 2011. Additional detail is provided in Table 4 below.

Table 4 – Vehicle Ownership Statistics for London

	2011	2016	Change
Total registered vehicles	210,700	264,300	25%
No. of adults 20-84 years old	274,000	290,100	6%
Vehicles per adult	0.77	0.91	18%
Hybrid gas-electric vehicles (excluding plug-in hybrids)	930	2,050	136%
Electric vehicles	0	140	
Annual fuel use per vehicle (GJ per year)	65	60	-8%
Average vehicle age	n/a	8.5 years (2008 & 2009 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%) Mid-sized car (16%) Compact SUV (15%) Minivan (9%) Large Pickup (8%)	

This highlights the importance of city-led transportation initiatives such as Shift (rapid transit) and London ON Bikes. 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 2016 was 12 percent lower than 1990 and 18 percent lower than 2007. Part of this can be attributed to the warmer weather in 2016. However, local utilities such as London Hydro and 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) grew by 73 percent between 1990 and 2016.

As noted by the Conference Board of Canada in its Metropolitan Outlook for London in Winter 2017, after years of sluggish growth following the 2008–09 recession, London finally turned the corner with real economic growth (as measured by Gross Domestic Product – or GDP) averaging 2.0 percent from 2014 to 2015. The economy then grew at its fastest pace since 2005 last year, as real GDP rose by 2.6 per cent.

Based on GDP estimates for 1990, London's energy productivity - GDP generated per unit energy used in London's employment sector - has improved by 57 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 – 1990-2016 Energy Productivity of London's Employment (IC&I) Sector

	1990	1998	2007	2016
Gross Domestic Product ($ millions GDP[1])	$9,600[2]	$11,600[2]	$15,400	$16,600
Energy Used by IC&I Sector (TJ)	20,200	22,500	25,100	22,300
Energy Productivity ($GDP per GJ)[3]	$474	$515	$615	$746
Improvement in Productivity Since 1990		9%	30%	57%
Average Annual Productivity Improvement		1.0%	2.0%	2.2%

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 (SMEs) 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 greenhouse gas emissions by commodity is outlined in Table 6.

Natural gas is the largest source of energy used in London, accounting for 39 percent of all energy used in London in 2016. Natural gas is primarily used for space heating and water heating in buildings, as well as process heat for industrial facilities. Gasoline was the second largest source of energy, accounting for 27 percent of London's energy use. Electricity accounted for 20 percent of all of the energy used in London. 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.

For electricity, it is important to note that over 90 percent of the electricity generated in Ontario comes from emissions-free sources. In 2016, as reported by the Independent Electricity System Operator (IESO), 61 percent of Ontario's electricity was supplied by nuclear generating stations, while hydroelectric generating stations supplied 24 percent and other renewable sources of electricity (wind, biomass, solar) provided seven percent of our electricity needs. Natural gas-fired generating stations provided nine percent of Ontario's supply.

Table 6 – 2016 Community Energy Use by Energy Commodity

Energy Commodity	Total Used	Energy (Terajoules)	Energy (%)
Natural Gas	597,000,000 m^3	22,200	39%
Gasoline[1]	452,500,000 L	15,700	27%
Electricity	3,283,000 MWh	11,800	21%
Diesel[1]	114,000,000 L	4,400	8%
Fuel Oil[1]	29,000,000 L	1,100	1.9%
Aviation fuel	24,000,000 L	900	1.6%
Ethanol (in ethanol-blended gasoline)	40,400,000 L	800	1.4%
Propane[1]	27,500,000 L	700	1.2%
	Total	**57,600**	

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; 2015 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 converstion 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 efficienct 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 our energy needs emerges, as seen in Table 7.

Table 7 – 2016 Energy Use in Electricity Generation Accounting for Thermal Efficiency

Source of Energy	Energy (Terajoules)	Energy (%)
Uranium[2]	20,700	77%
Hydroelectric	2,700	10%
Natural Gas[1]	2,300	9%
Wind	750	2.5%
Solar	230	0.8%
Biofuels[2]	140	0.5%
Total	**26,600**	

NOTE: due to rounding of numbers, individual numbers may not add up to the total
1 – Assumed 50% thermal efficiency for generating electricity
2 – Assumed 33% thermal efficiency for generating electricity

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 2016, around 26,600 terajoules of energy resources were consumed to provide London with 11,800 terajoules of electricity – the remaining 14,800 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. Note that gasoline is the only energy commodity that is increasing on a per-person basis.

Table 8 – 1990-2016 per Person Energy Use by Energy Commodity

Energy Commodity	Total Energy Use Per Person (Gigajoules/person)			
	1990	2007	2016	Change from 1990
Natural Gas	67	70	58	-13%
Gasoline (including ethanol-blended gasoline)	41	40	43	5%
Electricity	34	36	31	-11%
Diesel	13	12	11	-11%
Fuel Oil	7.2	5.3	2.9	-60%
Aviation fuel	3.2	2.4	2.3	-26%
Propane	2.4	2.1	1.8	-25%
Total	**168**	**167**	**150**	**-11%**

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 we collectively spend 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 2016

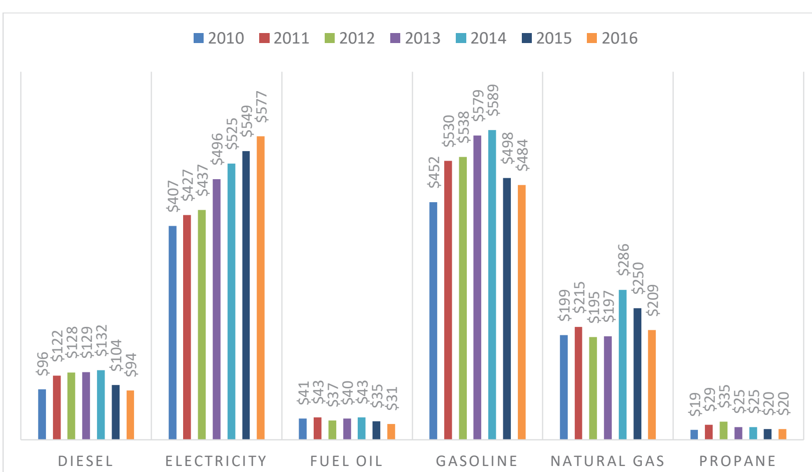
Energy Commodity[1]	Estimated Energy Cost			
	Cost ($ million)	Share (%)	Energy (terajoule)	Price per gigajoule
Electricity	$ 577	41 %	11,800	$ 49
Gasoline (including ethanol-blended gasoline)	$ 484	34 %	16,500	$ 29
Natural Gas	$ 209	15 %	22,200	$ 9
Diesel[1]	$ 94	7 %	3,900	$ 24
Fuel Oil	$ 31	2 %	1,100	$ 27
Propane	$ 20	1 %	700	$ 29
Total	**$ 1,415**		**56,200**	**$ 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

In total, London spent over $1.4 billion on energy in 2016, a decrease of three percent from 2015. Most of this was driven by the drop in petroleum fuel prices combined with lower natural gas use due to warmer weather. Electricity costs increased by five percent.

Electricity and gasoline remain the most prominent costs, accounting for 41 and 34 percent respectively of the total cost. Natural gas use still accounts for only 15 percent of energy costs, even though it is the largest source of energy we use. Natural gas prices in 2016 were well below the levels seen last decade.

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 we use 2010 as a baseline year in terms of energy use per capita, we can see in Figure 5 that recent improvements in energy efficiency have created ongoing savings. In 2016, it is estimated that over $100 million in energy costs were avoided through energy efficiency. Every percentage that Londoners reduce their energy use results in around $12 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 over $1.4 billion spent on energy in 2016, it is estimated that 13 percent of this money stayed in London, most of which goes towards London Hydro's and Union Gas' local operations. The rest leaves London.

With the drop in global oil commodity prices, Western Canada's share of our energy dollars has dropped significantly. In 2014, Londoners and London businesses sent about $440 million (28%) of their energy dollars to Western Canada compared to about $200 million (14%) this year. In fact, for gasoline and diesel, it is estimated that more of our energy dollars in 2016 went to petroleum refineries in Sarnia rather than the oil fields of Western Canada.

About $440 million (31%) 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

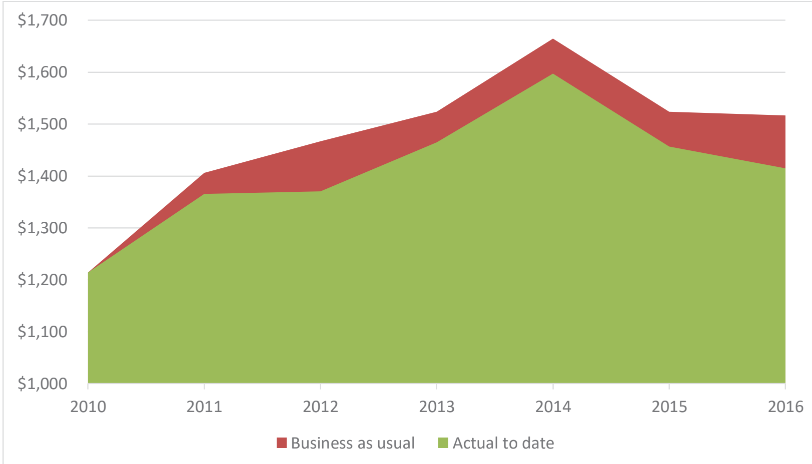


Table 10 – Estimated Share of Energy Revenue (2016)

Commodity	Where the Money Goes (% share) London Region	Ontario - Business	Ontario - Government	Western Canada	Canada - Government	United States
Diesel	1%	2%	1%	2%	1%	-
Electricity	5%	31%	4%	-	1%	-
Fuel Oil	1%	1%	<1%	1%	<1%	-
Gasoline	2%	11%	8%	9%	5%	-
Natural Gas	4%	3%	1%	3%	1%	2%
Propane	1%	1%	<1%	-	<1%	-
Total	**13%**	**48%**	**14%**	**14%**	**8%**	**2%**

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 and other infrastructure. 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 65 megawatts (MW) of local electricity generation capacity installed to date, an increase of 5 megawatts from last year due to new solar power projects coming on line.

As of April 2017, there was 14.1 megawatts of solar photovoltaic (PV), 2.85 megawatts of biogas, and 0.675 megawatts of hydro-electric power generation in operation in London. Almost all of this electricity is sold to the Independent Electricity System Operator (IESO) through the Feed-in Tariff program.

However, most of London's local generating capacity is associated with combined heat and power cogeneration plants at London District Energy (18.8 MW), Ingredion (14.1 MW), London Health Sciences Centre (9.6 MW), and Labatt Brewery (4.2 MW). Combined heat and power plants at industrial locations such as Labatt and Ingredion generate steam as well as electricity "behind-the-meter" for use in their operations. London District Energy 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.

Between 2008 and 2016, embedded electricity generation purchases (i.e., locally produced electricity sold to the grid) have increased from 0.2 percent to 1.6 percent of London's electricity needs. This does not include the electricity produced and used "behind-the-meter" at industrial locations such as Labatt and Ingredion. 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 is driven by province-wide electricity demand. In the winter of 2015, demand was higher due to colder-than-normal average temperatures.

6 TRANSLATING ENERGY USE INTO GREENHOUSE GAS IMPACT

6.1 New Information Included For 2016

As a result of London having joined the Compact of Mayors in 2015, nitrous oxide (N_2O) emissions from sewage treatment were included within London's energy and GHG emissions inventory as per the Global Protocol for Community-Scale GHG Emission Inventories (GPC). Nitrous oxide, a potent greenhouse gas with 310 times the global warming potential of carbon dioxide, is a combustion byproduct from the incineration of sewage sludge and its formation is influenced by incinerator operating conditions (i.e., combustion temperature). This new source accounts around 0.2 percent of London's GHG emissions. Additional information on the estimation methods for these sources is included in Appendix A.

6.2 Greenhouse Gas Emissions for 2016

Energy use in London was responsible for almost 2.8 million tonnes of greenhouse gas emissions (expressed in terms of equivalent carbon dioxide, or CO_2e) in 2016. Table 11 provides additional information on greenhouse gas emissions associated with the various sources of energy used in London.

Table 11 – 2016 Greenhouse Gas Emissions by Energy Commodity

Energy Commodity	Energy (Terajoules - TJ)	GHG Emissions (kilotonnes CO_2e)	GHG (%)	GHG Intensity (tonnes/TJ)
Natural Gas	22,200	1,130	41%	51
Gasoline	16,500	1,050	38%	64
Diesel	4,400	310	11%	70
Electricity	11,800	100	4%	8
Fuel Oil	1,100	80	3%	70
Aviation Fuel	900	60	2%	68
Propane	700	40	2%	60
Total	**57,600**	**2,770**		

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

Energy use is responsible for 95 per cent of all greenhouse gas 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 greenhouse gas associated with human activity – but the use of electricity also contributes to greenhouse gas emissions.

Over 90 percent of Ontario's electricity is generated from emissions-free sources, 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 8.5 percent of the electricity we use. In 2016, it is estimated that every 1,000 kilowatt-hours of electricity generated in Ontario produced less than

30 kilograms of carbon dioxide emissions. This is an order-of-magnitude better than it was 14 years ago (2003), when electricity generated in Ontario produced around 300 kilograms of carbon dioxide emissions.

The remaining five percent of greenhouse gas emissions from human activity in London comes from the anaerobic decomposition of organic materials in active and closed landfills. This brings London's total greenhouse gas emissions to 2.92 million tonnes, expressed in terms of equivalent carbon dioxide.

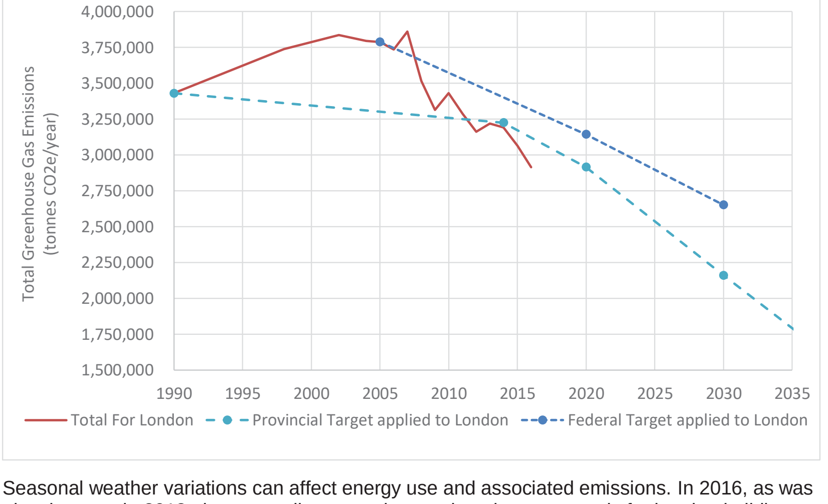
Figure 6 illustrate the total greenhouse gas emission trend since 1990, including landfill gas emissions.

To date, London has followed the greenhouse gas reduction goals of the Province of Ontario, namely:

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

The increase in greenhouse gas emissions began to stabilize around 2002 after a continued climb from 1990. Since 2005 there has been a downward trend (Figure 6).

Figure 6 - Targets vs. Actual Greenhouse Gas Emissions from London



Seasonal weather variations can affect energy use and associated emissions. In 2016, as was also the case in 2012, the unusually warm winter reduced energy needs for heating buildings. Contrast that to 2014, when the colder-than-normal winter 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).

The 2008 to 2010 economic recession also contributed to reduce energy demand, both for businesses as well as those Londoners who may have lost their jobs and were no longer commuting to work during that period.

Table 12 illustrates the greenhouse gas 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 – 1990-2016 Community Greenhouse Gas Inventory in London

Sector	Greenhouse Gas Emissions (kilotonnes/year)		
	1990	**2007**	**2016**
Transportation	1,290	1,370	1,450
Residential	730	820	510
Industrial, Commercial & Institutional	1,120	1,430	820
Landfill Gas Emissions	290	250	140
Total	**3,430**	**3,860**	**2,920**

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 greenhouse gas emissions by building type, as shown in Table 13.

In terms of per person emissions, as illustrated in Table 14, emissions today are 32 percent lower than they were back in 1990 (11.2 tonnes per person in 1990 versus 7.6 tonnes per person in 2016).

Table 13 – 2016 Breakdown of Greenhouse Gas Emissions by Subsector

Sector	Sub-sector	GHG Emissions (kilotonnes/year)
Transportation	Fuel sold at gas stations	1,010
	Road freight transport	300
	Corporate fleets	30
	London Transit	20
	Railway freight transport	40
	Domestic aviation	60
Residential	Low-density homes	440
	Medium-density homes (e.g., townhomes)	70
Industrial, Commercial & Institutional (IC&I)	High-density residential buildings	30
	Commercial – office buildings	110
	Commercial – retail buildings (e.g., malls)	180
	Industrial	310
	Institutional - schools	20
	Institutional - hospitals	50
	Institutional - colleges & universities	100
	Institutional - municipal energy use	10
	Institutional - sewage sludge incineration	3
Landfills	W12A Landfill	80
	Closed landfills	40
	IC&I waste disposed outside of London	30

Table 14 – 1990-2016 Per Person Greenhouse Gas Inventory in London

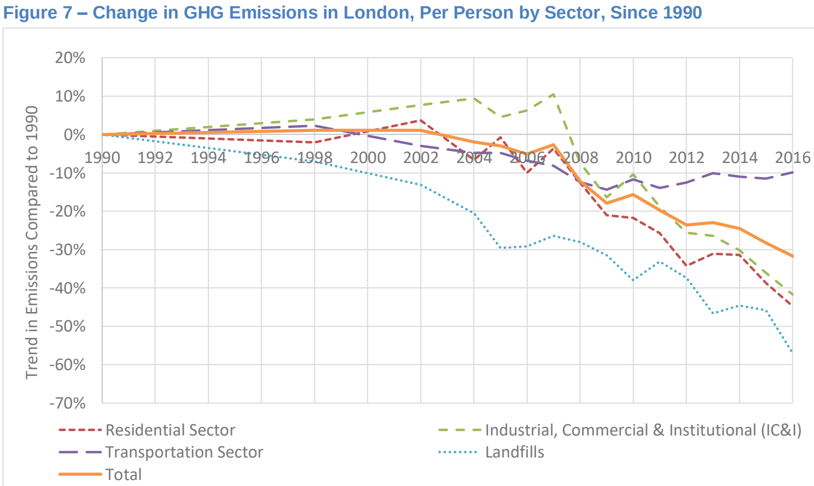
Sector	Greenhouse Gas Emissions (tonnes/person)			
	1990 (Pop. 307,000)	2007 (Pop. 355,000)	2016 (Pop. 383,800)	Change from 1990
Transportation	4.2	3.9	3.8	-10%
Residential	2.4	2.3	1.3	-45%
Industrial, Commercial & Institutional	3.6	4.0	2.1	-42%
Landfill Gas Emissions	1.0	0.7	0.4	-57%
Total	**11.2**	**10.9**	**7.6**	**-32%**

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

As discussed before, this reduction in greenhouse gas emissions has been created by a reduced greenhouse gas intensity of 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 the use of ethanol-blended gasoline (10% ethanol by volume) as well as vehicle tailpipe emission controls that have reduced emissions of nitrous oxide.

It is important to note these greenhouse gas 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 greenhouse gas 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.

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



6.3 Publicly-Reported Local Emitters

Both the federal and provincial governments require facilities that emit more than 25,000 tonnes of greenhouse gases to report their emissions on an annual basis. In London, there are six 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 Veresen Energy (i.e., 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 greenhouse gas reporting.

Table 15 – Ontario Regulation 452/09 Reporting Facilities in London

Reporting Facility (based on fuel combustion)	Annual GHG Emissions (tonnes CO_2e) 2010	2013	2014
Fanshawe College of Applied Arts and Technology	3,143	2,924	3,240
Ingredion Canada Incorporated	124,320	115,988	119,653
Labatt Breweries of Canada LP	26,594	27,503	27,005
London Health Sciences Centre (Victoria Campus CHP)	37,108	41,707	48,290
Western University (steam plant)	51,364	47,322	46,200
Veresen Energy Infrastructure (London District Energy)	39,844	44,622	46,229
W12A Landfill – Corporation of the City of London	160,430	106,349	117,676
Total	**442,803**	**386,415**	**408,293**
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 greenhouse gas 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 2013, the most recent information available. 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 streetlighting 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 2014 (tonnes CO_2e)
University of Western Ontario	52,822
London Health Sciences Centre	52,359
Thames Valley District School Board	15,782
St. Joseph's Health Care London	15,814
City of London	12,785
London District Catholic School Board	5,231
Fanshawe College	5,496
Conseil scolaire de district des écoles catholiques du Sud-Ouest	533
County of Middlesex (buildings in London)	364
Conseil scolaire de district du Viamonde	227
Municipality of Thames Centre (building in London)	17
Boreal College	7
total	**161,436**
Percentage of industrial, commercial, and institutional emissions	**17%**
Percentage of total emissions from London	**5%**

7 CONCLUSIONS

7.1 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 been increasing consistently over the last five years.

7.2 Opportunities for London

Out of the over $1.4 billion spent on energy in 2016, it is estimated that about 13 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 $12 million staying in London. 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.

7.3 Greenhouse Gas Emissions

From a greenhouse gas 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. Greenhouse gas 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 greenhouse gas 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 greenhouse gas emissions directly under municipal government control.

APPENDIX A - METHODOLOGY

This document builds upon two foundational energy use and greenhouse gas 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 greenhouse gas emissions inventory on an annual basis.

The methodology employed is consistent with the greenhouse gas 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 greenhouse gas 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 territorial 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 2004-2016 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 2015.

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 2015.

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 (2016 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 2015.

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 was changed from 21 to 25, as per the Intergovernmental Panel on Climate Change's *Fourth Assessment Report*

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, 1990-2015 - 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 2015.
- 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 2015.

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

- For 2016, GHG emissions were estimated by taking the reported GHG emissions from the Twin Creek Landfill and Ridge Landfill for 2015, 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, 30,000 tonnes to the Ridge Landfill, and 8,000 tonnes to landfills in Michigan.

- For the 1990 to 2015 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 2016, only 25% landfill gas capture for 1998, and no landfill gas capture for 1990.

A.2. New Sources Required for Reporting to Compact of Mayors

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 byproduct 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 – 2016 Stack Test Results for N_2O Emissions from the Greenway WWTP Sewage Sludge Incinerator

	N_2O emissions					
Year	**Measured average emissions g/s**	**Measured average emissions kg/h**	**Estimated annual emissions tonnes/y**	**Estimated annual CO_2e tonnes/y**	**Sewage sludge burn rate during stack testing (tonnes/h)**	**Estimated CO_2e emissions per tonne sludge**
2008	0.1	0.4	4	1,200	10.4	0.01
2009	1.1	3.9	34	10,700	9.5	0.13
2010	1.1	3.9	34	10,600	9.9	0.12
2011	1.2	4.4	39	12,000	9.0	0.15
2012	1.0	3.5	31	9,600	10.6	0.10
2013	0.2	0.6	5	1,700	no data	
2014	1.1	4.1	36	11,000	7.3	0.17
2015	1.0	3.7	32	10,000	7.2	0.16
2016	0.3	1.1	9	2,900	6.8	0.05

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 considers reducing the reporting threshold for facility emissions to 10,000 tonnes per year of carbon dioxide equivalent emissions for the 2017 reporting year, it is possible that the Greenway WWTP 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 1990-2015*, except for the 2016 grid-average emission factors for Ontario, which have been estimated based on the 2016 electricity supply mix for Ontario reported by the IESO, combined with the data from *Canada's National Inventory Report 1990-2015*. A summary of emission factors has been provided in Table A-1.

All greenhouse gas emissions are expressed in terms of equivalent carbon dioxide (CO_2e), based on the global warming potentials (GWP) of the various greenhouse gas emissions provided by *Canada's National Inventory Report 1990-2015.*

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

Source of Emission	Emission Factor (CO_2e)	Information Source
Electricity - Ontario 2016	0.030 kg/kWh	Estimated based on IESO information for 2016
Electricity - Ontario 2015	0.043 kg/kWh	National Inventory Report, 1990-2015 - Greenhouse Gas Sources and Sinks in Canada ANNEX 11: ELECTRICITY IN CANADA: SUMMARY AND INTENSITY TABLES
Electricity - Ontario 2014	0.040 kg/kWh	
Electricity - Ontario 2013	0.080 kg/kWh	
Electricity - Ontario 2012	0.110 kg/kWh	
Electricity - Ontario 2011	0.110 kg/kWh	
Electricity - Ontario 2010	0.150 kg/kWh	
Electricity - Ontario 2009	0.120 kg/kWh	
Electricity - Ontario 2008	0.170 kg/kWh	
Electricity - Ontario 2007	0.240 kg/kWh	
Electricity - Ontario 2006	0.210 kg/kWh	
Electricity - Ontario 2005	0.240 kg/kWh	
Electricity - Ontario 2004	0.220 kg/kWh	
Electricity - Ontario 2003	0.300 kg/kWh	
Electricity - Ontario 2002	0.290 kg/kWh	
Electricity - Ontario 1998	0.230 kg/kWh	
Electricity - Ontario 1990	0.220 kg/kWh	
natural gas	1.89 kg/m^3	National Inventory Report, 1990-2015 - 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)	2.11 kg/L	TSA's Canadian Cities GHG Emissions Strategy Software
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 - 2003-2016 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.

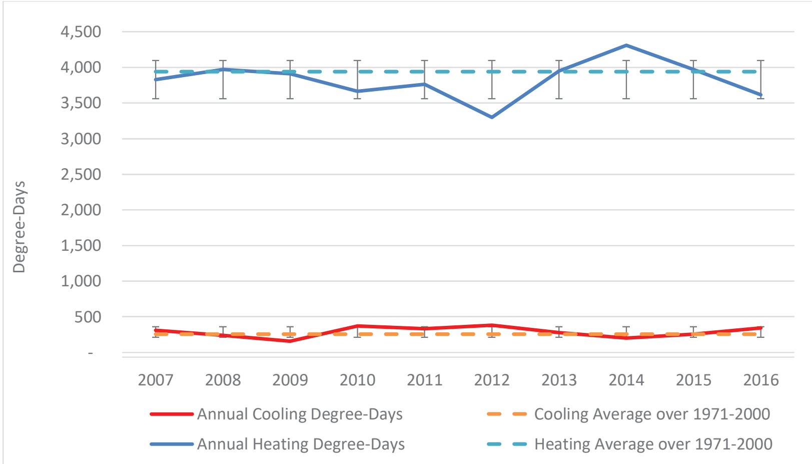
Table A-3 – Annual Residential Heating and Cooling Degree-Days for London

	Degree-Days		Difference from 30 Year Average	
Year	**Heating**	**Cooling**	**Heating**	**Cooling**
2007	3,827	310	-6%	32%
2008	3,974	241	-2%	2%
2009	3,914	159	-4%	-33%
2010	3,664	369	-10%	57%
2011	3,766	330	-7%	40%
2012	3,297	381	-19%	62%
2013	3,951	276	-3%	17%
2014	4,309	201	6%	-15%
2015	3,971	254	-2%	8%
2016	3,615	343	-8%	34%
Average for 2007-2016 period	**3,829**	**287**	**-6%**	**22%**
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 six percent lower than they would have been back in the 1971-2000 period, and that air conditioning needs were about 22 percent higher.

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



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