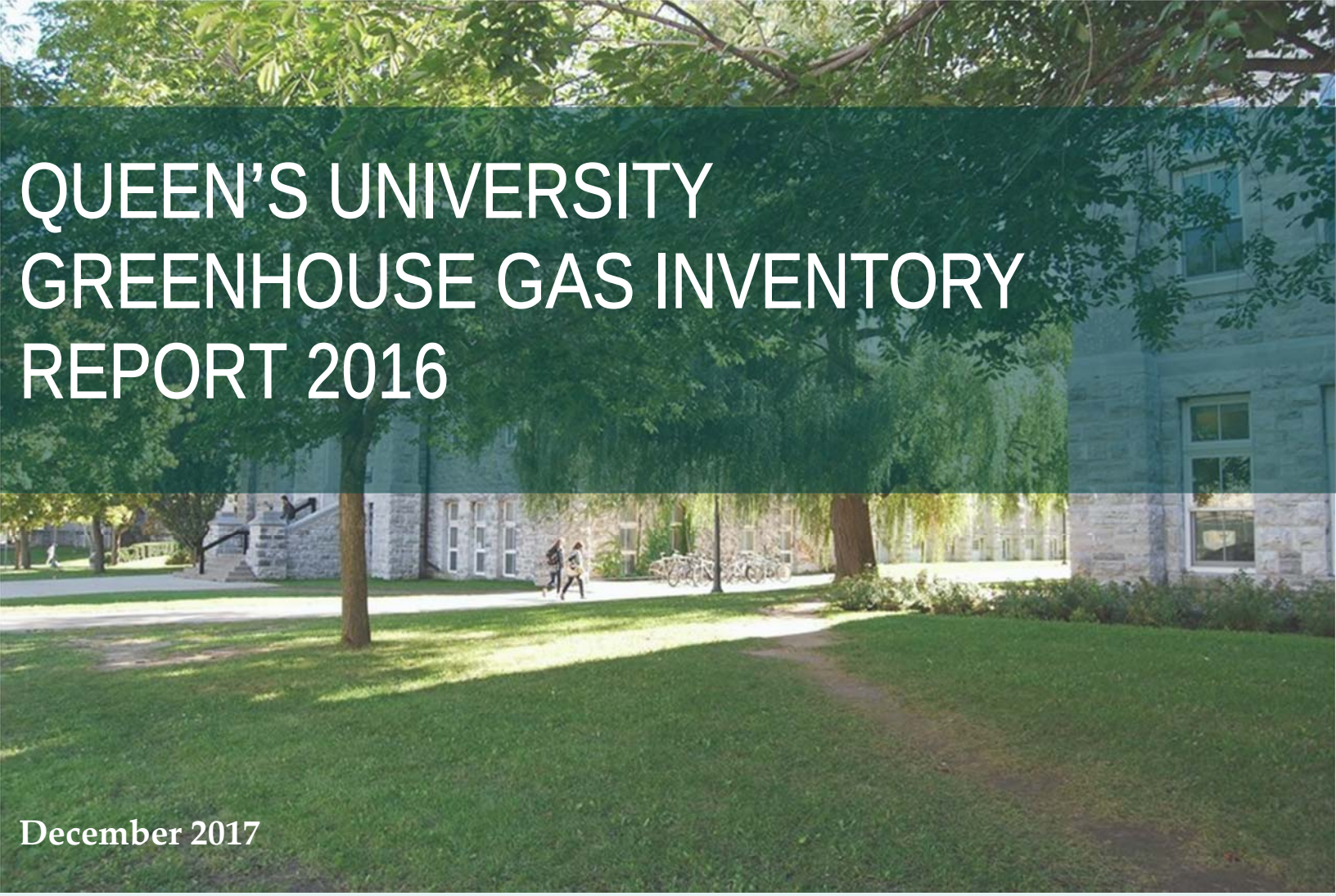

QUEEN'S UNIVERSITY GREENHOUSE GAS INVENTORY REPORT 2016

December 2017

INTRODUCTION

In 2010, Queen's University signed the *University and College Presidents' Climate Change Statement of Action for Canada*, thereby committing to taking firm action in reducing its greenhouse gas (GHG) emissions. As part of this agreement, Queen's is required to track and report all GHG emissions. This is the seventh GHG Inventory Report published, and contains data from January 1, 2016 until December 31, 2016.

In 2014, the tracking of emissions has changed from following the Queen's fiscal year (May-April) to the calendar year (January - December), in order to reflect the style required by the Ontario Ministry of the Environment and Climate Change (MOECC) Provincial GHG Report. The goal of these inventory reports is to clarify and identify opportunities to reduce the university's overall emissions.

SCOPE OF EMISSIONS

This report reviews the overall emissions associated with the operations of Queen's University, including the direct (Scope 1) and indirect (Scope 2) emissions of all Queen's facilities and operations within the province of Ontario. This encompasses leased and owned buildings both on and off campus. The report excludes any satellite offices outside of Ontario, the Bader International Study Centre at Herstmonceux, England, and student rental homes leased by Queen's Community Housing.

Scope 1 emissions include all emissions directly produced by the University, most of which are caused by local energy production to heat the campus. The main contributors to Scope 1 emissions include:

- Stationary combustion from the boilers, cogeneration plant, generators, furnaces, and kitchen equipment
- Mobile combustion from various fleet vehicles and ground maintenance equipment
- Fugitive emissions from electrical switches, fire suppression equipment, lab chemicals, and refrigerants

Scope 2 emissions include all indirect emissions associated with energy that the University purchases, including:

- The University's main and west campus electricity usage
- The electricity consumption of Queen's Biological Station (QUBS)
- The electricity, heating, and cooling in all leased spaces

Figure 1: The Queen's Central Heating Plant (CHP)

METHOD

The methods used to determine GHG emissions in this report have been developed according to standard approaches. Emissions calculations are based on a standard equation, where an activity level is multiplied by a corresponding emission factor. Activity levels are derived from reports documenting the consumption of different fuels and energy. Throughout the year, invoices and metering data are collected and stored for all fuel combustion, electricity consumption, and heating of independent buildings. This information is then compiled and the associated greenhouse gas emissions are calculated. The calculations represent approximately 97% of all Queen's University emissions. The final 3% is calculated based on assumptions and includes elements such as fugitive emissions from laboratory chemicals and fire suppression units, leased space, and some small fuel-consuming equipment.

The emission factors used in the calculator are based on national industry standards that tend to remain static for most fuels. However, the grid emission factors used for electricity calculations come from Environment Canada's National Inventory Report. Additionally, data for lighting energy use, as well as heating and cooling for office spaces come from Natural Resources Canada. For both emission factor sources, there is usually a two-year lag period in the availability of these values. Thus, data from 2015 was used for this year's report, and the calculation will be updated when values for 2016 become available. This methodology is consistent with previous reports.

The Grid Emission Factor

The Grid Emission Factor is a measure of the Provincial Electricity Grid's carbon intensity, or the average output of carbon dioxide per unit of electrical output.

Different types of electricity generation have their own carbon intensities. Output from fossil fuel plants have varying levels of carbon intensity depending on the fuel, which in Ontario is natural gas. Carbon-neutral sources such as nuclear, hydro, wind, and solar are generally viewed as having no carbon emissions and so their carbon intensities are zero. The transmission infrastructure also adds to carbon intensity when accounting for line losses. A weighted calculation of these elements within the grid is equal to the annual Grid Emission Factor.

2016 RESULTS

Scope 1 and Scope 2 emissions were calculated to demonstrate the overall carbon footprint of the University. Two final numbers have been calculated: a total emissions value and an adjusted emissions value. This is because Queen's owns and operates a Central Heating Plant (CHP) which produces steam to heat campus buildings by burning natural gas and oil. A portion of this steam (20%) is used to heat other facilities including Kingston General Hospital and St. Mary's on the Lake Hospital. As such, some of the emissions produced by the University are not directly associated with its own facilities. Shown below are tables depicting the overall emissions of Queen's University, including energy produced for the above external facilities, and the adjusted emissions which exclude energy exported from campus. The total adjusted GHG emissions for Queen's University was **43,954 $MTCO_2e$**. See Table 1 for a summary of the 2016 campus emissions.

$MTCO_2e$ *is a metric tonne of carbon dioxide equivalents. This is a universal unit of measure that indicates the global warming potential (GWP) of each of the six greenhouse gases (CO2, CH4, N2O, HFCs, PFCs and SF6) expressed in terms of the GWP of one unit of carbon dioxide.*

	2016 Total Emissions – including hospitals ($MTCO_2e$)	2016 Adjusted Emissions – Queen's only ($MTCO_2e$)
Scope 1	46,845	38,911
Scope 2	5,042	5,042
Total	**51,888**	**43,954**
Per Capita Emissions	1.651	1.399
Emissions Per 1000 SF	7.266	6.155

Table 1. Breakdown of the 2016 Queen's University emissions by scope, population, and campus area

2016 RESULTS BY SCOPE

Scope 1 Emissions

Scope 1 emissions are those emitted on site due primarily to energy generation and unintentional release from laboratory chemicals. The greatest contributor to these emissions is the Central Heating Plant (CHP) used to heat the campus in the winter. The CHP emissions represented 86% of Scope 1 emissions in 2016. The next largest emissions source is from the standalone heat generation in buildings that are not connected to the CHP, contributing approximately 10% of the Scope 1 emissions in 2016. The remaining emissions are created by fuel combustion from the campus vehicle fleet, chemical emissions from laboratory chemicals, and fire suppression systems.

Scope 1 GHG Sources (adjusted)	2016 Totals ($MTCO_2e$)
Net CHP Emissions	33,526
Heat Generation in Buildings	3,929
Refrigerant Leakage	1,033
Fuel Combustion in Equipment	344
Laboratory Chemicals	29
Fire Suppression Systems	34
SF6 Leakage	16
Wood Combustion	2
Scope 1 Total	**38,911**

Table 2. Breakdown of Scope 1 emissions in 2016

Scope 2 Emissions

Scope 2 emissions are indirectly produced by the University through electricity usage in Queen's owned and leased offices.

The associated emissions per kWh of electricity are calculated by the province as grid emission factors, representing an average based on all forms of electricity production contributing to the provincial grid.

Scope 2 GHG Sources	2016 Totals ($MTCO_2e$)
Owned Offices – Net Grid	4,535
Leased Offices – Heating	426
Leased Offices – Grid Electricity	67
Leased Offices – Cooling	15
Scope 2 Total	**5,042**

Table 3. Breakdown of Scope 2 emissions in 2016

RESULTS IN CONTEXT

Total GHG emissions have fluctuated annually over the past 8 years, but show an overall downward trend. This is reflected in the 24% decrease in emissions from 2008 to 2016. In 2016, the total adjusted emissions were 43,954 MT CO_2e, an increase from the 42,989 $MTCO_2e$ in 2015 and 43,420 $MTCO_2e$ in 2014. The increase is a result of a combination of factors, including a higher provincial grid emission factor (decreasing emission factors have been the norm for the past several years), and greater consumption of both campus-wide electricity and natural gas consumption at the central heating plant.

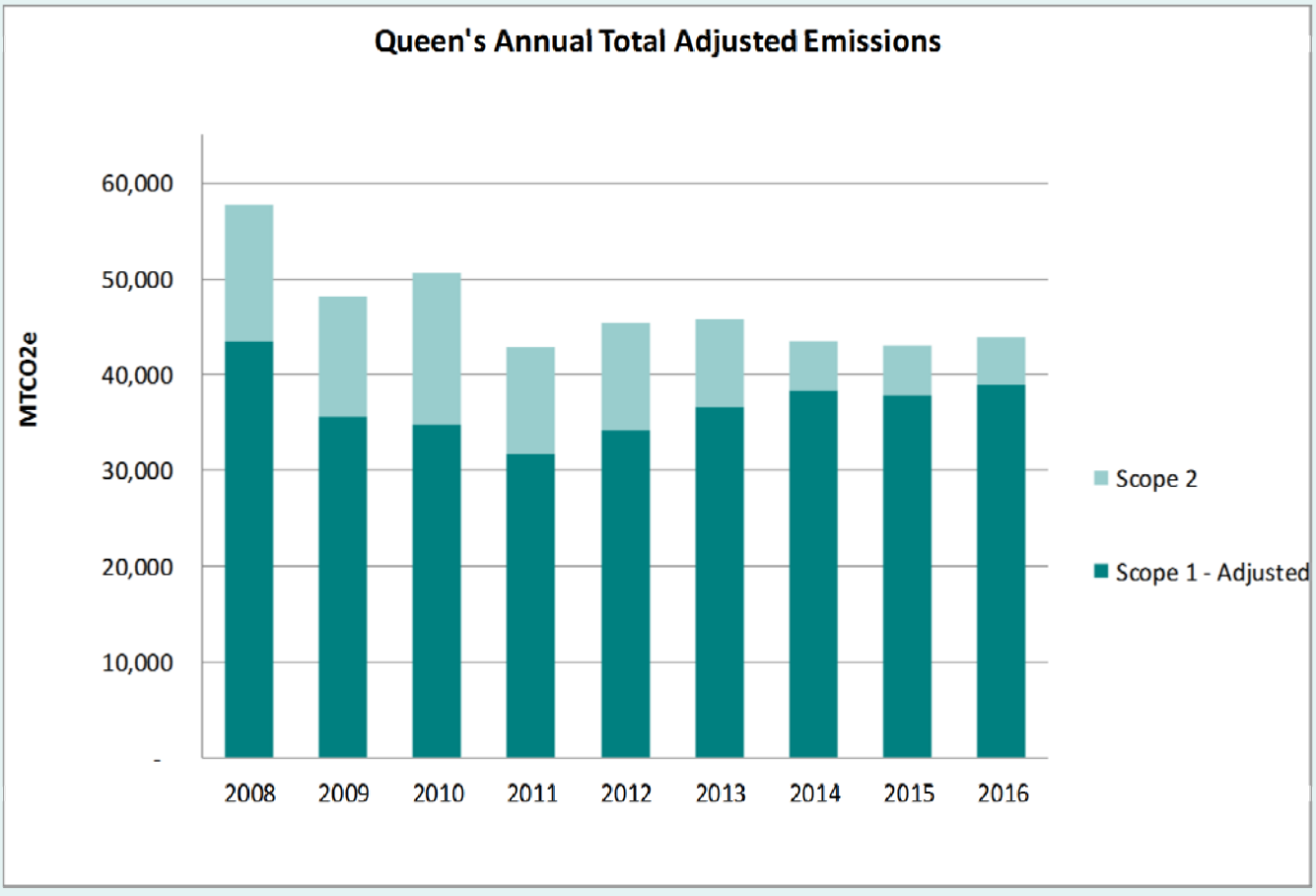

Figure 2: Total Queen's University GHG Emissions from 2008-2016

Upward Trends

Between 2015 and 2016, the overall campus GHG emissions rose by 965 MT CO_2e, due largely to the following carbon sources.

Electricity Loads

Electricity consumption continues to increase with campus expansion and growth, with 2016 experiencing an increase of over 2 million kWh of electricity over 2015. This translates to additional emissions of approximately 80 $MTCO_2e$.

Grid Emission Factor

In addition to increased electricity consumption, the provincial electric grid emission factor has also increased this year, after decreasing for the past 7 years. The provincial grid continues to get cleaner and rely on more carbon-neutral sources (such as nuclear, hydro, wind, and solar), which has a direct impact on the emissions of our university. However, in 2016, without significant new renewable energy coming online to the grid, the emission factor increased roughly 7%. This resulted in an increased campus carbon footprint of over 300 $MTCO_2e$.

Increased Building Stock

This past year was also the first full year that the new residences, David C. Smith House and Brant House were operating throughout a full heating season and academic year. Combined, the two residences account for an increase in annual emissions of approximately 1100 $MTCO_2e$.

Cooling Degree Days

Cooling Degree Days (CDD) indicate the energy demand required to cool a building with air conditioning systems. The CDD value is defined as the number of degrees that a day's average temperature is above a baseline of 18°C. For example, if the average temperature is 25°C, the CDD value for that day would be 12. The total number of CDDs for 2016 was 320, compared to the 179 in 2015. At Queens' the carbon consumption of 1 CDD was approximately 2.5 in 2016. This translates to an increase of over 350 $MTCO_2e$ between 2015 and 2016.

Reduction Trends

Although the university's overall emissions increased, Queen's continues to burn less oil at the Central Heating Plant (CHP). In 2016, 57,427 liters of oil was consumed compared to 2015's consumption of 123,745 liters, which was offset by using more natural gas. There is an approximate 30% reduction in carbon emissions per gigajoule of energy when burning natural gas versus oil.

CONCLUSION

Although the total adjusted emissions for Queen's University increased from 42,989 $MTCO_2e$ in 2015 to 43,954 $MTCO_2e$ in 2016, the overall downward trend since 2008 remains promising for the school. This increase was driven primarily by an increased grid emission factor, more cooling degree days, load increases in electricity as well as in heating and cooling due to the operation of two new residence buildings.

It will be important to continue introducing energy reduction projects to the university over the coming years to counter balance the increasing energy demand created by new buildings and an increasing student and staff population. The Queen's Climate Action Plan aims to reduce GHG emissions by 35 percent from 2008 levels by 2020, and by 70 percent by 2030. The 2016 total is equivalent to a 24 percent reduction in GHG emissions since 2008.

Year	Scope 1 adjusted ($MTCO_2e$)	Scope 2 ($MTCO_2e$)	Total ($MTCO_2e$)
2008	43,532	14,182	57,716
2009	35,675	12,451	48,126
2010	34,700	15,973	50,672
2011	31,710	11,171	42,881
2012	34,167	11,248	45,415
2013	36,575	9,204	45,779
2014	38,414	5,006	43,420
2015	37,815	5,174	42,989
2016	38,911	5,042	43,954

Table 4. Scope 1 and 2 emissions from 2008-2016

In collaboration with Honeywell, an Energy Service Company (ESCo), Queen's is in the midst of implementing the two largest energy reduction projects to ever take place on campus. Through the CAPit energy conservation program, ventilation improvement projects in both Chernoff Hall and Duncan McArthur Hall aim to significantly reduce campus emissions. These, along with other CAPit energy conservation methods are being implemented with a target of 2,800 $MTCO_2e$ in annual GHG reductions.

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