



QUEEN'S UNIVERSITY GREENHOUSE GAS INVENTORY REPORT 2021

July 2022

INTRODUCTION

In 2010, Queen's University signed the *University and College Presidents' Climate Change Statement of Action for Canada*, thereby committing to actions to reduce greenhouse gas (GHG) emissions. As part of this agreement, Queen's is required to track and report all GHG emissions. This is the thirteenth GHG Inventory Report published, and contains data from January 1, 2021 until December 31, 2021. The [Queen's Climate Action Plan](#) was developed to reduce GHG emissions by the University, with a goal of being carbon neutral by 2040, with milestone goals for 2020 and 2030 to structure an achievable timeline for carbon neutrality. Notably, **the target of 35% GHG reductions by 2020 was successfully met and in 2021 the reductions improved slightly to 35.2%**. The breakdown of these results is explained in the *Results in Context* section of this report.



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SCOPE OF EMISSIONS

This report reviews the overall emissions associated with operations at 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 includes all direct emissions, most of which are generated by campus heating systems. The main contributors to Scope 1 emissions include:

- Stationary combustion from the boilers, cogeneration plant, backup generators, furnaces, and kitchen equipment
- Mobile combustion from various fleet vehicles and grounds maintenance equipment
- Small amounts of fugitive chemical 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 2020 was used for this year's report, and the calculation will be updated when values for 2021 become available.

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 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.

Each type of electricity generation has a specific carbon intensity. Fossil fuel generating stations 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. Line losses in transmission infrastructure also adds to carbon intensity. A given year's Grid Emissions Factor is calculated from these elements.



2021 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. A portion of this steam (20%) is used to heat other facilities including Kingston General Hospital. As such, some of the emissions produced by the University are not directly associated with its own facilities. The table below includes overall emissions, as well as the adjusted amount which excludes emissions related to heating the hospital. The total adjusted GHG emissions for Queen's University was **37,399 MTCO_{2e}**. See Table 1 for a summary of the 2021 campus emissions.

MTCO_{2e} is a metric tonne of carbon dioxide equivalents. This is a universal unit of measure that relates the global warming potential (GWP) of each individual greenhouse gas such as CO₂, CH₄, N₂O, HFCs, PFCs and SF₆; and expresses it in terms of the GWP of one tonne of carbon dioxide.

	2021 Total Emissions – including hospitals (MTCO _{2e})	2021 Adjusted Emissions – Queen's only (MTCO _{2e})
Scope 1	40,809	32,660
Scope 2	4,739	4,739
Total	45,548	37,399
Per Capita Emissions	1.229	1.009
Emissions Per 1000 SF	5.937	4.875

Table 1. Breakdown of the 2021 Queen's University emissions by scope, population, and campus area

2021 RESULTS BY SCOPE

Scope 1 Emissions

Scope 1 are direct emissions emitted on site primarily from fossil fuel heating equipment, as well as a small amount from unintentional chemical release. The greatest contributor to these emissions is the Central Heating Plant (CHP), used to heat buildings and hot water. The CHP was the source of 83% of Scope 1 emissions in 2021. The next largest emissions sources are from smaller heating systems in buildings that are not connected to the CHP, contributing approximately 16% of the Scope 1 emissions in 2021. The remaining 1% of emissions come from a combination of the campus vehicle fleet, chemical leakage, wood combustion and fire suppression systems.

Scope 2 Emissions

Scope 2 emissions are indirect, such as those related to the generation of grid electricity purchase by the University.

Per kWh emissions related to grid electricity are calculated by the province and provided as an annual “grid emissions factor”, representing the average emissions of all electricity supplied to the provincial grid.

Scope 1 GHG Sources (adjusted)	2021 Totals (MTCO ₂ e)
Net CHP Emissions	27,000
Heat Generation in Buildings	5,159
Refrigerant Leakage	173
Fuel Combustion in Fleet and Equipment	236
Laboratory Chemicals	24
Fire Suppression Systems	34
SF6 Leakage	16
Scope 1 Total	32,660

Table 2. Breakdown of Scope 1 emissions in 2021

Scope 2 GHG Sources	2021 Totals (MTCO ₂ e)
Owned Spaces – Electricity Purchased	3,801
Leased Spaces – Heating	796
Leased Spaces – Electricity Purchased	116
Leased Spaces – Cooling	26
Scope 2 Total	4,739

Table 3. Breakdown of Scope 2 emissions in 2021



Climate Action Plan 2021 Results

Queen's first conducted a GHG inventory in 2008 in order to establish a baseline from which to measure future emissions reductions. Total Scope 1 and 2 emissions from the inventory were 57,716 Metric Tonnes Carbon Dioxide Equivalent (MTCO₂e) with Scope 1 emissions of approximately 43,500 MTCO₂e and Scope 2 emissions of approximately 14,200 tonnes CO₂e. Queen's achieved the goal of 35% reduction by 2021 with a reduction of 19,934 MTCO₂e from the 2008 baseline.

Year	Target Reduction	MTCO ₂ e Emissions Reduction Target	Actual Reduction	Actual MTCO ₂ e Reduction
2020	35%	20,200	34.5%	19,934
2021	>35%	>20,200	35.2%	20,317
2030	70%	40,400	TBD	TBD
2040	100% - Carbon Neutrality	57,716	TBD	TBD

Table 4. Breakdown of the Climate Action Plan 2021 Results



RESULTS IN CONTEXT

Total GHG emissions have fluctuated over the past 13 years, but show an overall downward trend, with 2021 representing a decrease of over 35% from 2008. Yearly variation is primarily due to weather, emissions are higher in cold winters where there is more demand for heating. The greater downward trend in emissions however is the result of projects undertaken by the university to reduce GHG emissions and will last long-term. In 2021, the total adjusted emissions were 37,399 MTCO₂e, a decrease from 37,782 MTCO₂e in 2020 and 43,805 MTCO₂e in 2019. This reduction is compelling, but it is important to acknowledge that there are more factors at play. It was expected that there would be significant reductions in 2020 due to the global pandemic. As campus activity returned to a more normal level in 2021 Queen's GHG emissions were predicted to increase from, but due to a warm winter and some lasting effects of the pandemic on campus activity there was a slight further reduction in 2021.

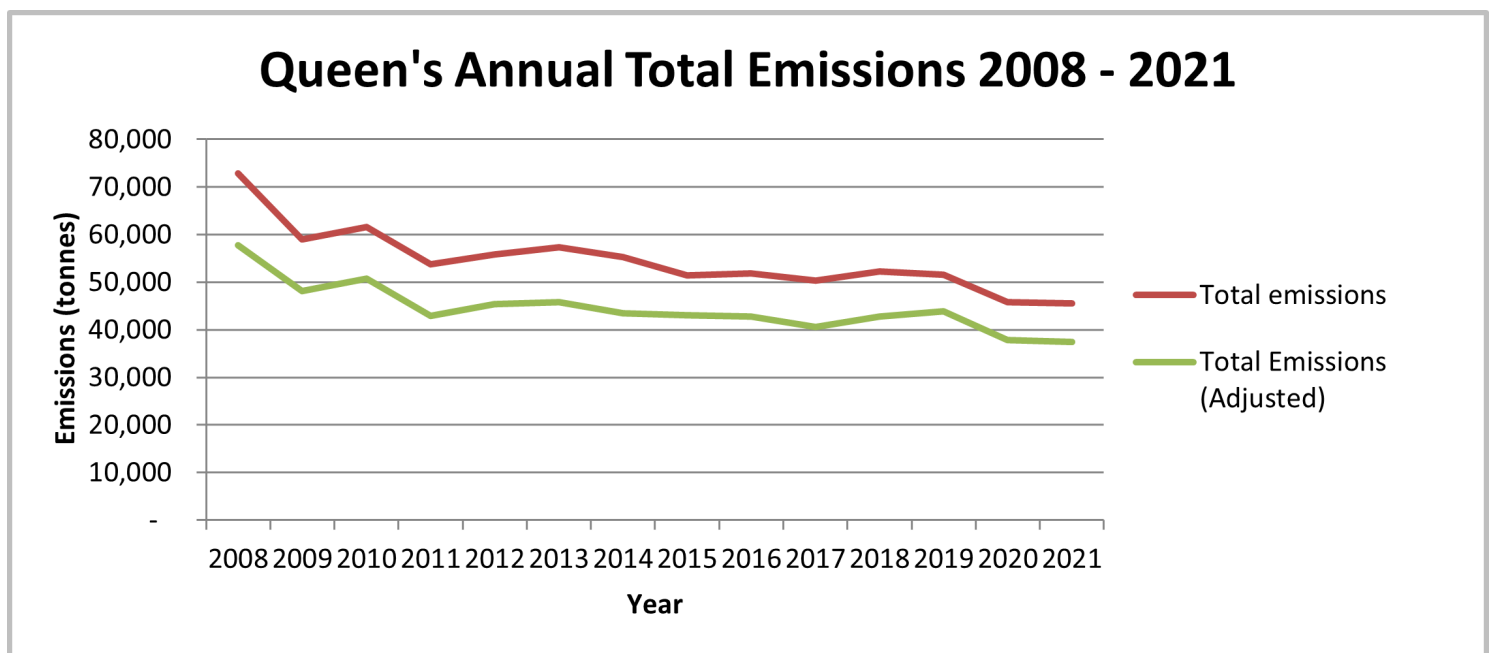


Figure 2: Total Queen's University GHG Emissions from 2008-2021



Significant Downward Trend

Between 2019 and 2021, the overall adjusted campus GHG emissions decreased by 6,406 MTCO_{2e}, due to the following reasons.

Heating Degree Days

Heating Degree Days is the total number of degrees that a daily average temperature is below 18°C. Producing steam and electricity at the central heating plant (CHP) is responsible for 84% of the total scope 1 emissions. In 2021 the total number of HDDs was 3737, this is 6.55% less than the average of 3982 over the past 25 years. As almost all buildings on campus are currently heated using fossil fuels, this less severe heating season resulted in an estimated 10% reduction in natural gas usage.

Industrial Conservation Initiative

Queen's participates in the industrial conservation initiative for class A electricity consumers, which means that electricity costs are largely based on the campus usage during the five highest usage hours (peaks) in Ontario over the course of the year. To engage in this program Facilities will run cogeneration units using natural gas to offset electricity demand on a day when a peak is expected. This initiative can save Queen's over 5 million dollars on electricity costs which can go towards new sustainability projects to reduce emissions.

Queen's Leased Spaces

Since 2019 Queen's reduced the amount of space being leased by 40%. The emissions for leased spaces is determined by taking a standard estimate on the energy usage per square foot of space. Since the start of the pandemic there has been a 1,107 MTCO_{2e} reduction including a 492 MTCO_{2e} reduction in 2021.



Cogeneration Strategy

Queen's third largest source of emissions is the natural gas burning cogeneration units which produce heat and electricity. Cogeneration is essential on peak electrical demand days to achieve savings through the Industrial Conservation Initiative. On average the units are run for 659 hours per year to ensure Queen's grid electricity demand is as low as possible during the top 5 provincial peak electricity demand hours, whenever they occur. Predicting when these hours will be is a complicated task requiring deep knowledge of demand patterns in Ontario. In 2021 Facilities started implementing a new strategy to decrease cogeneration usage by 64% while ensuring the cogeneration units are running during the top 5 peaks. This reduction is possible because of manual data analysis and the machine learning peak prediction software that allows us to more accurately anticipate a peak day. This new strategy has resulted in CHP emissions to be reduced by 757.7MTCO₂e. The chart below shows cogeneration emissions from 2016 to 2021, and predicted emissions in 2022 and 2023.

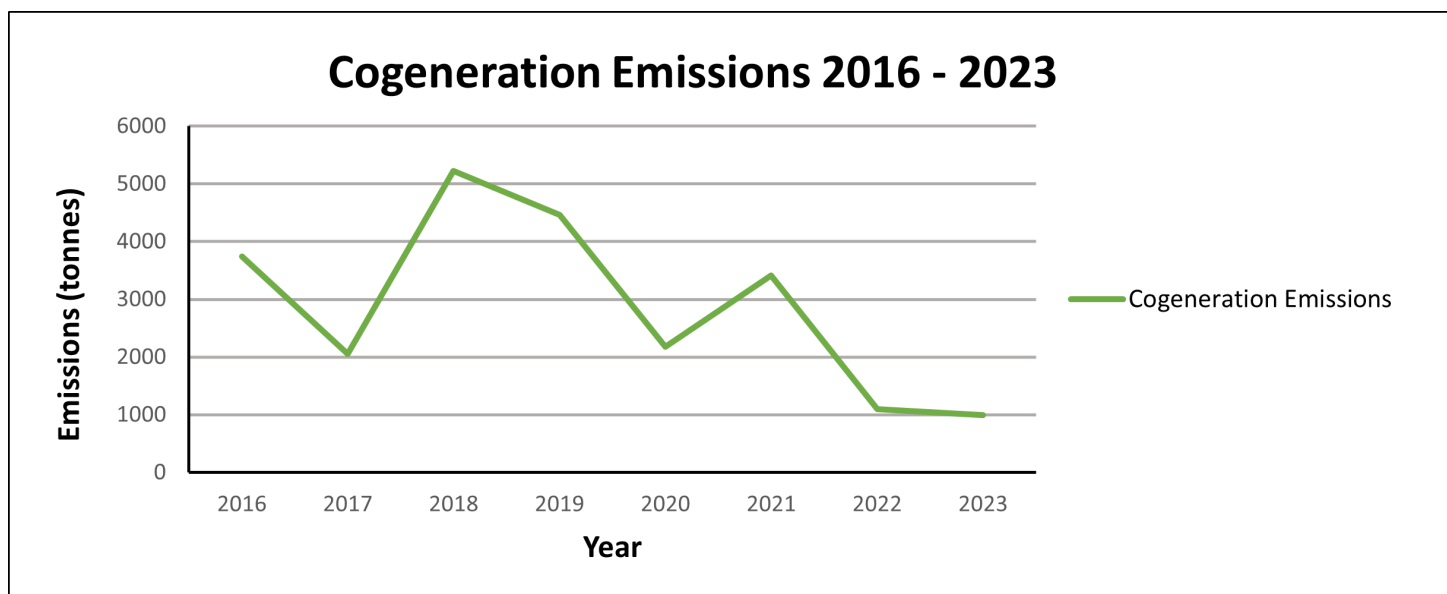


Figure 3: Total Cogeneration Emissions from 2016-2023



Energy Reduction Projects

The university continually invests in energy reduction projects. Central Heating Plant staff were able to increase steam distribution efficiency and the condensate return rate in 2021. This upgrade resulted in 18.2% decrease in water usage, along with the warmer winter this saved 2,532 MTCO_{2e} of emissions.

Facilities has completed an energy reduction project in the McArthur Library by converting fluorescent lighting to LED equivalents. The project also added daylight harvesting which turns off lighting when there is enough sunlight and electric lighting is not needed. Estimated savings from this project is \$22,000, or 200 MWh's of electricity per year.

The University has completed the design phase of addressing high energy use lab spaces and construction will begin on a \$5.5M upgrade project in 2022. The project will significantly reduce excess ventilation and heating of make-up air during the winter. Savings are estimated at 1,750 MTCO_{2e} per year.

The Queen's Building Standard requires that new buildings and major renovations shall no longer use fossil fuel based heating. This change has already impacted new developments on campus, including the installation of geothermal cooling and heating at 355 King St which opened in 2022. A large expansion at McArthur Hall will also have a geothermal system, currently slated for construction in 2023.

Although considered to result in "Scope 3" (non-energy purchases) emissions, Queen's Facilities are continually looking for water reduction projects as well. The Dupuis vacuum pump upgrade project reduced the water usage by 26,000 cubic meters, or \$65 000 in annual water savings. New opportunities for energy reduction projects on campus are continually being explored, and are planned for implementation in 2021/2022.

COVID-19 Global Pandemic

The pandemic has greatly decreased occupancy around campus over the past two years. This creates a drop in usage across the board, with cafeterias using less natural gas, research using less utilities, and an overall reduction in electricity use of 8.4% since 2019. While it may seem significant, the direct result of the decrease in occupancy has a relatively small impact on total GHG emissions.



Grid Emission Factor

The grid emission factor is a measure of the Ontario electrical grid’s average emissions per MWh of electricity produced, this is counted under Queen’s Scope 2 emissions. The factor has decreased significantly since 2005 due to the phase out of coal fired electrical generation and the support for solar, wind, hydro, and nuclear power. Ontario Power Generation has plans to temporarily shut down 3 nuclear reactors for refurbishment over the next two years, this will cause a large increase to the grid emissions factor as natural gas generation will supply the electricity normally provided by these nuclear reactors while the upgrades take place.

Due to a 1 year delay in data availability from the province the emission factor is always a year behind, the most recent available year (2020) was used for this report. The emission factor for 2020 is approximately 0.0406 tonnes/MWh, an approximately 19.7% increase from the previous year.

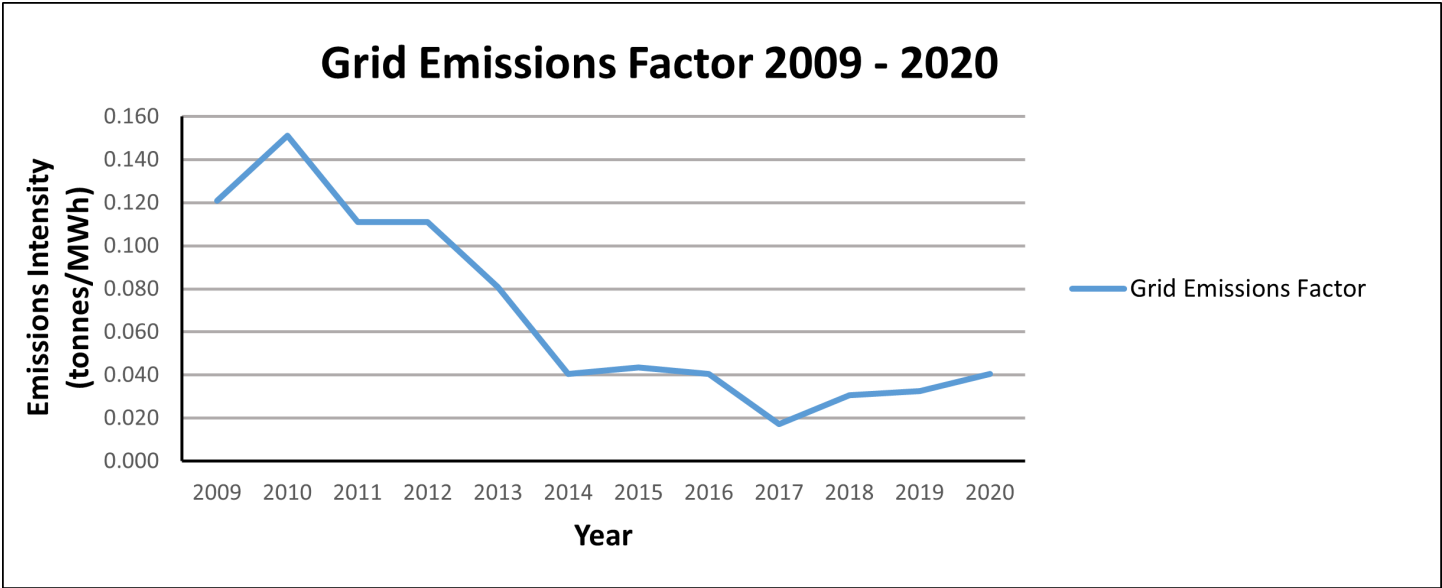


Figure 4: Change in Grid Emissions Factor since 2009

CONCLUSION

The total adjusted emissions for Queen's University decreased from 37,782 MTCO_{2e} in 2020 to 37,399 MTCO_{2e} in 2021. This decrease was primarily due to a warm winter, and energy efficiency projects taken on by the university. In 2021 there were still some lasting effects of the global pandemic so maintaining these reductions in the following years will be a true measure of progress.

The Queen's Climate Action Plan aimed to reduce GHG emissions by 35% from 2008 levels by 2020, and by 70% by 2030. Even with the increasing energy demand created by new buildings and an increasing student and staff population, the 35% decrease was attained and more projects are planned to continue to push us further towards 70% by 2030.



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	37,681	5,042	42,723
2017	35,972	4,670	40,643
2018	40,593	3,105	43,698
2019	39,226	4,579	43,805
2020	33,958	3,824	37,782
2021	32,660	4,739	37,399

Table 5. Scope 1 and 2 emissions from 2008-2021

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