Measuring York's Carbon and Ecological Footprints

During fiscal years 2016-2020

YORK U

Technical Report

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Ecological Footprint Initiative is a York-based research, training, and analytics hub that produces the National Ecological Footprint and Biocapacity Accounts used around the world, plus fee-for-service work. The initiative is housed in the Faculty of Environmental and Urban Change.

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Introduction

Organizations around the world are increasingly tasked to account for greenhouse gasses emitted from their operations and purchases. This accounting helps organizations to report on their emissions and to plan for a carbon-constrained future. Organizations in Ontario, including York University, are now paying for greenhouse gas emissions. Previously, greenhouse gasses were free to emit even though their climatic consequences were costly. The price of emissions is expected to continue to grow in the future, in Ontario and around the world, as the global community aims to reduce emissions. York has set a goal of reaching net zero emissions by 2049, which requires planning for emission reductions and potentially increased use of carbon offsets. Zero net emissions means that all emissions in that year would offset in that same year by an equivalent sequestration of emissions. York has also set a goal to help the world to achieve its Sustainable Development Goals, which include goals related to emissions and goals related to other aspects of sustainability including biodiversity on land and underwater. This context underlies the importance of quantifying York's emissions and its broader Ecological Footprint.

This report accounts for greenhouse gas emissions, and Ecological Footprint, attributable to York University from fiscal years 2016 to 2020. Greenhouse gas emissions are mostly carbon dioxide but also include other greenhouse gasses, which are comparable in units of carbon dioxide equivalents. Ecological Footprint is a measure of the area of land and water needed to sequester carbon emissions plus the areas used to provide food and renewable materials, plus the area occupied by buildings and infrastructure. The 5-year period ending with fiscal year 2020 was chosen as an approximate pre-covid-19 pandemic baseline, with the pandemic affecting activities only in the last two months of that fiscal year, which ended on April 30.

This report documents the accounting logic, methodology, assumptions, and parameters used to generate results. Results were generated from a relational database that was developed to systematize the integration and reconciliation and cleaning of multiple datasets. A sample of results are presented in this report, at an aggregated level and with detailed breakouts that were assumed to be helpful to understand the distribution of emissions by purpose and by stakeholder.

Even though the measurement of Ecological Footprint does not relate to regulatory requirements, or to a targeted reduction by York or by Ontario or Canada, the consideration of Ecological Footprint helps to demonstrate York's broader interest in sustainability and York's leadership in this measure of global significance. Altogether, and as a side benefit, this project developed and demonstrated capacity within York, and among the report's authors, to undertake enterprise-wide emissions accounting.

Accounting framework

We developed an accounting framework informed by the Greenhouse Gas Protocol, which was authored by the World Business Council for Sustainable Development and World Resources Institute (2022). The protocol is globally used as a standard for categorizing emissions from entities in the public, private, and not-for-profit sectors. Our framework aligns with the protocol to categorize emissions into one of three *scopes* with a further distinction of whether indirect emissions are *upstream* versus *downstream* of York University. Table 1 details the terminology and concepts that we applied.

Table 1: Scope 1 and 2 and 3 defined, as applied in this report, as adapted from the Greenhouse Gas Protocol.

<table>
<tr><th>Scope</th><th>Definition applied to emissions or Ecological Footprint</th><th>Relationship</th><th>Control</th></tr>
<tr><td>1</td><td>From facilities and equipment owned or controlled by York</td><td>(Self)</td><td>Direct</td></tr>
<tr><td>2</td><td>From York's purchase of electricity from the electrical grid</td><td rowspan="2">Upstream</td><td rowspan="3">Indirect</td></tr>
<tr><td rowspan="2">3</td><td>From commuting and York purchases and reimbursements that are not counted within scope 1 or scope 2</td></tr>
<tr><td>From non-York entities using York-owned assets, including commercial activities on campuses, and York investments’ scope 1+2 emissions</td><td>Downstream</td></tr>
</table>

The protocol asserts that all organizations should quantify and report scope 1 and scope 2 emissions, and there should be no double counting of emissions within their aggregation. Scope 3 is an optional reporting scope that is more challenging to measure, and more comprehensive, with emissions typically exceeding the total of scope 1+2. Quantifying scope 3 can help organizations to affect emissions by potentially adjusting their inputs and outputs and relationships with other entities.

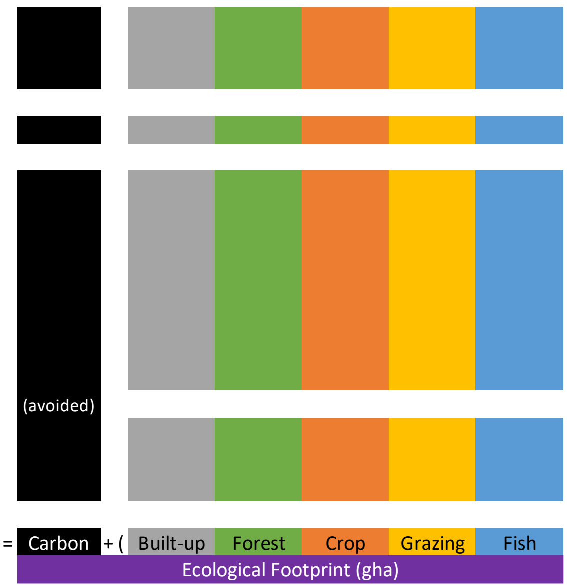
The protocol asserts a logic that scope 1+2 emissions of one entity are equivalent to scope 3 emissions from another entity that consumes (upstream) all its products or provides (downstream) all its inputs. Therefore, York’s scope 1+2 emissions would count towards scope 3 emissions of tri-council granting agencies; scope 1+2 emissions from an advertising agency promoting York would count, proportionally, to York’s scope 3 (upstream) emissions. If all entities in the world measured and reported scope 1+2 emissions, and did so using a consistent methodology, then scope 3 would be easy to derive. But since measurement and reporting are not mandatory, scope 3 emissions are inherently more challenging to estimate than scope 1 which are directly measurable and scope 2 which are increasingly regulated.

All scopes of emissions are increasingly being affected by public policy that aims to internalize the costs of greenhouse gas emissions, with about one quarter of global carbon emissions in 2022 being subject to some form of a carbon pricing regime (World Bank, 2022). York’s accounting for scope 1 and 2 and 3 emissions will help York to understand baseline emissions and to inform strategies of reducing them.

The protocol identifies 8 components of upstream scope 3 emissions and 7 components of downstream emissions. Most downstream emissions relate to the production of commodities, which are not as comparable to York and other universities which predominantly produce non-commodified outputs that are not transported or warehoused or discarded or franchised. We settled on 12 components of upstream and 3 of downstream emissions. Compared to the protocol, our greater number of upstream components reflects different methodological approaches or different possibilities of affecting emissions. For example, we found it useful to distinguish between commuting by transit versus commuting by car, since the methodology to attribute emissions varies and so does the possibility for affecting these two categories of commuting. Our categorization evolved during the project and could continue to evolve to help present emissions in a way that best aligns with how accountabilities and leadership is distributed across York. Figure 1 presents our accounting detailed by component, and how they relate to broader scopes and to aggregated sums of emissions and Ecological Footprint.

Figure 1: Accounting approach applied to scopes and components of York emissions and Ecological Footprint.

Scope 1	101	Electricity generation & heat cogeneration at Keele
	102	Additional stationary combustion at Keele and Glendon
	103	Fuel consumed by York vehicles and mobile equipment
+		
Scope 2	201	Electricity purchased from electrical grid
+		
Scope 3 up-stream	301	YorkU capital expenses (fund 700)
	302	YorkU repair and maintenance
	303	YorkU leases of buildings, equipment, software
	304	YorkU air travel
	305	YorkU reimbursed mileage
	306	YorkU other travel expenses
	307	YorkU purchased hospitality including food
	308	Solid waste collected from campus (net of diversion)
	309	YorkU carbon offset purchases (emission offset)
	310	YorkU other goods and services purchased
	311	Commuting to campus by driving
	312	Commuting to campus by transit
=		
Sum	All	Total quantified greenhouse gas emissions (CO2e)
		Investigated but not included in total
Scope 3 down-stream	313	Other food and vending purchased on campus
	314	Other retail and other commercial activity on campus
	315	Emissions from York investments including endowments



Greenhouse gasses trap heat and therefore contribute to a greenhouse effect when present in the atmosphere. Greenhouse gasses accumulate in the atmosphere to contribute to global warming, which generates climate change. The dominant greenhouse gas, by volume of anthropogenic emissions, has been carbon dioxide; other gasses include methane, nitrous oxide and fluorinated gasses. Greenhouse gas emissions are measured in units of mass of carbon dioxide equivalents, written as CO2e (or CO_2e) which is derived by weighting non-CO2 gasses in proportion to their warming effect. For this project, emissions by component are typically reported in (metric) tonnes (t) or kilotonnes (kt).

We extended the emission-accounting framework to account for Ecological Footprint. Ecological Footprint is the area of land and water needed to sequester anthropogenic GHG emissions, plus the area used to generate food and fibres and renewable building materials, plus the area used by settlements and infrastructure. Ecological Footprint is therefore more comprehensive than simply an area-based equivalent of the area needed to biologically sequester a "carbon footprint". An Ecological Footprint is the sum of six components that are detailed in Table 1 and measured in units of a global hectare (gha). A global hectare is a hectare that provides a world-average amount of biological regeneration each year. This unit of a global hectare allows for globally consistent and comparable comparisons of Ecological Footprint across the planet at over time. Global hectares can be converted to and from national hectares using a set of conversion parameters specific to each footprint component. These global hectares of Ecological Footprint can also be compared to global hectares of Biocapacity provided by any area of land or water, such as those across the entire planet or within a nation or a specific land deed.

Ecological Footprint is defined and measured according to standards developed by Global Footprint Network (2012) and which are now under the leadership of the Footprint Data Foundation (FODAFO). FODAFO was incorporated in 2019 by York University in partnership with Global Footprint Network, as a commitment made through a letter of intent signed by President Lenton on April 30, 2018. Since then, York established an Ecological Footprint Initiative within the Faculty of Environmental and Urban Change (EUC) to lead research, training, and analytics related to Ecological Footprint and Biocapacity.

Table 2: Components of Ecological Footprint which are additive (Miller et al., 2021).

Fishing grounds	Area of marine and inland waters used to produce the fish, invertebrates, and aquatic plants that were captured or cultured by humans
Built-up land	Area of land occupied by human-built infrastructure, including housing and other buildings, roads and paved areas, and urban greenspace
Cropland	Area of cropland used to grow food and fibre crops consumed by humans, and for crops that humans fed to animals and cultured fish
Grazing land	Area of grassland needed to feed livestock beyond the feed supplied by crops
Forest products	Area of forests harvested for timber products and pulpwood
Forest carbon uptake	Area of forests needed to sequester anthropogenic carbon emissions from the combustion of fuels including for electricity generation and for the production and transportation of globally traded goods, minus the proportion of anthropogenic emissions sequestered in the same year by the world's oceans

A key deliverable of York's Ecological Footprint Initiative is the world-renowned National Ecological Footprint and Biocapacity Accounts. These detail Ecological Footprint and Biocapacity for all countries from 1961 to the present, and with a world total. Accounts are produced annually by York's Ecological Footprint Initiative, drawing on the experiential education of a team of data analysts working towards their MES degree. All analysts employed to assess York's emissions (Apeksha, Sophie Angoh, and Elizabeth Holloway) were experienced in producing a prior edition of the national accounts. The 2022 edition of the accounts were produced by integrating about 48 million rows of data from global datasets including the International Energy Agency (IEA), the Food and Agriculture Organization (FAO) of the United Nations and its ProdStat and TradeStat and ResourceStat and FishStat databases, UN COMTRADE, CORINE Land Cover, Global Agro-Ecological Zones (GAEZ), Global Land Cover (GLC), Global Carbon Budget, World Bank, International Monetary Fund, and Penn World Tables. In this report, we measured Ecological Footprint using results and parameters from the 2022 edition of the accounts (Miller, Gomez, et al., 2022) and its downscaling to Ontario (Miller, Robinson, et al., 2021).

Methodological approach to quantifying emissions and footprint

Throughout the project we focussed on quantifying greenhouse gas emissions, in units of mass, ahead of expressing its equivalence in global hectares of the carbon component of Ecological Footprint. Added to the carbon component were the five other non-carbon components. Across all scopes, and starting with emissions, we attempted to obtain as much directly measured data as possible, in physical units, with a fallback of applying emission intensities to university expenses. Emission intensities are ratios of emissions per unit of an expense of a particular good or service. Our approach required significantly more effort than relying exclusively on the emission intensities.

We differentiated emissions into mutually exclusive categories, which we were able to attribute to further details such as the purposes of the activity/consumption and in some cases the campus and categories of persons that related to the activity/consumption. This detailed attribution will help to understand the potential for affecting emissions in the future. Later in this report, we detail the approach taken for each of the components within each of the scopes of emission. In general, throughout the project we followed an approach to be as specific as possible, with a fallback of using broader aggregates in the absence of more specific information. In decreasing order of priority and confidence in the results, we aimed to obtain or derive:

- Direct measurement of emissions where possible (e.g. central utilities plant);
- Estimates derived from quantities of purchases (e.g. air travel, by distance and class);
- Estimates from Ontario emission intensities (e.g. emissions from grid-purchased electricity);
- Estimates from Canadian emissions intensities (e.g. goods purchased or leased);
- Estimates from sampling (e.g. goods/services sold on campus).

Higher-priority and confident estimates were compared to approximations from Canadian or Ontario emission intensities to reassure ourselves about their reasonableness. For example, direct measurements of emissions from Verified Emission Reports about the Keele campus were compared to emissions estimated from York's expenditures on the emitting fuel such as gas and diesel.

At an aggregated level, the simplest and most approximate estimate of emissions was derived by multiplying York's total expenses by an average Canadian emissions intensity of greenhouse gasses per current dollars of production from the "university" sector. Statistics Canada identifies universities as a distinct economic sector (GS61130) with average (national) emission intensities per year. Statistics Canada provides these coefficients in Table 38-10-0098-01; from 2013 to 2019, the coefficient averaged around 0.15 tonnes of greenhouse gasses per thousand dollars of output. This coefficient accounts for the direct emissions from universities (equivalent to scope 1) plus indirect emissions attributed to goods and services purchases by universities (which is equivalent to scope 2 purchases from electrical utilities) plus scope 3 (upstream) but excluding commuting emissions (since York does not purchase commuting). Applying that coefficient to York's total expenses generated an estimate of comparable emissions. This anchored our initial expectations and served as an approximate national benchmark against which York could be compared. Since York is among the largest universities in Canada, York's emissions were expected to be somewhat close to this benchmark of all Canadian universities. As we detail later in this report, York's emissions were mostly below this benchmark.

In most cases, data were obtained on a fiscal-year basis to coincide with people-counts and expenditure data. When data was provided on a calendar year basis, we derived fiscal year equivalents by splitting annual data into 1/3 versus 2/3 components to relate to 4 versus 8 months.

We engaged with various teams and experts across York to understand what data was available and could be provided on a confidential basis. This included Finance, which provided us with non-salary expenses, by fund and account and fiscal year, and all Concur airfare reimbursement records. York's Utilities and Energy Management team provided us with energy-related data of gas and electricity consumed and produced and third-party Verified Emission Reports that followed the ISO 14064-3 standard and Ontario Regulation 390/18. Within Ancillary Services, Parking provided us with various types of permit records related to the type of customer, campus, and their home postal code as a 3-digit Forward Sortation Area (FSA). Food services, the bookstore, YUDC, and the management of York Lanes were engaged, and some provided us with data samples. The Office of Institutional Planning and Analysis (OIPA) provided us with a headcount of staff and full-time-full-term-equivalent students, by year and by Forward Sortation Area and campus affiliation. All engagements were facilitated by the Director of Sustainability and of the Office of the Vice President Finance and Administration. We requested that data be as broad and as detailed as possible, so that we could aggregate it after cleaning it to conform with expectations that we shared with the data providers. We appreciated the significant effort of colleagues and their trust in our work.

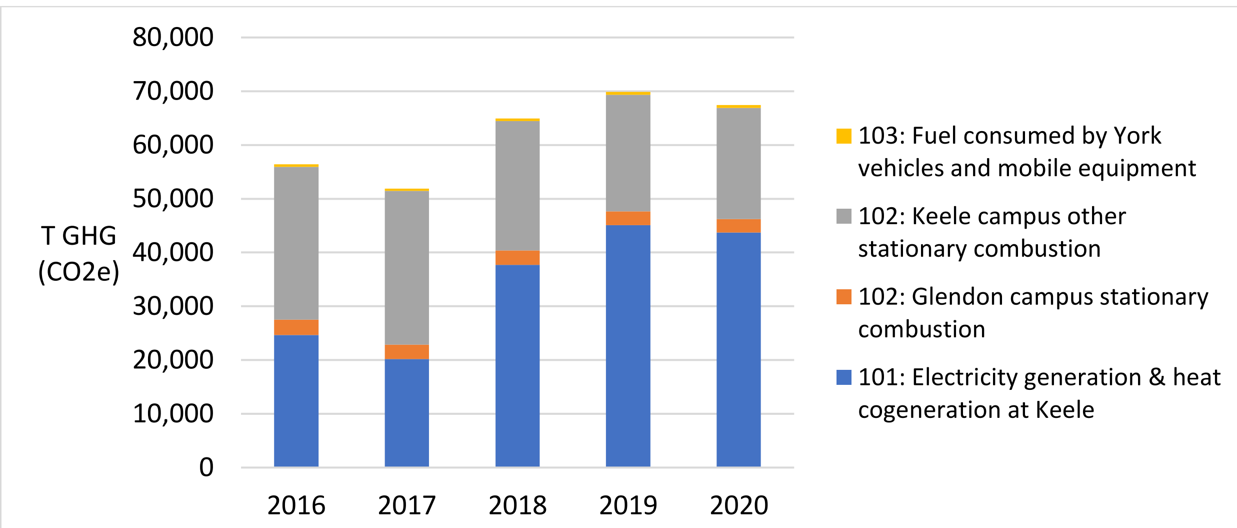
We built a Microsoft Access database to integrate and relate and clean raw data into refined relational records that map to each component in the accounting matrix, by year. Each component (cell) is the summation of several more detailed records. Most cells aggregate data that are detailed by Fund (100, 200, 300, 400, 500, 600, 700, 900) and a York account number if the data relates to York expenditures. Further dimensions and attributions could be possible if we were supplied with data that resolves expenses and personnel to departments or cost centres. Later in this report, we detail the resolution of each of the components to help understand the full scope of details that exist and could be queried. Since all the underlying data was made to be relational, any adjustments to the accounting framework would cascade to the underlying data, such that totals will remain summable across all categories. The database incorporates over a hundred queries and tables with user-built forms and functions. The database was encrypted and password-protected using the built-in features of Microsoft Office and was developed by team members running BitLocker on their machines running Windows 10.

Scope 1: Direct emissions

Scope 1 accounts for emissions that were directly attributable to combustion on York's campuses from equipment that was owned or operated by York University. This included emissions from heating and cooling campus buildings and powering laboratories, plus the university's self-generation of electricity (on its Keele campus), plus emissions from owned or leased fleet vehicles. We divided scope 1 into three components to facilitate their attribution to a purpose with distinct characteristics, and to facilitate comparisons with publicly reported emissions data attributed to York's Keele campus.

Figure 2 plots the sum of all aggregated components including a breakout of Keele versus Glendon emissions related to stationary combustion (omitting electricity generation and heat co-generation). Scope 1 emissions were 20% higher in fiscal 2020 than in 2016, with year-over-year growth in 2018 and 2019 and declines in 2017 and 2020. Scope 1 emissions peaked in fiscal 2019 at a level that was about 24% higher than the scope 1 total in 2016. Emissions from York's self-generation of electricity grew to become the largest component of scope 1. Emissions from the other components of stationary combustion and emissions from mobile equipment and vehicles remained relatively consistent.

Figure 2: Scope 1 emissions per fiscal year by component in tonnes of carbon dioxide equivalent (CO2e).



Some of York's scope 1 emissions were publicly reported. York's Keele campus was listed as facility G10652 under the federal Greenhous Gas Reporting Program. Data on total and component greenhouse gasses were accessible by a reporting website, which is currently climate-change.canada.ca. Glendon was not reported as a facility, and emissions from its campus were not included in the reports of emissions from York's Keele address. As of April 2022, the website listed emissions from 2010 to 2020. These emissions were meant to reflect the components that we categorized in this report as 101 and 102 relating to just Keele; totals in the present report are somewhat different for reasons that we detail later in the component sections. Other details about some of York's scope 1 emissions were provided on spreadsheets that York posted on its website, and which are also obtainable by querying a provincial website that reports on greenhouse gasses of provincial public-sector facilities. York's spreadsheet identifies total emissions and energy consumed by building and by address in Ontario. These emissions summed to a total significantly below the total reported on the federal website. All publicly available provincial and federal reports were examined for the present report, with additional details that were needed to derive a broader and more detailed accounting of scope 1 emissions on an annual and fiscal-year basis. We detail the methods and results in the following sections.

101: Electricity generation & heat cogeneration at Keele (by fuel, equipment)

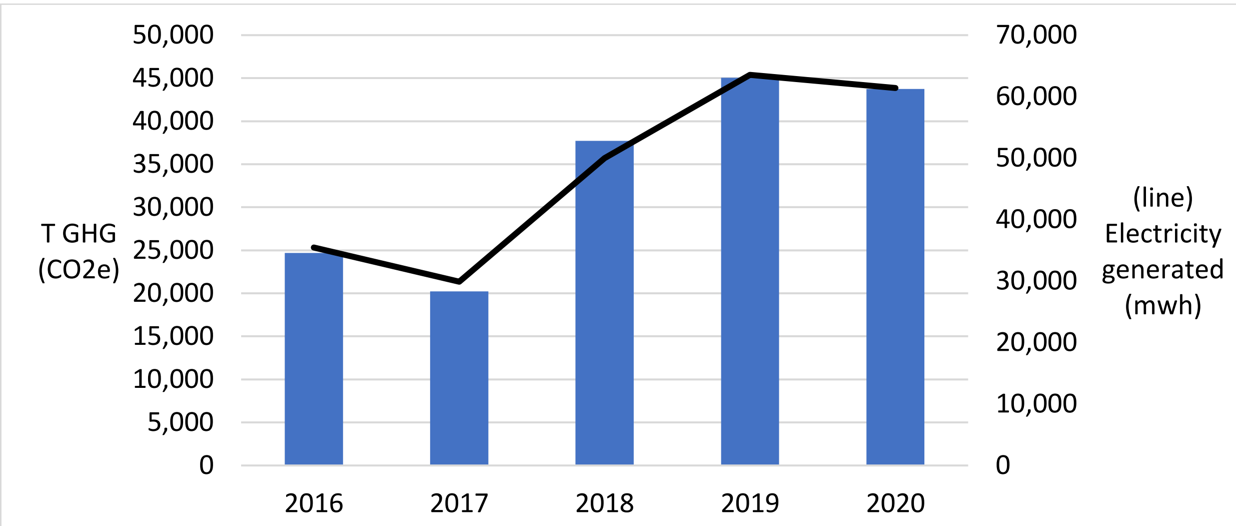
York consumed natural gas to generate a portion of electricity used on its Keele campus, with co-generated heat used for York's district energy system. The remaining portion of electricity used on campus was purchased from Toronto Hydro which is connected to the Ontario electricity grid. Fuels and emissions attributed to component 101 were sourced from copies of York's regulatory submissions to the provincial and federal government, and from Verified Emission Reports attached to the provincial submissions for the years 2016-2020. The 2016 report was prepared by GHD (2017) and the later-year reports from 2017-2020 were prepared by Internat Energy Solutions (2018, 2019, 2020, 2021). These verification reports were authored by experts with relevant accreditations including ISO 14064-3, using information provided to them from York University. Regulatory submissions and the Verified Emission Reports identified the natural gas burnt for the purpose of "electricity generation and cogeneration" and with a further detail in 2019 of two cogeneration units in that year (in other years the units' totals were combined). These reports also asserted the emission of greenhouse gasses, with details about carbon dioxide, methane, and nitrous oxide. These were allocated to scope 101.

Natural gas and combustion emissions were reported annually, which required a reallocation to York's fiscal years to be consistent with the approach used in the present project. Initially, this reallocation was done by allocating calendar-year emissions to the fiscal year that ended in the next calendar year. Thus January – December 2015 emissions would count as emissions in fiscal 2016 (May 2015-April 2016), since more months in 2015 existed in the fiscal year ending in 2016 rather than 2015. Upon reviewing these results, York's energy management team preferred a more elaborate reconciliation especially related to the last few months of the fiscal year 2020.

In 2023, York's energy management tasked a consultant to retrospectively re-allocate historic gas consumption and emissions on a monthly basis. The resulting tabulation's annual summation differed from the Verified Emission Reports. Some difference arose from different coefficients used to derive emissions from consumed gas. Most of the difference arose from a different quantity of gas, whose difference varied substantially over the years. This difference was said to relate to whether Glendon was included or omitted from the totals, but this could not be reconciled against billed quantities of gas from both campuses, which we had been provided in 2022. As a solution, we ranked the verified reports to be higher in authority for the annual quantity of consumed gas, and emissions. We then apportioned these annual totals *by the proportion* of the monthly-reconciled totals in the first four months of the year versus the last eight months. This ensured a consistency between the annual reported emissions (which informed federal and provincial reporting requirements) and the sum of the two components of fiscal years that exist within each calendar year. This proportionality also informed the reconciliation of gas consumption on a fiscal year basis, and the fiscal year in which electricity was generated. Electricity purchases were allocated such that they were higher (or lower) in the proportion of the fiscal year with lower (or higher) self-generation of emissions, by an amount equal to offset the difference by which the quantity of self-generated electricity was lower (or higher) than 1/3 in the first four months of the fiscal year, or 2/3 in the last eight months of the fiscal year.

Figure 3 plots direct scope 101 emissions attributed to York's generation of electricity and co-generation of district heating at the Keele campus. The figure also includes, as a line, the quantity of electricity generated, which is reported on the right axis in units of megawatt hours. The line follows the trend in the bars, with a slight deviation in fiscal years 2017 and 2018. York's energy team explained to us that there was significant work on the co-generation equipment in 2017 which reduced self-generated electricity. This reduction in self-generated electricity was offset with more grid-supplied electricity, whose emissions are captured in scope 2. Thereafter, emissions increased in relation to increased generation of electricity and heat on campus, which were offset by reduced grid-supplied electricity.

Figure 3: Scope 101 emissions per fiscal year from generating electricity and co-generating heat on Keele campus. Emissions are reported in tonnes of carbon dioxide equivalent (CO2e) by the left axis. The right axis reports the scale of the line, which is electricity generated in units of mwh.

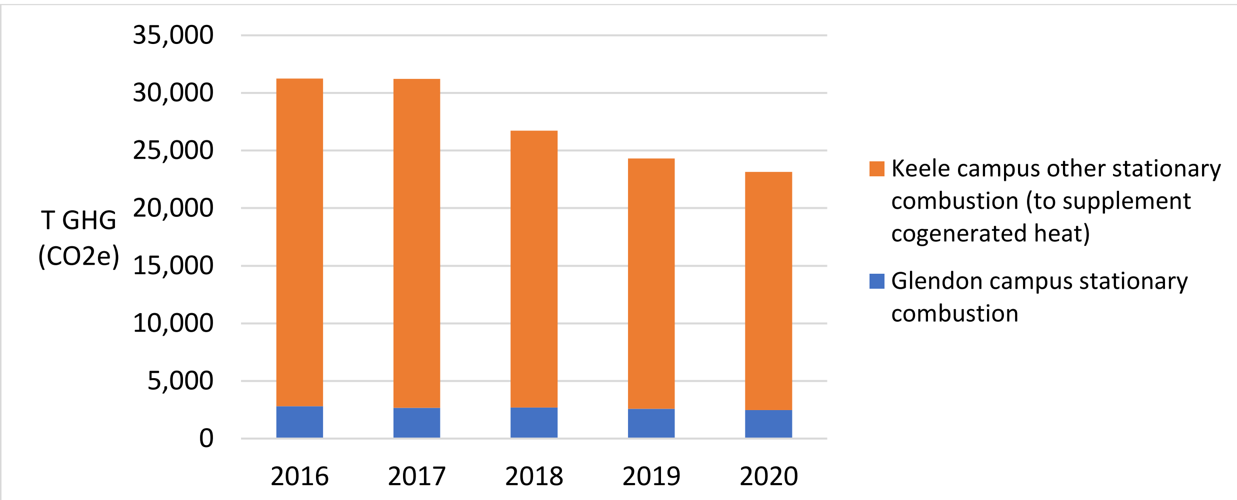


From fiscal years 2016 to 2020, York increased its proportion of self-generated electricity, so trends in emissions allocated to component 101 should be considered with trends in scope 2 emissions, to understand the broader picture about emissions related to the energy used to power York's campuses. This is evaluated later in the report, in the chapter, *Aggregations and Integrated Assessment*. Furthermore, a portion of component 101 relates to electricity, and co-generated heat, that would have been consumed by non-York enterprises on campus. The Greenhouse Gas Protocol specifies that no deductions/netting should be done from scope 1 to attribute emissions to other enterprises that directly consume York-produced / managed / controlled energy. However, this could still be measured and reported separately if there were demand, such as if non-York enterprises on campus would need that information to complete *their* reporting of upstream scope 3 emissions.

102: Additional stationary combustion at Keele and Glendon (by fund, campus)

Component 102 accounts for emissions generated by York on its Keele and Glendon campuses from burning gas or diesel to generate heat and steam and hot water and to fuel laboratories. These purposes supported academic and administrative activities, plus on-campus residences, plus retail and office space for other organizations. This scope excludes emissions from the generation of electricity and cogeneration of heat (included in scope 101) and excludes emissions used to power mobile equipment (covered by scope 103). York's energy management team supplied us with annual (calendar year) gas consumption quantities for Keele and Glendon (separately), from which we subtracted the gas consumed by the cogeneration units on the Keele campus as was detailed by the (annual) verified emissions reports. We also made use of the monthly reconciliation of gas consumption and emissions that were used to apportion emissions in component 101 on a fiscal year basis. Results are presented in Figure 4. Component 102 emissions at Keele fell from 2018 to 2020, concurrent with a growth in cogenerated heat at Keele from an increase in generated electricity. For this reason, we labelled the Keele component of 102 as "other stationary combustion to supplement cogenerated heat". We did not have data that could have been used to split component 101 emissions between generated electricity and co-generated heat; if we had this, we could have reallocated that component from 101 to 102. Without this reconciliation, we could not assess if (and by how much) the reduction in the Keele component of 102 related to changes in co-generated heat versus improved efficiencies.

Figure 4: Scope 102 emissions per fiscal year, by campus, from fuels consumed for stationary combustion to generate heat, steam, and hot water, and to fuel labs. Emissions are reported in tonnes of carbon dioxide equivalent (CO2e).



Glendon's consumption of gas was not identified separately in the retrospective monthly reconciliation of gas consumption. We therefore apportioned the annual totals to fiscal years by allocating 1/3 to the fiscal year with the same label (related to months January to April), with the remaining 2/3 (May to December) allocated to the fiscal year ending in the next calendar year. This was applied consistently to data covering the calendar years 2015 to 2020. The resulting reconciliation showed the same pattern of a general modest decline in gas usage when measured fiscally and annually.

Reconciling the gas consumption at the Keele campus involved first deducting the gas consumed by the co-generators of electricity (since those were allocated to component 101). The reconciliation of annual Keele gas campus to fiscal years was complicated by a difference in the quantities attributed to "stationary combustion" and "steam generation" on the verified emission reports, and the campus-wide total supplied by York's energy team. In 2018, the reconciled monthly gas usage summed to less than the total of the verified emission report. In prior years, the monthly gas usage summed to significantly more than the verified emission reports, which would have asserted about twice as many emissions as were attributed to Glendon. Totals were more comparable in the later years of 2019 and 2020. However, these later years' verified emission reports attributed significantly less gas consumption than was reported to us from annual billings of Keele gas consumption. As an additional cross-check, we examined York's fiscal accounts of gas expenditures, which reflected the quantity of annual gas consumption and not the allocation on the 2019 and 2020 verified emission reports. We therefore prioritized in authority York's annual metered consumption of gas as reported to us in a spreadsheet from the energy team. We discussed this difference with the team, such that about 4M m^3 of metered gas in calendar 2019 seemed to have been omitted from the stationary or steam total identified on the verified emission report. This could not be explained by year-over-year changes in verified consumption by cogeneration, since this was the residual after subtracting its consumption. This annual total of metered consumption was allocated to fiscal years using the same approach as for Glendon, with 1/3 of annual stationary combustion allocated to the fiscal year with the same label, and the remainder allocated to the fiscal year ending in the next calendar year.

Emissions in scope 102 were derived by applying emission intensities per quantity of gas and diesel. We integrated this data with York's annual expenses on gas, and diesel, which are allocated to expense accounts that differentiate between fuels purchased for use by vehicles and fuels purchased to power buildings and the utility plant. This integration of fiscal and physical data helped to assure the quality of our accounting of gas and their emissions. This also allowed us to allocate emissions to fiscal funds.

Through the years covered by this project, York was required to report Federally and Provincially on its emissions from co-generation and stationary equipment at its Keele campus. There was no requirement to report on emissions from the Glendon campus. Data from these reports were integrated into the present emissions database, which compares them to other datasets. Comparisons revealed differences that needed to be reconciled, with several complications. One complication was that different reporting requirements involve different boundary conditions as to what was included, and from which campus. Another complication was that reporting by York in some years differed from its verified emissions reports. Another complication was that different emission intensity factors were used for different legislated reporting requirements. A smaller complication was that reporting and third-party emission verification were done on a calendar-year basis rather than a monthly or York fiscal-year basis. Each of these complications were managed in collaboration with York's present-day energy team.

At the start of this project, York's energy team directed us to use York's web-posted spreadsheets of "energy consumption and greenhouse gas emissions" on the "regulations and reporting" section of York's energy management website. The posted spreadsheets are mandated reports under O. Reg. 507/18 (Broader Public Sector: Energy Reporting and Conservation and Demand Management Plans), made under the *Electricity Act, 1998*. All universities and broader public agencies are required to file these reports and post them publicly, using a government template in the form of an Excel spreadsheet. These spreadsheets attribute a quantity of electricity and gas and other fuels consumed by each building, plus each building's consumption of district heat/steam and cooling energy if it was connected to the district. Each row of the spreadsheet, corresponding to a building or component of a building, is identified with a total floor area and an intensity ratio in units of $ekWh/ft^2$. Each row of the spreadsheet is meant to report on "the total amount of greenhouse gas emissions for the year with respect to each type of energy purchased and consumed in connection with the operation" O. Reg. 507/18 s5(3)7.

When we compared the total gas consumption to York's expenses on gas attributable to the central utilities plant or buildings, and the total emissions relative to total energy consumption, we derived an estimate of 47 kg CO_2E/m^3 which seemed unreasonably high as compared to a typical emission of 1.9 Kg CO_2E/m^3. Upon inquiring with the energy team, we were supplied with third-party Verified Emission Reports for the central utility plant. This helped us to confirm that the published spreadsheets did not include all gas consumed nor the full associated emissions. The "central utilities building" was allocated 0 units of gas consumption. In calendar year 2019, the publicly reported spreadsheet accounted for a total gas consumption of 815,172 m^3 and the generation of 38.5 Kt of greenhouse gasses attributable to Keele and Glendon. In contrast, the verified emissions report for just the central utilities (on the Keele campus) reported 32,365,762 m^3 of gas consumed and 63.7 Kt of greenhouse gas emissions. This verified emissions data reflected the emissions reported federally by Environment Canada for York's Keele campus (Government of Canada, 2022); federal data was found to be available from 2010 to 2020, showing a relatively constant level of emissions from 2010 to 2016 at around 50Kt CO_2E per year. Our assessment was therefore unable to benefit from York's building-specific spreadsheets. Consequently, our most detailed reporting was by fund, with emissions attributed in proportion to expenses.

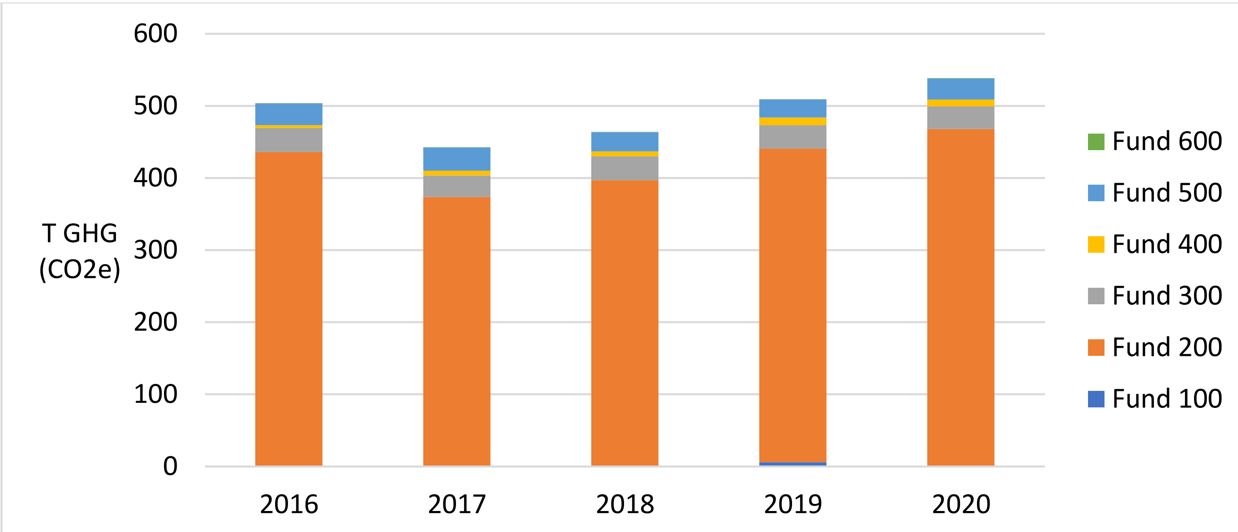
Since our database integrated expense data with gas quantities and emission coefficients, we could attribute emissions to the fund that York used to categorize relevant expenses. However this was challenging to apply to component 102 because gas purchases were not well distinguished between those for the cogenerators and those for other stationary combustion. York's chart of accounts defined account 462000 to be "gas-plant" with the purpose "to record cost of natural gas used for the cogenerators"; logically this would fit with component 101. Account 462100 was described as "gas-laboratory" with the purpose "to record cost of natural gas not used for the cogenerators - e.g. gas used in laboratories"; logically this would fit with component 102. However, in all years, expenses in the former account were significantly higher than the latter, even in fiscal year 2016 when cogeneration consumed about as much gas as other stationary combustion. This discrepancy had no effect upon emissions, but it limited the relevance of attributing emissions in components 101 and 102 by fund.

103: Fuel consumed by York vehicles and mobile equipment (by fund, type of fuel)

York managed and maintained about 60 vehicles for the maintenance of grounds and security. York's fiscal accounts differentiated the purchase of gasoline (account 464000 "vehicle fuel - gas") from diesel (account 464100 "vehicle fuel - diesel"). An account for propane reported no purchases from 2016-2020. We multiplied gas and diesel expenses, on a fiscal year basis, by an average emissions intensity for vehicles that consumed related to average Ontario fuel prices reported by Statistics Canada. We were mindful that York might have purchased fuel more cheaply than the average consumer, such that it obtained more fuel per dollar than an economy-wide average. We obtained a sample of diesel receipts from one fiscal year, which varied throughout the year but averaged surprisingly close to the Ontario retail average. We used annual average prices since we did not have monthly fuel consumption data. Results are presented in Figure 5.

Gasoline purchased from York would have also been used to power combustion engines in non-vehicle equipment, such as lawn mowers, trimmers, and snowblowers. These typically burn fuel at lower emissions efficiency than in vehicles, but presumably York used them much less frequently. As of 2018, Campus Services and Business Operations was on its way to replacing all such equipment with electric alternatives (York University YFile, 2018). The future electrification of fuel-powered equipment and vehicles will increase emissions captured in scope 101 (York-generated electricity) or scope 201 (grid-purchased), but those increases are likely to be less than the corresponding reductions in scope 102 since grid-purchased and York-produced power is more efficient than internal combustion engines.

Figure 5: Scope 103 emissions per fiscal year from fuels consumed by York vehicles and equipment, by fund. Emissions are reported in tonnes of carbon dioxide equivalent (CO2e).



Scope 2: Indirect emissions from purchased electricity (by fund, campus)

Scope 2 accounts for emissions embodied within the electricity that York purchased from the electrical grid in Toronto/Ontario, and with a very small amount in Costa Rica for its campus in that country.

York purchased electricity from Toronto Hydro for its Keele and Glendon campuses. Toronto Hydro distributed electricity that was generated through a mix of grid-connected suppliers, which we assumed to be representative of the Ontario average. From 2016-2020, about 60% of Ontario's grid electricity was generated by nuclear power, about 25% from hydroelectric power, and a varying mix of fossil-fuelled combustion and carbon-free renewables (Statistics Canada Table 25-10-0015-01, 2022a). The generation mix varied by month, with up to 17% of generation sourced from carbon-emitting sources in the summer months to a low of about 3.6% in the spring and autumn (ibid). Greenhous gas emissions per unit of electricity generated in Ontario was derived by dividing total emissions from electric power generation in Ontario by the quantity of electricity generated (Statistics Canada Table 38-10-0097-01, 2022b). Emissions were reported annually, whereas electrical generation was reported monthly. We derived annual measures of emission intensity and then adjusted each to a fiscal year equivalence by allocating 1/3 of it to the fiscal year with the same year label, and the remaining 2/3 to the fiscal year ending in the next calendar year. The resulting fiscal measures were applied to the fiscal year quantities of electricity consumed by York, which we derived as was described in section 101.

Figure 6: Scope 2 emissions per fiscal year attributed to Ontario electricity purchased by York, versus intensity of emissions per dollar of electricity purchased. The left axis reports tonnes of emissions of greenhouse gasses in units of carbon dioxide equivalent (CO2e); the right axis reports intensity as Kg of emissions per dollar spent. Emissions attributed to fund 100 and 400 are visibly insignificant but not zero.

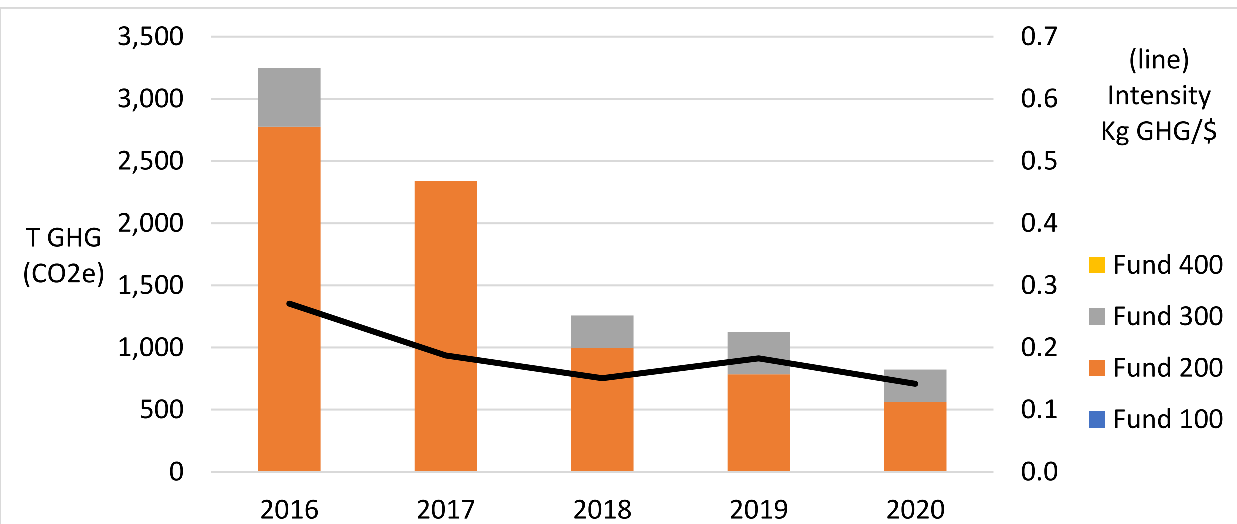


Figure 6 plots the trend in emissions, and emissions intensity, by fiscal year attributed to York's purchase of electricity in Ontario. York's declining scope 2 emissions (represented by bars) reflect a decrease in purchased electricity and a decline in the emissions intensity of grid-supplied electricity (as the line). Overall, York purchased less electricity in the later years when the Ontario grid was comparatively less emitting of greenhouse gasses. The solid line on the graph helps to contextualize this change, showing a fall in intensity with a rebound in 2019 followed by another decline in 2020. In fiscal 2018, electricity was generated in Ontario with almost half the emissions per unit of electricity as it was 2016, which reflected several factors including an increase in emission-free electricity imports from Quebec in 2018 (IESO, 2022). York purchased almost the same quantity of electricity in fiscal 2017 as in 2016, so the decline in emissions of about 30% reflects the reduction in embodied emissions from those purchases. Since York generated its own electricity by burning gas, its self-generated electricity was more emissions intensive than grid-purchased electricity in all years. The difference between the emissions per unit of self-generated electricity and grid-supplied electricity grew over time. York generated more of its own electricity in years when grid-supplied electricity embodied less emissions. In 2020, York's cogeneration of electricity released about 712 grams of greenhouse gasses per kWh, whereas just 26 grams were embodied within an average kWh from Ontario's electrical grid.

York's purchases of electricity (account 461000) were related to one of four funds (100, 200, 300, 400), which allowed us to report scope 2 emissions by fund, on a fiscal year basis. This fiscal data allowed us to also enhance our assurance of scope 2 emissions by comparing our (preferred) quantity-derived approach with an expense-derived approach. For the latter, we divided York's fiscal year purchases of electricity by the weighted average wholesale price of electricity in the real-time market administered by Ontario's Independent Electricity System Operator (IESO, 2023). We recognized that York might not have paid wholesale prices, but at least the trend in wholesale prices were presumed to follow the trends of what York paid to Toronto Hydro. Wholesale prices were reported monthly, so we could easily derive them on a fiscal year basis.

Figure 7 plots the trend in electricity consumed by York by adding self-generated electricity with grid-purchased electricity. The declining height of the bars reflects a decline in consumed electricity. At the same time, York trended towards generating a larger portion of its consumed electricity, as illustrated in Figure 8. Self-generated electricity increased in 2018 upon resolution of "internal York and Toronto Hydro electrical issues" which prevented the co-generators from running continuously in prior years (Internat Energy Solutions, 2020). In a later section of this report, we aggregate scope 2 emissions with components 101 and 102 to report on emissions related to heating and cooling and lighting of buildings.

Figure 7: Electricity consumed by York, in MWh by fiscal year.

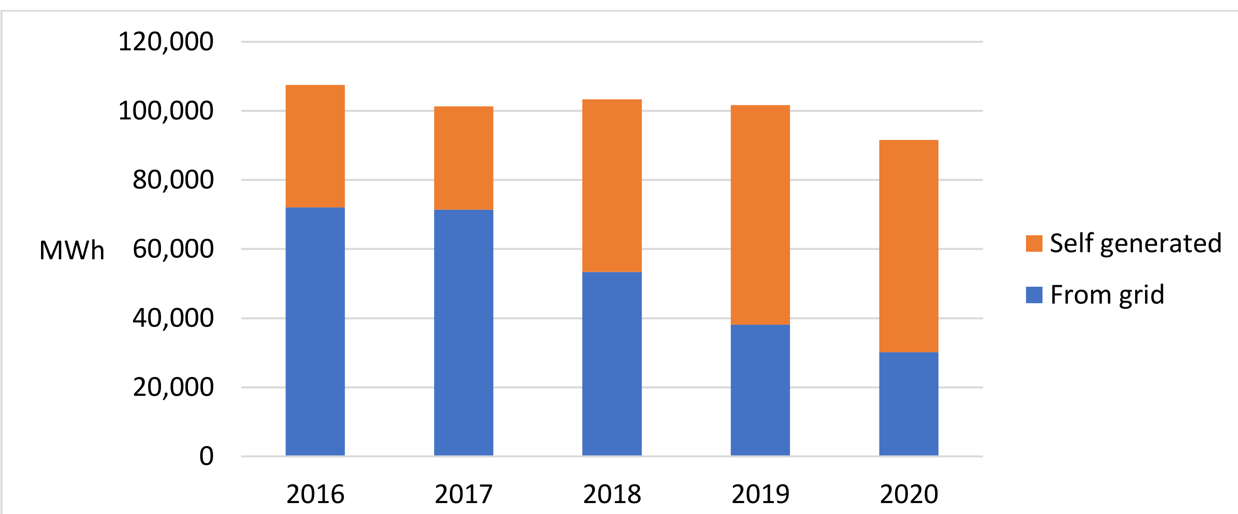
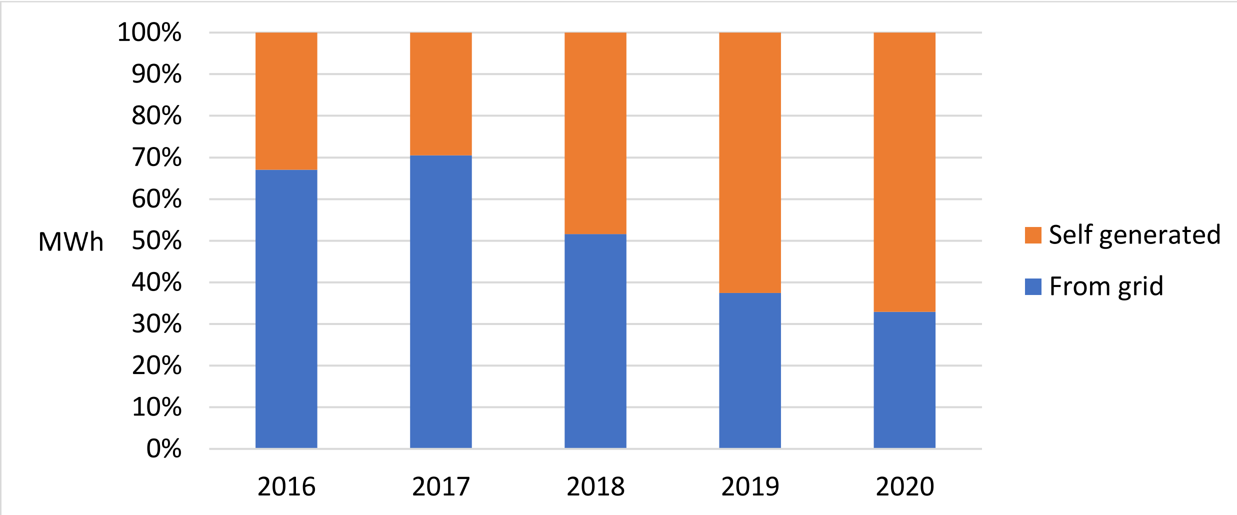


Figure 8: Proportion of electricity consumed by York that was self-generated versus from the electrical grid.



York also purchased some electricity from outside of Toronto. The associate director of the Las Nubes EcoCampus informed us that in 2020, York purchased about 2.5MWh of electricity to power the Lillian Meighen Wright Centre on the Las Nubes EcoCampus in Costa Rica. In that year, about 99.8% of the country's generation mix was from renewable sources; in 2015, about 99% was renewable (International Energy Agency, 2022). We did not request additional data about York's electricity purchases in Costa Rica since the very-low emission-intensity and York's low level of consumption generated relatively insignificant scope 2 emissions. We were not provided with data about York's purchase of electricity from other utilities in other jurisdictions related to other campuses/leases.

Scope 3: Indirect upstream emissions

Scope 3 is a broad category that aims to account for emissions related to the full "value chain" of York's interactions with other enterprises and its staff and students, through purchases, commuting, and the use of York-owned assets. Emissions in this scope can be further qualified as being either upstream, from York purchases and reimbursements and from commuting, or downstream from non-York entities using York-owned assets, including commercial activities on campuses and the returns from York investments. The Greenhouse Gas Protocol asserts that scope 3 is an optional reporting category that typically accounts for more emissions than scope 1+2. We applied emission intensities from Statistics Canada to estimate the emissions embodied within goods and services that York purchased or reimbursed and which were sold on campus. This was our best approximation to follow the logic of the Greenhouse Gas Protocol equating an entity's scope 3 emissions to be equivalent to the sum of scope 1 plus 2 emissions of the enterprise's upstream consumption.

National emission intensities from Statistics Canada (Table 38-10-0098-01, 2022c) were used to estimate the emissions embodied within York's purchase of goods and services, apart from those related to mobility (air or ground travel and commuting), waste diversion, and investments. Statistics Canada publishes annual national average energy and emissions intensities attributable to 109 sectors covering business services, government, and non-profits serving households. Statistics Canada did not publish these on a provincial basis; we inquired about ordering a custom run of provincial (Ontario) intensities, but they declined to quote us a cost of obtaining this data presumably because it did not exist.

Statistics Canada accounts for economic sectors in a hierarchical system related to the North American Industrial Classification System (NAICS). We compared these to York's Chart of Accounts that described the intended purpose of each York account, who can use the account, and an account category that signals who controls it or whether it relates to a specific policy. In our database we created an interactive form to ease the matching of over a thousand York accounts used from 2016-2020 to one (or more) sector(s) out of the list of 109 from Statistics Canada. We setup the database to be ready to accommodate additional York accounts and changes in economic sectors, to help with future uploads of data from either. We did not ask York Finance for any expenses related to salaries or wages and benefits, since labour payments are not attributed with greenhouse gas emissions. Humans exhale carbon dioxide but this is not included in emissions accounting.

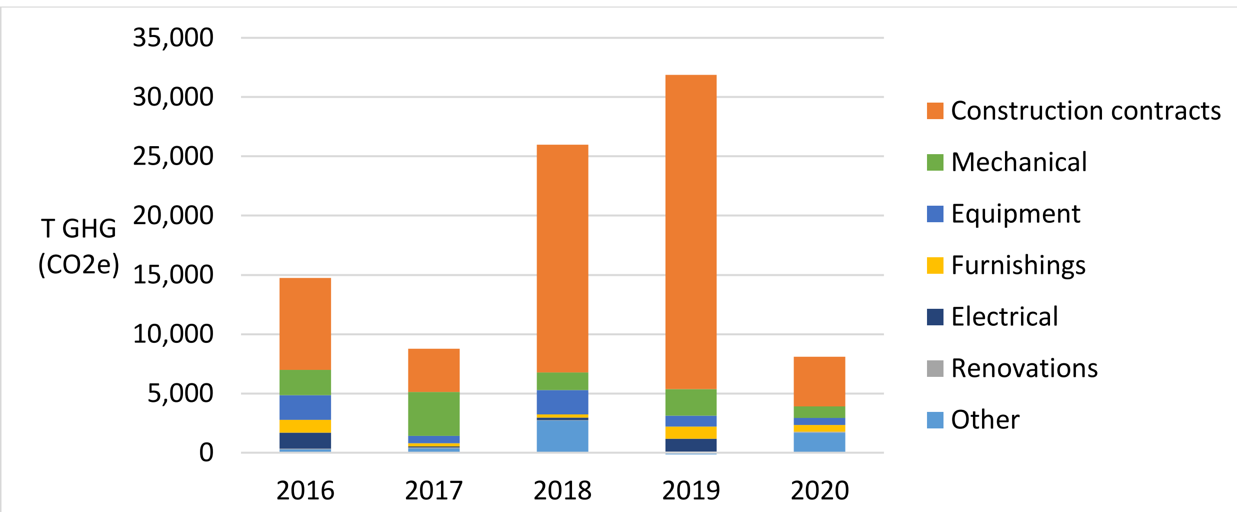
National emission intensities from Statistics Canada measure the sum of direct plus indirect energy or emissions attributable to each dollar of output, averaged across all enterprises within that sector. Indirect energy or emissions reflect the energy or emissions attributable to that sector's output from its purchases of inputs from other sectors. These interrelationships reflect inter-sectoral Input-Output relationships tracked by Statistics Canada as part of its economic accounts. This data enabled us to estimate emissions embodied in the supply chain from York purchases, but with the limitation that these intensities are sectoral averages. This limitation means that we could not account for the potential of York to have purchased goods and services from suppliers with better-than-average emissions.

We equated Statistics Canada's definition of direct emissions to be equivalent to Scope 1 emissions in the Greenhouse Gas Protocol. We inferred that Statistics Canada's measurement of indirect emissions is equivalent to Scope 2 emissions (from grid-purchased electricity) and upstream Scope 3 emissions without commuting. Commuting emissions would only be included in Statistics Canada's measure of a sector's emissions to the extend that the sector purchased commuting fuel or reimbursed employees for their commuting costs. This may be done in some sectors but is not a general practice. We also inferred that Scope 3 downstream emissions were not included in Statistics Canada's intensities, since they are instead allocated to the output of the downstream sectors.

301: YorkU capital expenses (fund 700) (by account)

From 2016-2020 York added to its stock of durable (capital) goods by constructing new buildings, undertaking major renovations to existing buildings, purchasing equipment and furnishings, and other activities that were expensed as fund 700. Fund 700 is termed "capital" in the York Chart of Accounts, to record "major capital expenditures of the university, capital expenditures issued via Facilities Service Requests, internal and external funding of capital projects". We considered all fund 700 expenses as capital, without adjusting for expenses that we felt did not fit the definition, such as some small amounts of hospitality, postage, printing and other consumables which we found to have been allocated to fund 700. By considering all fund 700 expenses within category 301, we excluded any fund 700 expense in other scope 3 categories to avoid double-counting.

Figure 9: Scope 301 emissions per fiscal year attributed to major capital expenses (fund 700). Emissions are reported as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).

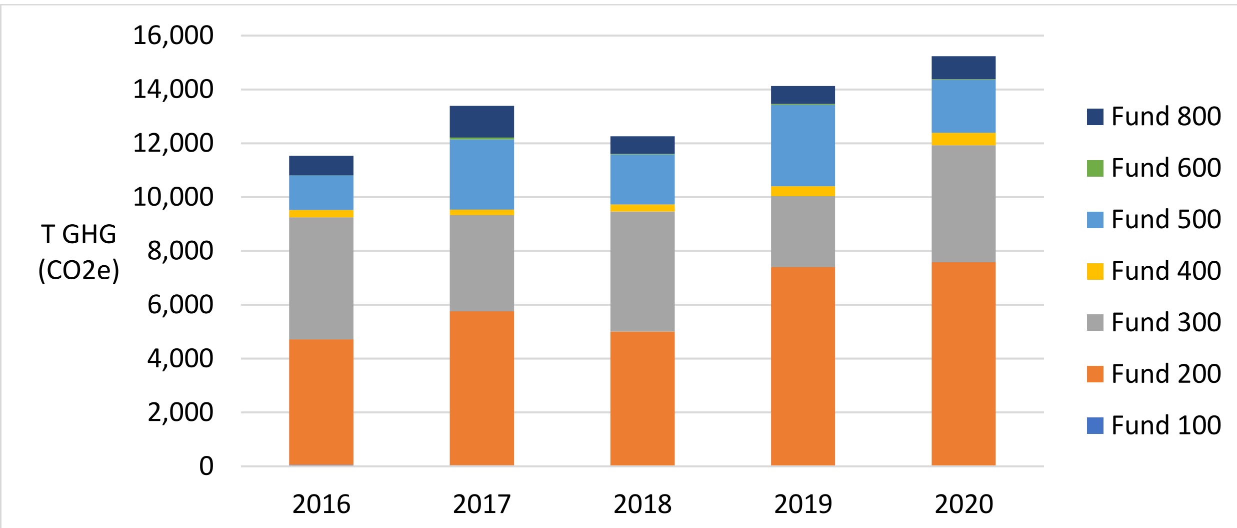


In all years, the largest and most variable fund 700 expenses were construction, which we matched to the average Canadian emission intensity for sector BS23B00: non-residential building construction. As another example, we matched computer equipment purchased by York through accounts 486600 and 482600 (for equipment under, or over $20,000, respectively) to BS33410: computer and peripheral equipment manufacturing. Thereafter we multiplied the sector's emission intensity (GHGs per dollar) by the total expense within the fiscal year. Financial accounting amortizes costs over many years, whereas emissions are attributed to new capital in the year in which it was manufactured or constructed. We attributed emissions to the year in which the expense was made. Figure 9 illustrates the trend in emissions allocated to capital expenses, in categories that we created to aggregate common purposes.

302: YorkU repair and maintenance (by fund, account)

York spent between $30-$40 million annually to repair its stock of buildings and the equipment it owns. We assigned to scope 302 all expense accounts that related to repair and maintenance and which were not allocated to fund 700. This ensured that we did not double-count any expenses which were already allocated to category 301. Without this clear distinction, we would have been challenged by many account names and descriptions that could be considered as capital or repair, such as “major renovations” (York account 439100). York’s Chart of Accounts categorizes the “major renovations” account to contain “repair & maintenance expenses” although there were expenses in this account allocated to fund 700. Most of the expenses allocated to category 302 were matched to either, or both, of the economic sectors “repair construction” (BS23D00) and “repair and maintenance” (BS81100). These sectors had similar emission intensities throughout the five years.

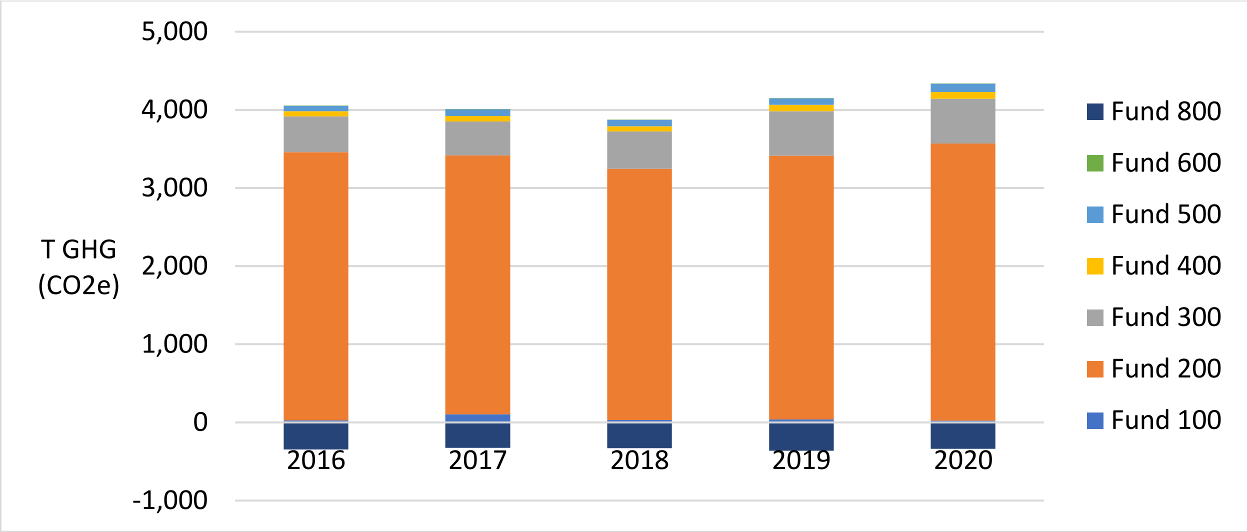
Figure 10: Scope 302 emissions per fiscal year from York expenses on repairs and maintenance, by fund. Emissions are reported as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).



303: YorkU leases of buildings, equipment, software (by fund, account)

York rents some of the space it uses (especially at its non-core campuses) and rents equipment including vehicles that it uses but does not own. Emissions related to expenses in this category can therefore be summed with those related to York’s ownership of capital goods. This category 303 includes computer software licenses. Software purchases were allocated to category 301 whereas software license fees including the institutional subscription to Microsoft Office were included in this category 303. Each account was matched to its relevant economic sector, with a common matching being to “lessors of real estate” (BS53110) and “rental and leasing services and lessors of non-financial intangible assets” (BS53B00). In every year York’s expenses included negative expenses on “building space” allocated to fund 800, which was not otherwise used or described. We included this in the figure, and in the rollup of emissions, assuming that the negative expense offset a positive expense.

Figure 11: Scope 303 emissions per fiscal year from expenses on leased space, goods, and software, by fund. Emissions are reported as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).



304: YorkU air travel (by person-type, seat class, distance flown)

This component accounts for emissions related to airfare expenses, which were tracked by expense accounts that differentiate between faculty, staff, students, and "other" meant to relate to visitors who do not have a staff or student number. Figure 12 plots emissions attributed to airfare paid by York, based on a sample of reimbursements that identified the seat class, departure and destination cities, amount reimbursed, and type of person who was reimbursed. Figure 13 plots the same data as a proportion of the total, which reveals that first-class/premium was a relatively small portion.

Figure 12: Scope 304 emissions per fiscal year from airfare paid by York, by category of person. Emissions are reported as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).

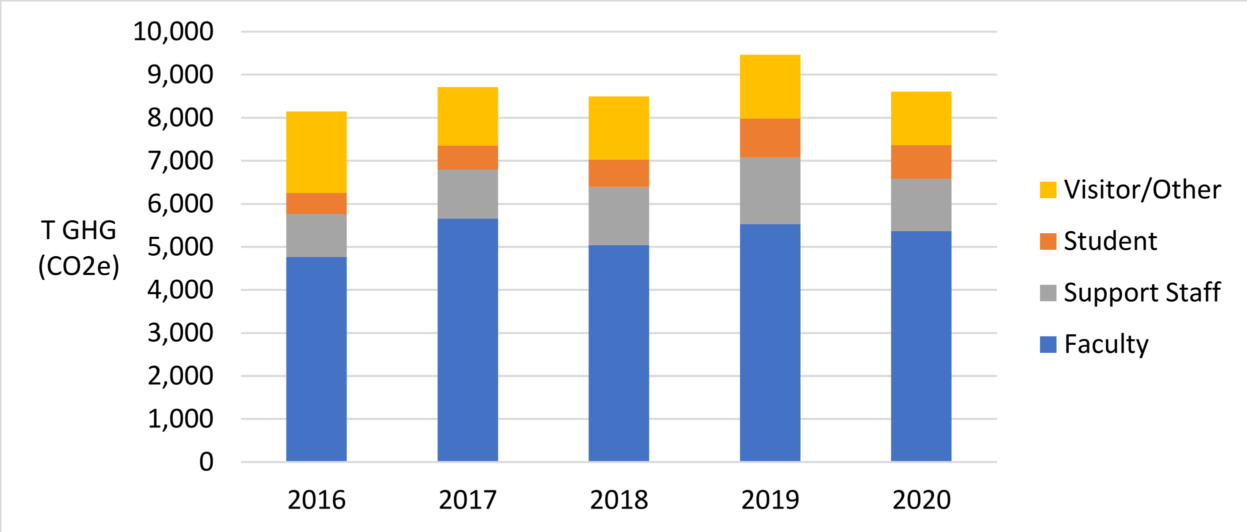
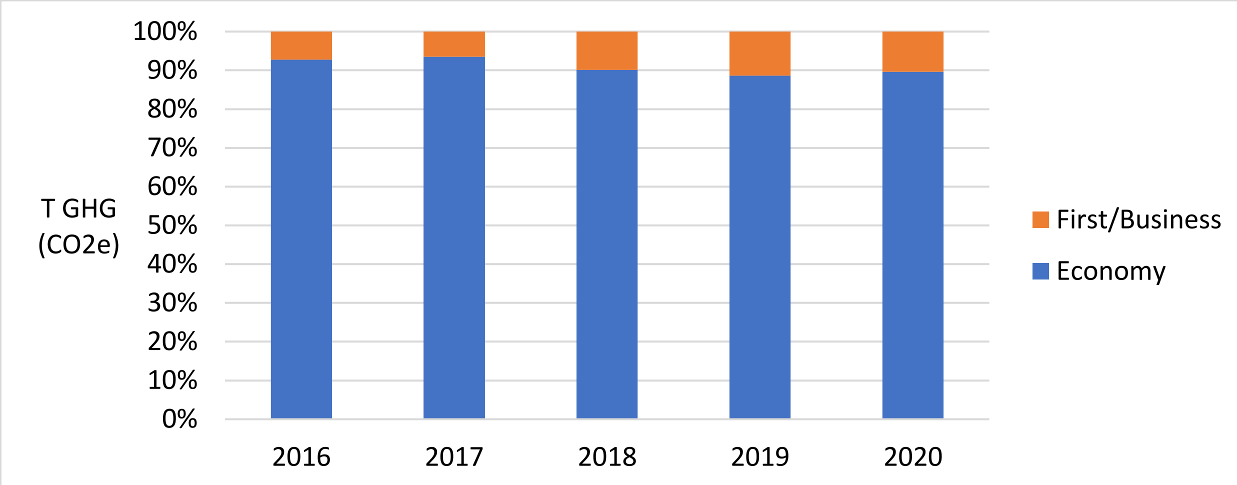


Figure 13: Proportion of scope 304 emissions attributed to airfare seat class, per fiscal year.



Air travel emissions are a function of the type of jet, its altitude, length of flight, whether the flight is direct or part of a multi-stop journey, and the occupancy/density of travellers which relates to available seat classes. We therefore tried to factor in as many of these variables as were available from York's travel data. More emissions were allocated to travellers occupying a premium/first-class seat rather than an economy seat, since each first-class seat occupies more area in the aircraft than each economy seat. Flight emissions were derived from the distance travelled, such that short-haul flights are attributed more emissions per distance than long-haul flights which are attributed more emissions than medium-haul flights. Multi-leg flights were attributed more emissions than single-leg flights. We therefore sought as much detail as possible about York flights since a simple tally of aggregate expenses within a year was not sufficient for a robust estimate.

From 2016-2020 most airfare expenses were submitted for reimbursement through Concur. We were provided a dump of over 23,000 airfare expense claim records submitted through Concur, with their accompanying report headers. Each record included: report ID, approval status, airfare class (economy or "first/business/other premium"), travel start and travel end dates, transaction date, amount claimed, amount approved, a destination category ("within Canada" or "within continental US" or "outside Canada/continental US") and several free-text fields: report name, travel location(s), departure city, and vendor. We summed the approved expenses by person type and compared them to the corresponding totals from York's account ledger to understand the proportion of expenses that were captured by Concur. We were not provided with any other data related to flight reimbursements that were not made through Concur. Table 3 reports on the proportions of reimbursements made through Concur, with 100% of staff airfare reimbursed in 2020 versus 63% of student airfare in that year and 25% of other. We therefore treated the Concur records as samples and weighted the sample to account for its undercount in each of the assessed years (fiscal 2016-2020). Airfare accounts in the York ledger distinguished between the person travelling but not between the class, so we could not infer whether the Concur records were representative of the seat class. Later we flagged many Concur records with ambiguous or unusable data, thus further reducing the size of the sample of data, and therefore increasing its weighting. This weighting is reported in the right-half of Table 3; for example, we weighted our sample of faculty airfare by 1.4 in 2020 to estimate total kilometers and emissions.

Table 3: Proportion of air travel reimbursements made through concur, by person type. Weighting applied to our sample reflects the reimbursements that were not reimbursed through concur and the proportion of records that had incomplete or spurious details.

	Proportion expensed through Concur				Weighting applied to our sample from Concur			
Fiscal	Faculty	Support staff	Students	Other	Faculty	Support staff	Students	Other
2016	81%	93%	36%	5%	1.7	1.5	4.0	54.3
2017	91%	96%	39%	8%	1.4	1.6	3.5	19.2
2018	99%	100%	42%	15%	1.3	1.4	3.1	8.8
2019	99%	99%	47%	25%	1.4	1.6	3.0	6.4
2020	93%	100%	63%	25%	1.4	1.4	2.1	5.5

The Concur system used by York does not enforce any standardization on its free-text fields related to locations, which it labels as cities and not as the name of an airport. As one starts entering data, Concur assists with a lookup list of common cities paired with their country, but Concur still allows any text to be entered. Many records show that the user didn't accept the suggested name after entering a few characters, leaving it as "toront" as an example or having it simply be "San Jose" without being followed by a comma and the name of the state or country (to distinguish between different "San Jose" cities in different countries). Concur allows a user to select a destination category ("within Canada" or "within continental US" or "Outside Canada/Continental US") independently of the city, such that many records conflicted. Also, there was no Concur field to identify whether a flight was one-way, or part of a multi-stop journey, or a return flight. Also, there was no distinction for an expense claim related to the travel of just one person or potentially related to a group of people whose tickets were jointly reimbursed.

Figure 14: Frequency plot of all airfare reimbursements approved through Concur from 2016-2020.

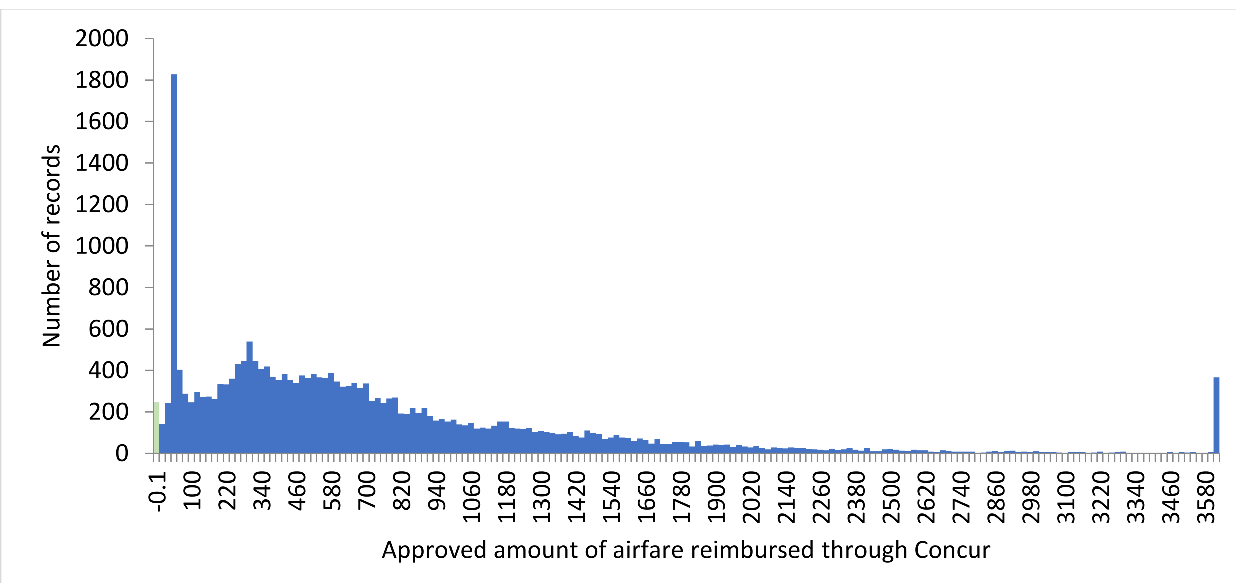


Figure 14 plots the number of Concur transactions for all flights grouped into categories of an approved amount. This shows that most transactions were for very low amounts which we inferred as incidental fees for which we did not attribute any emissions. Transactions in the range of $300-$320 were more common than higher-priced reimbursements, but there were some very high-priced reimbursements that reflected a combination of the high cost of a seat and the possibility that multiple seats were reimbursed (purchased) on a single ticket transaction.

These complications challenged us with a tremendous amount of work to interpret and clean the data to derive meaningful insights into York's reimbursed flights, so that we could estimate their corresponding emissions. We also encountered a surprising number of reports with nonsense travel locations ("travel", "registration fee"), highly ambiguous locations ("Africa", "United States"), conflicts between the destination category and the destination city, and the same city listed as the origin and destination (typically Toronto). Therefore we rejected many Concur records, to settle upon a logical sample that we amplified to cover the rejected records. Table 3 identifies the resulting weighting applied to the sample.

Our data cleaning and standardization process involved many steps:

- We obtained a database of world cities (REF) and another of georeferenced world airports (REF), and linked the two, to identify whether city names were unique, or shared, and therefore whether city names are prone to being mismatched.
- We created a master list of unique departure or destination cities from the Concur data and linked them to the related world cities and airports if they matched to unambiguous locations.
- We manually linked unmatched Concur cities, in decreasing order of their share of reimbursements so that we focussed our effort on more empirically significant records.
- We resolved ambiguous Concur cities based on other accompanying data.
- We flagged departure or destination cities that were multiple cities; e.g. "Halifax/Paris".
- We asserted a Pearson Airport (YYZ) departure for departure cities in the Greater Golden Horseshoe that did not have their own airport (e.g. Ajax, Oakville, Port Hope, Etobicoke, Vaughan, Whitby, etc.) which seemed to reflect travel reports with the departure city as the traveller's home city.
- We flagged transactions described as travel insurance, baggage fees and other incidentals.
- We flagged transactions that were under $100 on the assumption that they were incidental even if there was no mention of "baggage" or "insurance" or "incidental" or "meal".
- We flagged transactions that were reported as cancelled flights/conferences, so that we would omit them in the calculation of emissions.
- We used a ratio of dollars expensed per air kilometers travelled to identify potentially questionable matchups that were very high or very low.
- We coded the number of non-incidental records per claim to deduce multi-stop/person trips.
- We selected the median transaction of common pairwise travel routes as a presumed return trip as a $/air-km reference applied to the sum of all expenses on that route, to derive total air km.

Since we established the code and queries to automate as much airfare data as possible, we anticipate that additional Concur records in future years could be much easier to process. Recurring city/state/country combinations will automatically follow the same logic used on this initial Concur sample, so we anticipate less manual processing for additional records in the future. When transactions were related to a unique person ID, and when we investigated some to understand ambiguities or problems with our semi-automated processing, we found that data inputters tended to be consistently good, or weak, in supplying useful and standardized information. Perhaps if some of the claimants were prompted to resolve questionable records, they would be nudged to improve their future data entries.

Figure 15: Distribution of single-flight economy airfare between Toronto and Ottawa reimbursed by York through Concur from 2016-2020. Values in bracketed ranges are nominal Canadian dollars.

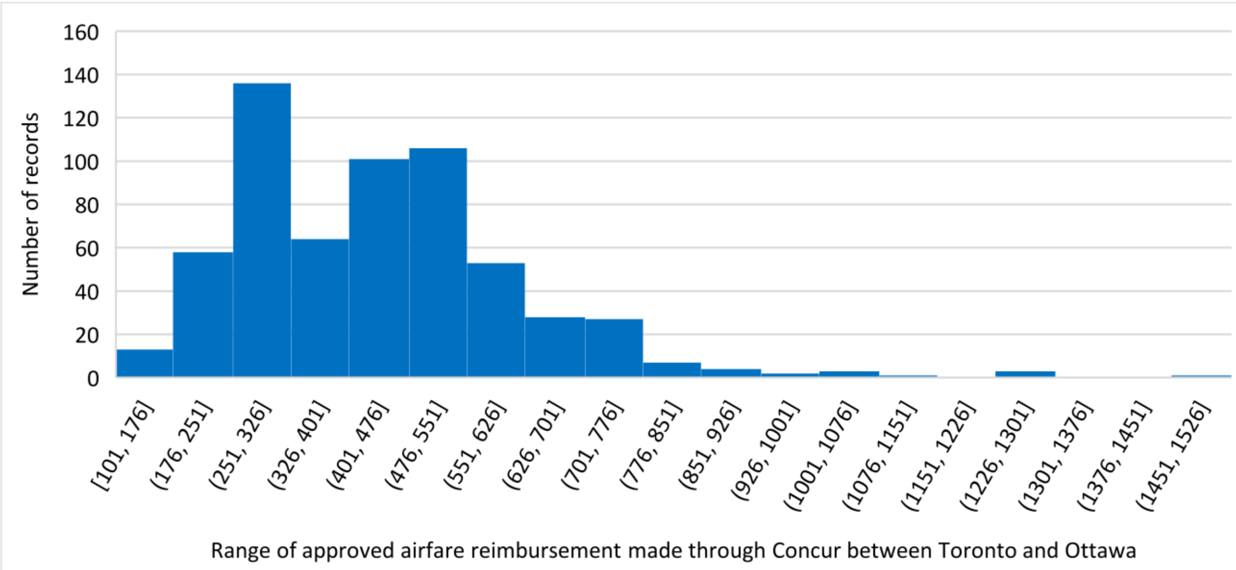


Figure 15 is a frequency distribution of all (cleaned) economy airfare reimbursements between Toronto and Ottawa that were not part of a multi-airfare-transaction or multi-city trip. This pair of cities was the most common among all Concur transactions we were provided. Note that some transactions were incredibly expensive, likely reflecting multiple flights (for multiple people) which were reimbursed through one Concur transactions, potentially related to a team visit to Ottawa. Some flights were surprisingly cheap, while most were clustered in a reasonable range considering seasonal variability in pricing and potentially whether the traveller purchased the ticket in advance or at the last minute. This shape of a distribution was common with other frequent destinations, such as to Montreal, Vancouver, New York, and Heathrow. This presented us with the challenge of deducing the number of persons that would have flown on all routes, thus the total kilometers by person and class.

Over 700 airfare transactions were reimbursed for travel between Toronto and Ottawa with just one (non-incidental) transaction in the report. Theoretically these were the most likely to be return trips. Arranged in order of approved amount, the median transaction was $426.54, thus reimbursed at the rate of $1.17/km for the one-way air-arc distance of 364km between airports YYZ and YOW. In 2022, Google reported that economy flights to Ottawa usually cost $255-$700. The most expensive Concur transaction was a 2016 faculty reimbursement of $1487 (or $4.09/km) followed by a visitor/other reimbursement at $1436 ($3.94/km). These could have reflected multiple seats on a single transaction, such as three persons travelling at the median rate. Possibly these transactions could have been a single person on business travel that was incorrectly inputted into Concur as economy, although the reimbursement would have been more expensive than all of the business-class Concur records (which were reimbursed at rates between $2.21/km and $3.50/km). High-priced economy transactions could have been a very expensive economy flight, although we suspect this to be unlikely since Google in 2022 revealed that a maximum economy price of about $1000 for a single-day return on the Saturday of a busy Family-day weekend. At the low end of economy flights between YYZ and YOW, a single transaction of $100.59 was reimbursed to a faculty at the effective rate of $0.28/km. This cheapest transaction could have been a single-way flight, with the return trip completed through a different concur reimbursement report or by another means such as by train or driving, or it could have been a very cheap return flight. We were thus faced with the challenge of how to derive total person-km air travel: should it be derived from the value of all expenses or from the number of reimbursements? When we applied both approaches, results differed by just 2%, reassuring us that it would be reasonable to presume that all Concur reports with a single airfare transaction were a one-person return flight. Table 4 presents the details used to confirm this finding.

Table 4: Comparison of two approaches to derive person-km air travel between YYZ and YOW airports.

Approach 1: Expense-derived distance flown			Approach 2: Transaction-derived distance flown		
Sum value of all reimbursements	312,782	$	Number of single-transaction (non-incidental) reimbursements	719	#
Median reimbursement rate per km one-way air-arc flight distance	1.17	$/km	One-way distance	364	km
Multiplier assuming median was a return flight	2		Multiplier assuming all transactions were for a return flight	2	
Total person_km flown Calculated as $ / $/km x multiplier	534,670	km	Total person_km flown Calculated as # x km x multiplier	523,432	km
Difference in total person_km between two approaches: 2.15 %					

Air travel emissions are a function of the type of jet, its occupancy, its length of flight, whether the flight is direct or part of a multi-stop journey, and the seat class. From the cleaned sample, we could derive the seat class, length of the flight, and whether the airfare reimbursement was unique in the report (after ignoring presumed incidental fees such as for baggage and seat selection). This information was sufficient to derive a sampled estimate of emissions, with coefficients related to the flight distance and seat class. We settled upon an approach to assume that Concur reports represented a return flight if they had just one airfare transaction, after excluding incidental transactions such as one or more baggage fees in addition to the ticket fee. Most Concur reports were of this type, totalling about 16,600. Concur reports with multiple (non-incidental) transactions were presumed to represent single-seat single-leg transactions, affecting about 5000 transactions. Transactions with a very expensive reimbursement rate ($/km) were manually investigated to deduce whether the transaction should be presumed to represent more than one seat. One exceptionally large transaction was investigated by York's Comptroller who revealed that it reflected the reimbursement of over a dozen seats for a team which travelled together and whose flights were reimbursed through one expense report.

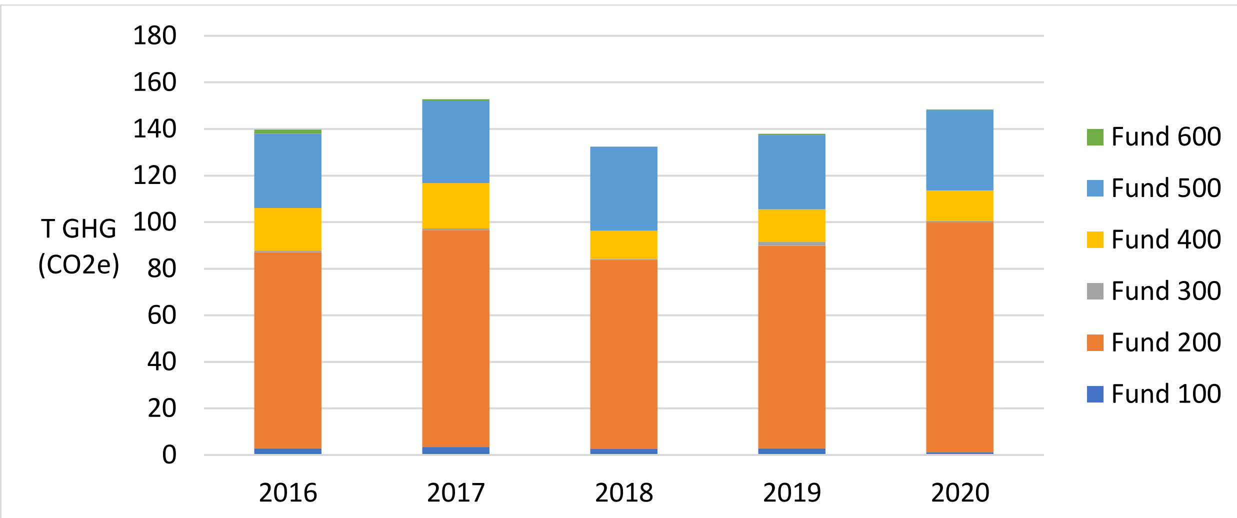
We concluded our assessment of Concur data by omitting ambiguous records, such that the analysis of unambiguous records were amplified to cover the difference. We setup the database in such a way that when ambiguous transactions are manually investigated and resolved to become unambiguous, their effects would automatically generate a cascade of revisions to the sample size and weighting. To the extent that the same departure or destination city is used again in a future transaction, its geographic attribution will be automated through a lookup of a master list that we developed and calibrated.

There is a global interest in minimizing the carbon associated with air travel, including through carbon offsets. Google currently identifies estimated emissions next to competing flight options, with notable differences based on the make/model/size of the aircraft and whether the trip is direct or with a stopover. Many websites have devised user-friendly forms to deduce emissions by allowing users to type in either the airport code or name or city, with the potential of multiple legs for connecting flights or multi-city/country journeys. The International Civil Aviation Organization (ICAO) now offers an Application Programming Interface (API) for their calculator so that any website in the world could be built to interface with ICAO data and assumptions. These developments could potentially be used by York to inform its flying faculty and staff and students, either before flying or afterwards.

305: YorkU reimbursed mileage (by fund, person-type)

Emissions were attributed to mileage that York reimbursed at the rate of $0.45/km. We derived Kilometers driven from total reimbursements, by fund, and multiplied this distance by the average emissions intensity of vehicles in that year. Figure 16 plots the results by fund.

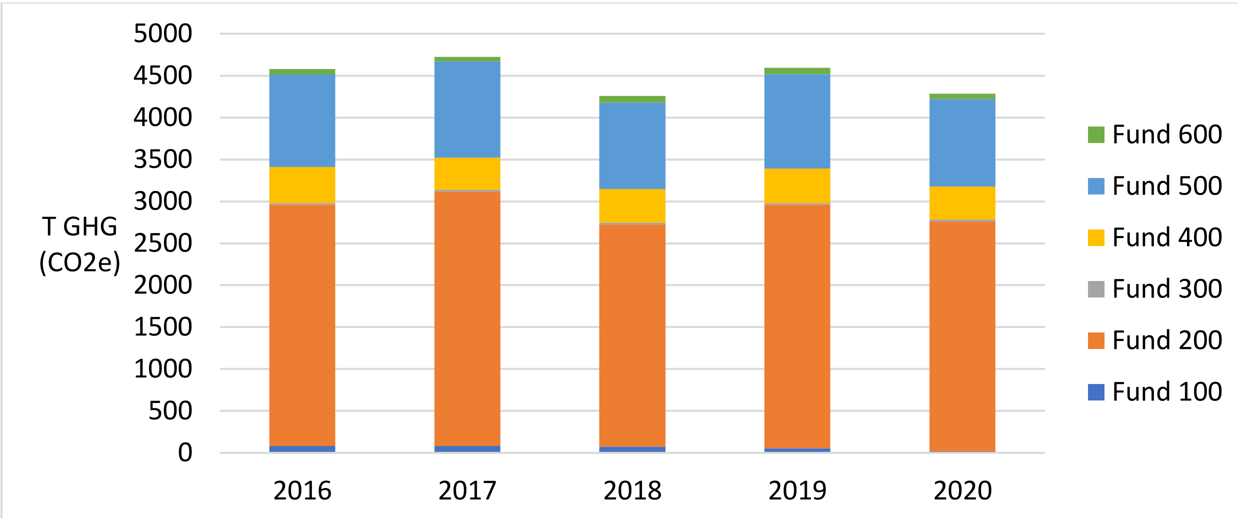
Figure 16: Scope 305 emissions per fiscal year from mileage reimbursed by York, by fund. Emissions are reported in tonnes of carbon dioxide equivalent (CO2e).



306: YorkU other travel expenses (by fund, account)

About $13 million was expensed annually by York on hotels, accommodations, and ground travel in accounts that amalgamate these activities. We applied general Canadian emission coefficients to the value of expenditures, by matching York's accounts of "hotel/accom/food" and "guest amenities" to the economic sector "accommodation and food services". York's accounts of "transportation (guests & cater)" were matched to the economic sector "transit, ground passenger and scenic and sightseeing transportation, taxi and limousine service and support activities for transportation". York's expenses to relocate faculty and staff and students were included in this category and were matched to the average of the emission intensities from "warehousing and storage" and "truck transportation". Figure 17 plots the emissions attributable to these other travel expenses, revealing a relatively constant sum.

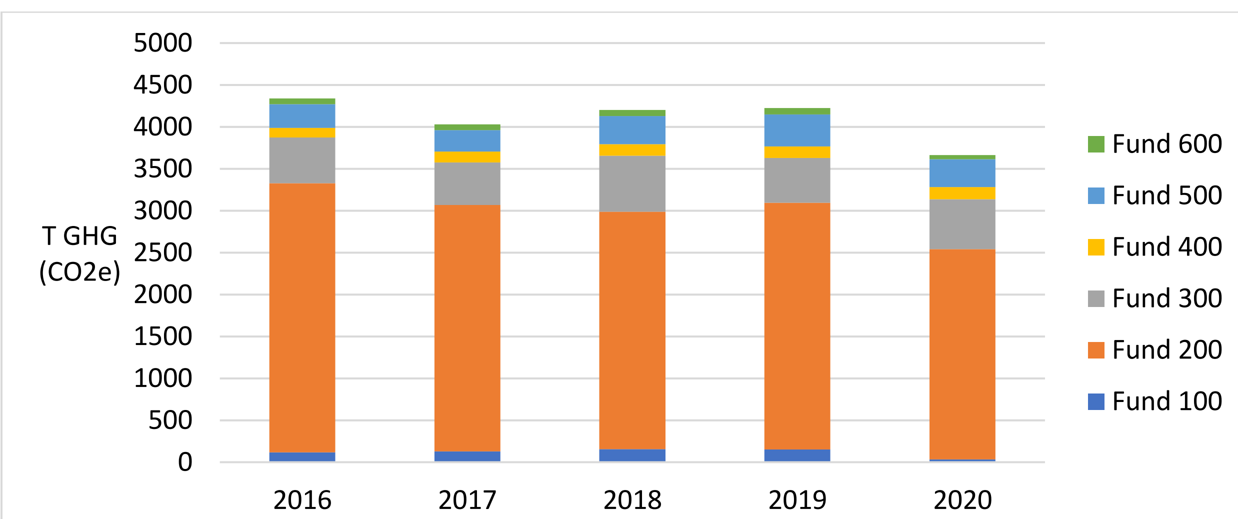
Figure 17: Scope 306 emissions per fiscal year from other travel expenses reimbursed by York, by fund. Emissions are reported as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).



307: YorkU purchased hospitality including food (by fund, account)

This category accounts for emissions related to York's expenses of about $10 million annually on hospitality and up to about $2 million annually in reimbursed conference fees. We related most of the expense accounts in component 307 to the sector "accommodation and food services" BS72000. We averaged that sector's emissions with "non-profit education services" (NP61000) to derive an estimate for emissions embodied in conference fees. Figure 18 plots the results. We suspect that the drop-off in fiscal 2020 related to the pandemic curtailing hospitality in the last two months of that fiscal year. Prior years had a relatively constant total of emissions attributed to hospitality and conference expenses.

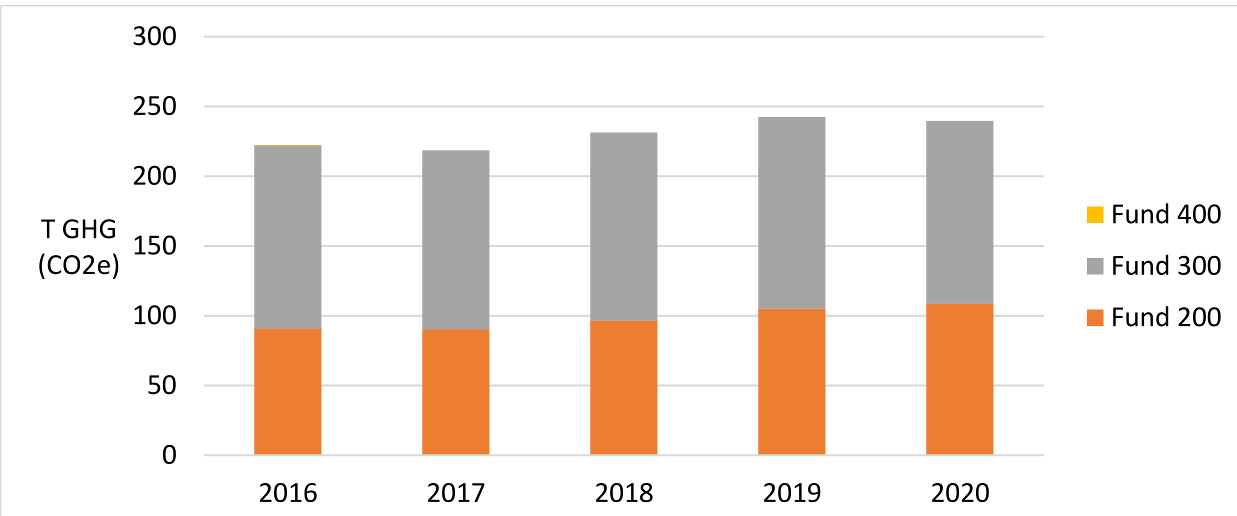
Figure 18: Scope 307 emissions per fiscal year from hospitality and conference expenses paid by York, by fund. Emissions are reported as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).



308: Solid waste collected from campus (net of diversion)

York spent under $1 million per year on waste and garbage disposal, mostly related to ancillary services such as food services and residences, which related to fund 300. We attributed emissions to expenses by using national emissions intensities from the sector "waste management and remediation services". We were also provided with physical information about waste diversion through recycling and organic diversion which we input into the WARM calculator from the Environmental Protection Agency (2021). Their calculator attributed emissions to landfilling and averted emission to recycling and diversion of organics as either composting or anaerobic digestion. Emissions from York's expenses on demolition were not included in this component; emissions from demolition were allocated to component 301 since they were attributed in the general ledger as a fund 700 expense. Results are plotted in Figure 19.

Figure 19: Scope 308 emissions per fiscal year from solid wastes managed by York, by fund. Emissions are reported as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).

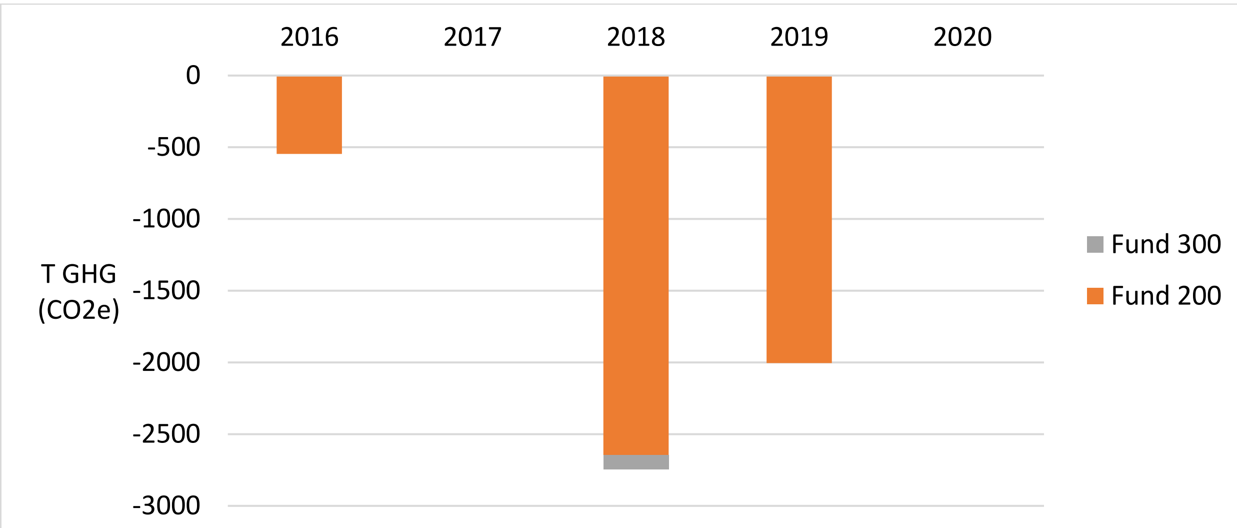


309: YorkU carbon offset purchases (by fund)

This component attributes emission reductions to York's purchase of carbon offsets. York's purchases were relatively small and irregular from 2016-2020 but we included this category to highlight its existence and its potential to be used more frequently in the future. Carbon offsets are a verifiable and exclusive claim to a reduction of carbon dioxide from the atmosphere, or a reduction in emissions that would have happened in the absence of the offset. Reductions can be achieved in many ways, such as by afforesting previously non forested landscapes, reducing fugitive greenhouse gas emissions, and by replacing carbon-intensive processes with low- or no-carbon alternatives. Offsets can be purchased for domestic or offshore activities, with their reduction in carbon counting equally anywhere on the planet since global warming relates to the global concentration of greenhouse gasses. Since carbon offsets withdraw carbon dioxide from the atmosphere, we measured them as negative emissions.

We discovered that York account 457400 was named "carbon offsetting" which was described with the purpose "to record the purchase of carbon emission credits". To convert expenses from this account to emissions, we needed a reasonable estimate of the purchase price of offsets. We had no sample of transactions from this account, so we queried Less.CA which sells offsets by the tonne and is a reputable Canadian offsetting enterprise that is the official provider for Air Canada. Various accounting and verification standards have emerged to qualify the confidence and permanence of offsets. In 2022, Less.ca sold CSA-standard-certified Canadian offsets for $20/Tonne and gold standard-certified international offsets at $24/T. We assumed that York could have purchased these Canadian offsets, and we assumed that its price would have changed from 2016 to only reflect changes in the growth of Canadian CPI. We divided offset expenses by our assumed offset price-path to estimate the quantity of emissions reductions that could reasonably be attributed to York's purchase of carbon offsets.

Figure 20: Scope 309 negative emissions per fiscal year attributed to carbon offsets purchased by York, by fund. Emissions are reported as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).

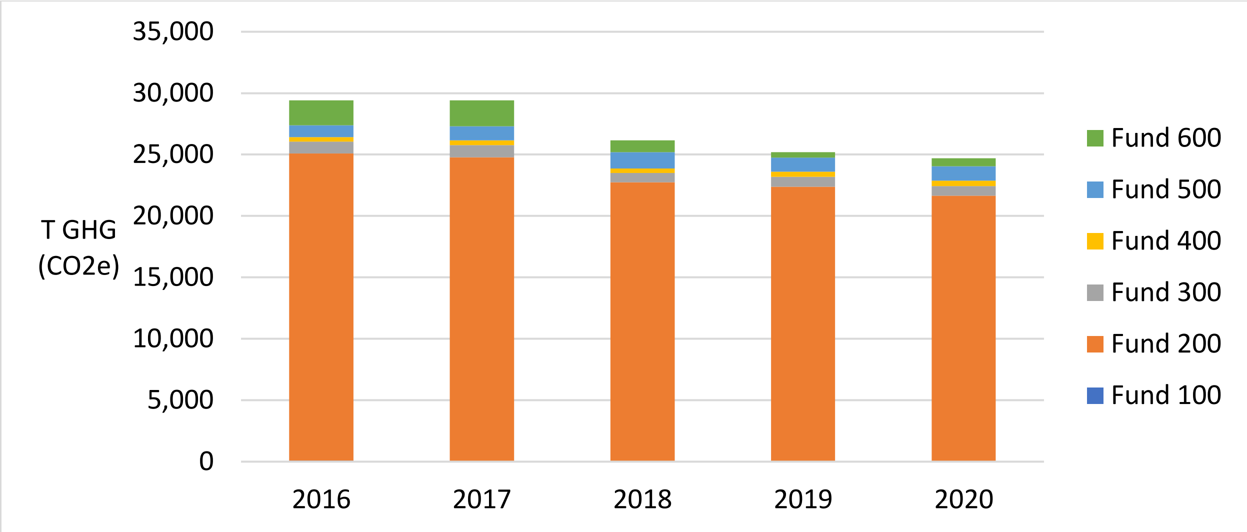


When we queried the purchase of offsets, we noted a surprisingly large expense in fiscal 2020: $1.2 million. This was significantly more than prior years' expenses. A deeper inquiry through York's comptroller revealed that this total was a single transaction related to York's payment of a carbon tax in fiscal 2020. In our opinion, that tax payment should have been allocated to a different account, so that York's carbon offset account can remain true to its stated purpose. Figure 20 omits that transaction.

310: YorkU other goods and services purchased (by fund, account)

This category attributes emissions to all York expenses or reimbursements that were not allocated to other categories, and which we did not deliberately exclude. Included in this category is insurance, advertising and promotion, and payments to external legal professionals. We excluded all expenditures that were labelled as transfers ("Transfer" or "Tsf" or "Trf") or waivers or payments on financial liabilities (including all labelled as "debenture" or "interest" or "debt" or "amort"). York's direct expenses on labour were also excluded from consideration. Emissions were not indirectly attributed to York's labour expenses because Statistics Canada's emission intensities do not attribute emissions to labour. When York purchases consulting services, the attributed emissions from Statistics Canada will cover the emissions embodied in the non-labour inputs such as energy, paper, and the use of office space, and not any measure of the exhaled greenhouse gas emissions from the employed workforce.

Figure 21: Scope 310 emissions per fiscal year from other purchases made by York, but fund. Emissions are reported as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).



311: Commuting to campus by driving (by postal code, campus, category of person)

This component attributes emissions to the distances driven by York parking permit-holders and an estimate of distances attributed to pay-per-use parking on York's Keele and Glendon campuses. This component includes emissions attributed to carpoolers. York's Parking team supplied us with the number of regular, and continuous, permit-months purchased by category of person, by Forward Sortation Area (FSA), which is the first three digits of a postal code. We were also supplied with records of the number of "diamond permit" holders, which is a permit that could be used by two vehicles to provide added flexibility for potential carpooling. Permit holders were categorized as one of 17 types, including as a student or staff or faculty of Keele, or Glendon, or Seneca, or one of several other categories of permit holders that include vendors and contractors on campus. Continuous permits were permits that renewed annually and were valid for 12 months of the year; continuous permit holders were only faculty or staff, at Keele or Glendon. We were also supplied with pay-per-use transactions, which we attributed to FSAs in the same proportion as parking permits.

Figure 22 presents the emissions attributed to the total kilometers that we estimated based on an assumed frequency of commuting the most time-efficient route. Assumed frequency of commutes are detailed later, with a discussion of the sources and methodology employed, and caveats. Since total emissions reflected distances and the number of drivers, it was interesting to explore the integrated effects of both. Although York had many commuters travelling far distances, their share was proportionally lower, such that the highest emissions were attributed to commutes that geographically close to York's Keele campus. Our database allows for detailed breakouts, including emissions attributed to an originating FSA postal code and the type of person and their campus destination.

Figure 22: Scope 311 emissions, and km travelled, per fiscal year from driving to campus and parking. Emissions are reported as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).

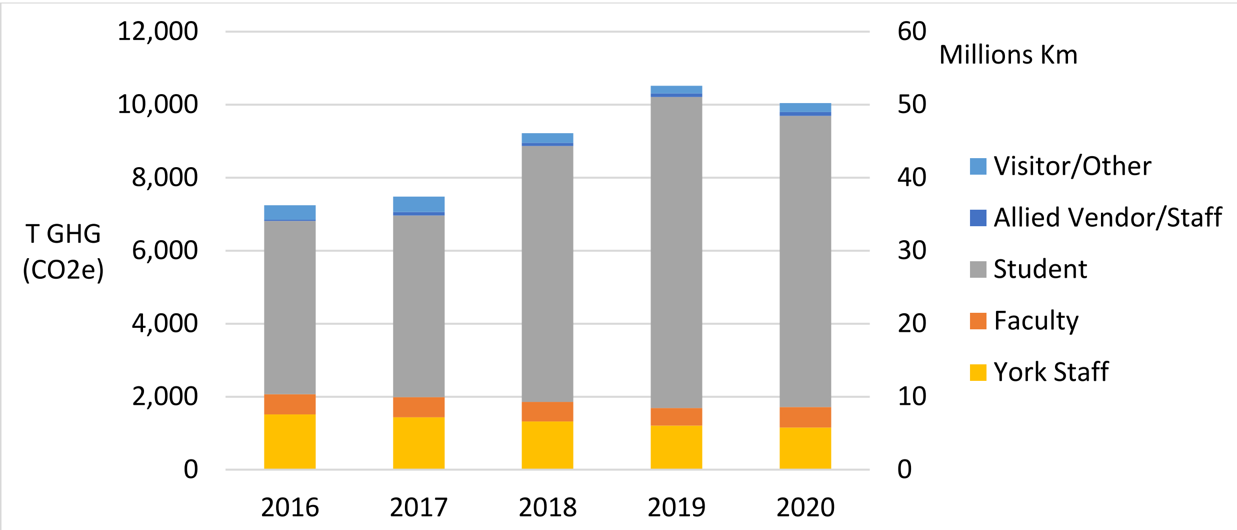


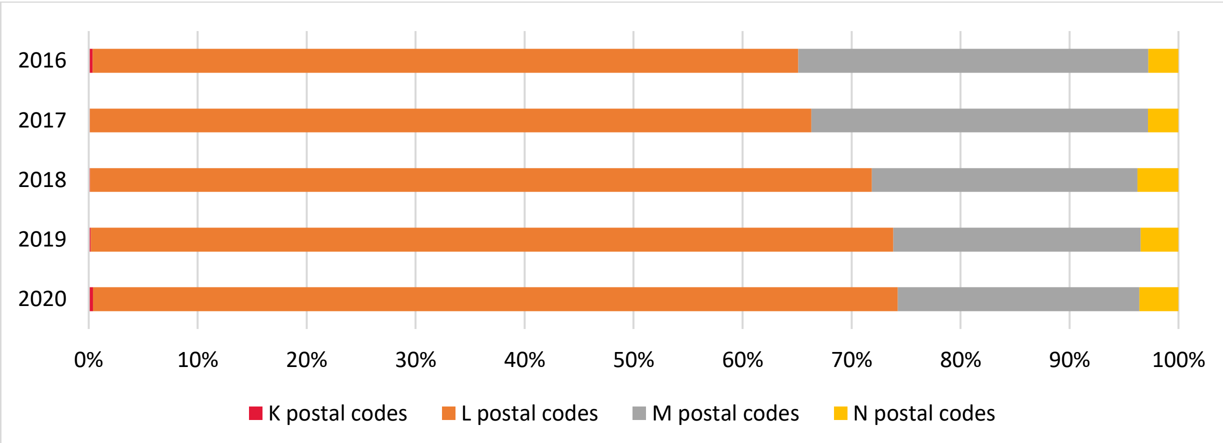
Table 5 reports the FSAs associated with the highest total emissions from driving to either campus in fiscal year 2019, aggregated from all types of people. Fiscal year 2019 was chosen rather than 2020 which had some effects of the pandemic in the last few months. Keele campus was the destination in 2019 with the highest driving emissions, at 607 tonnes from just L6A which was about 15 kilometers from the Keele campus. By comparison, the highest annual emissions from driving to Glendon in 2019 were 55 tonnes from L4N which was about 90 km away. Postal codes with the top originating commutes were geographically clustered. The top five of these origins were commonly known as Maple (L6A), Woodbridge (L4H), Richmond Hill (L4E, L4C), and Aurora (L4G). These five alone accounted for more emissions than were attributed to all the gas burned at the Glendon campus (component 102).

Table 5: Top 10 origins associated with the highest commuting emissions from driving to York in 2019. Emissions are reported as tonnes (T) of greenhouse gasses in units of carbon dioxide equivalent (CO2e).

Origin	Destination	Driving emissions (T)	Driving emissions / all commuting emissions from origin
L6A	Keele Campus	607	93%
L4H	Keele Campus	496	97%
L4E	Keele Campus	493	97%
L4C	Keele Campus	486	97%
L4G	Keele Campus	432	97%
L6P	Keele Campus	397	81%
L4N	Keele Campus	375	97%
L7E	Keele Campus	351	100%
L3X	Keele Campus	312	90%
L0G	Keele Campus	297	100%

Figure 23 illustrates trends in the proportion of driving emissions attributable to different postal codes. Codes are aggregated by their starting letter, such that M postal codes are essentially "Toronto". The proportion of driving emissions attributable to M postal codes declined from 2016 to 2020 as the share attributable to L increased. Nevertheless, in 2019, driving from M postal codes contributed 4427 tonnes of greenhouse gas emissions, which was 72% greater than all the gas burned at the Glendon campus to heat its buildings and supply hot water (component 102). Postal codes starting with M tended to have more competitive transit alternatives when compared to postal codes starting with L, especially since the opening of the TTC subway station at the Keele campus in the later half of fiscal year 2018.

Figure 23: Scope 311 emissions related to originating postal code, starting with K, L, M, or N, by fiscal year.



We verified with York's parking team a set of assumed number of trips per permit month for each type of permit holder. We asserted that a minimum number of commutes would be the point at which a permit is equivalent to paying for each parking transaction separately. We also estimated a maximum number of commutes that would equate to daily weekday commuting omitting holidays and the university's holiday closure (and the exam period for students). From within a range of the minimum to maximum number of commutes, we asserted a "typical" number of commutes related to the type of person. Table 6 reports this range of minimum, typical, and maximum commutes. Permits were typically purchased in 4-month increments, so assumptions about number of commutes per permit month were derived that way, and applied annually to average months, so would not be affected by shorter vs longer months in an academic term. Our database allows us to easily vary the number of assumed trips per year although we used the same assumptions from 2016-2020.

Table 6: Assumed number of commutes applied to permit holders travelling to Keele or Glendon.

	Number of assumed commutes per permit month		
Aggregated person type	Minimum	Typical	Maximum
Allied Vendor/Staff	7	19.27	19.27
Faculty	7	15.41	19.27
Student	7	12.25	17.5
Support Staff	7	19.27	19.27
Visitor/Other	7	14	19.27

All unique FSAs attributed to all parking permit records over the five years were assessed. We flagged as illogical all records that did not follow the Canadian pattern of letter-number-letter. We also flagged as not commutable all postal codes that did not begin with K, L, M, N, or P. We then coded the remaining records with the distance from the midpoint of the FSA to the Keele campus and to the Glendon campus.

Records with a one-way distance greater than 130 Km were deemed to be not commutable, thus the maximum commutable distance to York would be from approximately Peterborough in the east, Kitchener in the west, St Catherines in the south, and Elmvale in the north (north of Midhurst which is north of Barrie). Out of 968 unique FSAs from the parking records, 320 were not logical and 355 were logical but not commutable; out of a total of 323,699 permit-months over the 5-year period, 94% were commutable and logical. Illogical and non commutable FSAs related to relatively few permit-months, but they have grown over time. Table 7 reports the trend in total permit-months.

Table 7: Permit-months related to Forward Sortation Areas. An illogical FSA is one that does not follow the Canada Post convention of letter-number-letter; not commutable FSAs are beyond 130km from campus.

Fiscal	Proportion of total permit-months			Total permit-months
	Illogical FSA	Logical FSA not commutable	Logical and commutable FSA	
2016	2.0%	2.9%	95%	53,151
2017	2.9%	2.8%	94%	56,279
2018	3.1%	2.8%	94%	66,075
2019	2.9%	2.9%	94%	76,864
2020	3.6%	3.1%	93%	71,330

Total permit-months attributed to records that had illogical or non-commutable FSA were reallocated to those that were logical and commutable, as a multiplier applied to each logical and commutable record. This allowed us to retain the number of permit months of commuting in a way that did not alter the shape of the frequency distribution by FSA. Results were not highly sensitive to incremental changes in the cut-off commutable distance because relatively few permit-months were attributed to far distances.

York parking supplied us with a total number of pay-per-use transactions over the reporting period, which had been cleaned by parking with a note about changes in the method of collecting payments that increased the confidence in later-year numbers relative to the earlier years. We used the aggregate pay-per-use transactions to generate an additional multiplier of all permit commutes so that we could infer a distance travelled by pay-per-use transactions. This embodies an assumption that pay-per-use drivers would tend, on average, to be travelling from the same locations in the same proportions. With *y*% of permit-months attributed to FSA *z*, then *y*% of pay-per-use transactions were attributed to *z*.

Emissions were estimated from each commute by applying an average rate of emissions per kilometer travelled. We kept these constant but could be yearly variable if we had data about the make and model and type of vehicle. Emission intensities of passenger vehicles can vary, based on their size and weight and shape and based on whether the internal combustion engine is paired with a larger battery system in a hybrid or plug-in hybrid arrangement, or whether the engine is entirely electric. These details could be useful in future assessments, especially to the extent that electricity grows in its share of the energy used to move passenger vehicles.

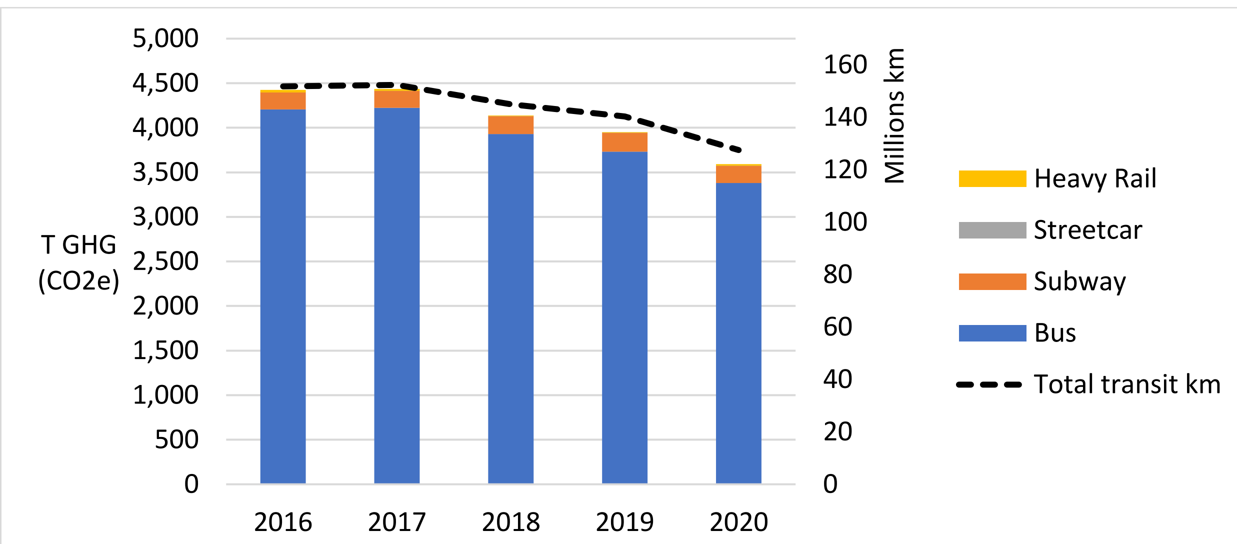
312: Commuting to campus by transit (by postal code, campus, category of person)

This component attributes emissions to commuting by transit, based on the originating Forward Sortation Area (FSA) of a student or staff or faculty's residence, and a presumed destination of either the Keele or Glendon campus according to their home department. Only commutable FSA codes were considered, based on the same definition applied to driving (as explained for emission component 311).

Each commutable FSA was identified with its optimal transit mode, and distance, from querying Google maps for the transit route to arrive on campus by 9AM. This allowed us to specify the distance travelled by type of transit, differentiating between bus versus subway versus streetcar versus train. This was an important differentiation because their emission intensities varied, with electric subway and streetcars emitting relatively little carbon (embodied in their consumed electricity) as compared to fossil-fuelled buses emitting significantly more. Transit commutes were estimated as the number of trips necessary to move York's commuters who did not drive (and park on campus) or did not carpool or did not use active transportation. This logic reflects the absence of York-specific transit statistics, and the presence of statistics about on-campus parking and the frequency of carpooling and active transportation.

Figure 24 totals scope 312 emissions per year from transit mode, and total distance commuted by transit. This reveals a decline in transit emissions from a decline in transit travels. Transit emissions fell faster than transit kilometers, reflecting a slight increase in transit efficiency as a greater proportion of transit usage involved the subway. Parking permits were less likely to be purchased by commuters living in Toronto in later fiscal years than in the earlier years, which resulted in a shift to transit among postal codes that were beyond the capacity for active transit. The bus share of transit kilometers declined slightly over the years to about 80% in fiscal 2020.

Figure 24: Scope 312 emissions per fiscal year from commuting by transit, by transit mode and distance. Emissions are reported on the left scale as tonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e). The right scale reports the millions of kilometers commuted by all modes of transit.



Our integrated data allows for various breakouts and aggregations, by originating FSA postal code, by destination campus, by category of commuter, by the number of transit trips, and by the breakout to different transit modes of the number of kilometers travelled and attributed greenhouse gas emissions. These details are available in each of the fiscal years, allowing us to observe interesting trends. At an aggregated level, Figure 25 reveals that students accounted for the greatest share of transit emissions (as they also did of driving emissions in scope 311). The student share of transit emissions declined with a growth in the share from staff and faculty.

Figure 25: Share of transit emissions per fiscal year from commuting faculty, students, and support staff.

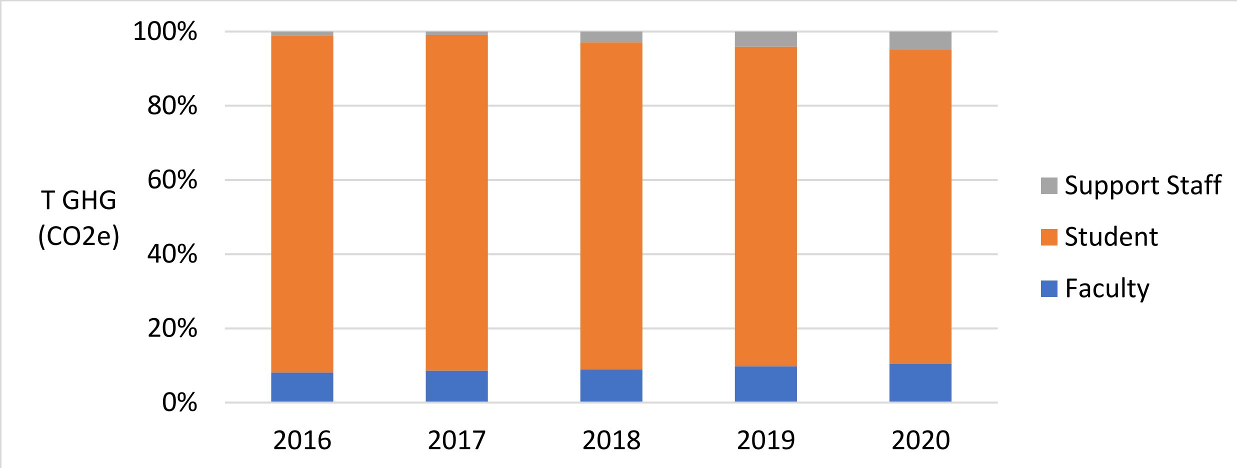


Table 8 reports trends in transit usage among faculty versus students versus staff, by fiscal year. This data is aggregated for both Toronto campuses, but it could also be broken out by campus. From 2016 to 2020, the transit share of commuting distance increased for faculty and support staff while it decreased for students. By fiscal year 2020, students and faculty were almost equally as likely to have used transit in their journey. The same table could also be produced for the share of commuting trips, which would vary because not all commuting trips were the same distance per each year and person.

Table 8: Percent of commute distance taken by transit (to Keele or Glendon), by type of person, per year.

Fiscal year	Faculty	Student	Support Staff
2016	57%	74%	7%
2017	59%	73%	7%
2018	59%	66%	20%
2019	61%	61%	24%
2020	64%	61%	28%

Table 9: Originating postal codes with the highest transit distances travelled, in 2019, by type of commuter.

Origin	Destination campus	Commuter	Transit km	Transit km / all commute km from origin
L5M	Keele	York Student	3,921,888	86%
L6Y	Keele	York Student	3,369,373	83%
L6R	Keele	York Student	3,138,493	76%
L7A	Keele	York Student	3,051,545	70%
L6P	Keele	York Student	3,005,814	61%
L6X	Keele	York Student	2,717,806	77%
L5V	Keele	York Student	2,220,583	86%
M1B	Keele	York Student	2,171,523	89%
L3S	Keele	York Student	2,019,839	83%
L5B	Keele	York Student	1,948,216	82%

At a more detailed level, Table 9 identifies the top 10 originating FSA postal codes for York's transit commuters in 2019. In that year, L5M (in Mississauga) accounted for the highest distance travelled by students using transit to reach the Keele campus. Among these top origins, there was a potential to increase the proportion of commutes done by transit rather than driving. For example, L6P accounted for the fifth most frequent origin for transit-using York students, yet only 61% of student commutes from there to Keele used transit. Details like these could be useful to plan and promote better transit options and anticipate the emission reductions of a shift from driving to transit.

To derive transit emissions, from transit commutes, we needed to first identify the total number of commuters. OIPA provided us with headcounts of faculty and staff and students, by FSA, and by the campus of their department, for each of the five fiscal years. Undergraduate students were specified by term and by courseload, which revealed the extent to which they were studying full-time or part-time. This full versus part-time distinction would presumably correspond to a difference in commuting frequency, so we converted part-time students to full-time equivalents. We also converted part-time faculty and staff to fulltime equivalents. These full-time equivalent number of people, by FSA, were presumed to commute based on the assumed frequency of weekly travel as discussed in the prior section (and reported in Table 6). The headcounts by FSA included some FSAs that were not commutable (including some from other provinces and countries), so we inflated the number of commutable FSA commuters by the amount to offset the people attributed to non-commutable FSAs.

Each commuter was allocated to one of four possible modes: driving a single occupant vehicle, carpooling in a two-person vehicle, active transportation such as walking or cycling, or transit. Although commuters might use multiple modes per trip, we followed a simpler approach to assign each commute to just one type of dominant mode. Single occupant vehicle commutes were derived from York's sales of parking permits and an allocation of pay per-use parking, as explained earlier in this report and as allocated to scope 311. Proportions of carpooling and active transportation, by FSA, were derived from a spreadsheet of results from a 2016 survey of York students and faculty and staff (York University and Smart Commute, 2017). This survey asked respondents about their commuting mode and home postal code and campus. Raw survey data were cleaned enough to derive a subset of useful information for many postal codes, to derive the proportion of carpoolers and active commuters that did not use transit on their journey to either campus.

Transit trips, by FSA, were derived as the residual of commutes that were not driven (as a single occupant) or not taken as a carpooled passenger or not done by means of active transportation. This approach worked well for most FSAs although there were a few in which there were more parking permit-holders (from parking office data) than commuters (from OIPA data), which resulted in a negative residual of transit trips. This was not surprising since the addresses of parking permit records were collected independently by the parking office, and not derived from York's registrar or human resources data. Nevertheless, we kept negative transit residuals since this would be needed to offset a surplus of transit residuals elsewhere, in other FSAs with fewer permit holders than actual single occupant drivers. Conceptually this was the best we could do, although we recognize that the offset would be imperfect to the extent that the mismatch of home-versus-parking-permit addresses could coincidentally be more frequent in FSAs that are farther from, or closer to, either campus, thus affecting total emission estimates in components 311 and 312.

Transit commuters were allocated to a transit mode based on their originating FSA. Modes were either bus, electric TTC streetcar, (TTC) subway, or heavy-rail commuting (by GO train). Google Maps was queried for the optimal peak-hour transit trip from an FSA to reveal the extent to which one or more of these transit modes would be used. For Toronto-area FSA, most queries directed the journey through a local subway station, sometimes with a prior bus or (electric) streetcar trip if the FSA was beyond walking distance from the station. Once on the subway, trips to Glendon involved a final bus trip from Lawrence. Transit distances were provided by Google maps in units of time, and not kilometers, so we overlayed a distance measurement to approximate the kilometers of the journey. We did this for the subway journey as well, so that we could account for each transit trip in terms of its distance by bus, streetcar, subway. Starting in December 2017, York University Station opened; previously, subway trips would have included a final bus trip from Downsview Station. We applied the same (contemporary) transit trip routing throughout our 5-year assessment even though some trips before December 2017 might have been routed differently, and even though subway riders would have completed their journey with a final 6km bus trip from Downsview to Keele campus.

Transit commuters from FSAs outside of the city of Toronto were directed by Google Maps to use one or more bus routes (such as offered by GO Transit or York Region Transit) for almost all the journey, before a final transfer at a TTC subway stop such as Highway 407 or Yorkdale or Vaughan Metropolitan Centre. Some FSAs in Mississauga were close enough to Kipling Station to allow their journey to be mostly by subway. The bus portion of any transit trip was assumed to travel the same distance as would have been driven. This was a simplifying assumption to avoid a more effort-intensive investigation into the details of specific circuitous bus routes being possibly longer than driving, and/or possibly shorter if the bus stop was farther from a person's home than a home parking spot.

We built the database to include the possibility that transit riders of certain FSAs would travel part of their journey by GO train. Relatively few FSAs were codified with this possibility since the 2015 transit survey revealed very low usage of the GO train. From 2016-2020 a York University GO station existed off-campus, with connection to campus by a York shuttle. Service was limited and since 2021 the station was abandoned. It was also possible for transit commuters to have used the GO train to connect to other transit nodes including Bramalea. To fully quantify the extent of GO train usage we would have needed either transit usage statistics from GO transit or York, or a larger sampling of York commuters to identify relevant FSAs to query through Google Maps. This could be possible and relevant for future extensions of the present assessment, with the added complication of inferring the likelihood that train commuters would drive to the originating station.

Emission intensity of commuters within this section 312 were derived on a yearly per-person-per-kilometer basis. We derived these with great effort because there were no readily available coefficients that matched the realities of Toronto, or even Ontario. We applied the resulting intensities to the number of commuters, by FSA, based on the mode. Although our database applied intensities on a yearly basis, we used the same intensity for many years because we did not have enough data to differentiate if and how emission intensities might have varied over the years, in response to changing vehicle efficiencies and changing ridership. We followed the usual convention of assigning no emissions to active commuters since, by definition, they did not use any fuel- or electric-powered equipment. Carpoolers were presumed to add only their mass to the vehicle shared by our assumption of just two occupants, thus they could reasonably be assumed to not increase the emissions of the vehicle that was already counted in scope 311. Therefore, the virtue of additional carpoolers would be the avoided emissions of additional paid parking or avoided additional transit rides.

Subway commuting was allocated an emission intensity based on how much electricity was assumed to move each rider per kilometer, which was then multiplied by emissions intensity of Ontario's electrical grid (as we did to derive scope 2 emissions). We hoped to derive an assumption of electricity usage per passenger-kilometer based on the TTC's annual consumption of electricity, and the annual number of riders, but we would have needed data about the average length of a trip (or total number of subway and streetcar passenger-kilometers). But without this data, we resorted to using the lower end of the range of emission intensity estimates of subways on a per-passenger-kilometer basis to reflect the low carbon intensity of Ontario's grid electricity from 2016-2020.

Emissions intensity for intracity buses and inter-city buses were available on a one-year basis through various emission calculators and tools, such as some identified by the Greenhouse Gas Protocol (WBCSD and WRI, 2022) and the American Passenger Transportation Association (2018). These aggregated and average intensities were also somewhat crude since actual intensities vary depending on the vehicle and, significantly, upon ridership. The TTC provided us with emission intensities of various bus models but not the resulting intensity of passenger use, so we could not use it in our calculations needing emissions on a per-passenger-kilometer basis. Since 2015, the fleet of TTC busses evolved towards more low-floor hybrid-electric buses which carry different numbers of passengers and have different emissions per kilometer travelled. More recently the TTC has added all-electric buses to its fleet, although their service mostly started fiscal 2020. GO transit buses also evolved, towards more being double decker; the consequences on emissions per-passenger-kilometer was unknown so we could not calibrate our parameter to any potential gains in efficiencies from local transit equipment.

Scope 3: Indirect downstream emissions could be estimated

Indirect downstream scope 3 emissions were investigated but not quantified to the same extent as upstream scope 3 emissions. We investigated the feasibility of including estimates of downstream emissions attributable to food and vending consumed on campus, retail and other purchases on campus, and emissions from investments including endowments. Emissions from food and vending and retail purchases on campus could be easily estimated if we had confident estimates of expenditures by staff, faculty, students, and guests on York's campuses. Without directly sampling consumers, we would need a good sample of revenue earned by on-campus providers. Some of this could be obtained from York revenue data, such as with the sale of meal plans, but this would need to be supplemented with revenue information from private enterprises on campus. In lieu of revenue information from private enterprises, we could derive a range of estimates related to industry-standard sales per floor area leased by the type of enterprise.

313: Other food and vending purchased on campuses

In the future, York revenue data related to sales of meal plans, and information about vending contracts, could be used to estimate emissions attributable to food and vending purchased on York campuses. This could also be related to relevant components of Ecological Footprint, assuming the food would reflect the average type/diet consumed in Ontario in 2015. Our research team previously assessed Ontario's Ecological Footprint in 2015, which included the consumption of food in Ontario.

314: Other retail and other commercial activity on campuses

Through the leadership of food services at York, we engaged the team who managed York's portfolio of buildings and commercial food and retail contracts on the Keele campus. We created a fillable spreadsheet that asked for the area leased by category of tenant and if the tenant or York could disclose approximate gross sales. Categories included grocery, convenience store, clothing, restaurant (seating), restaurant (takeout), child-care, pharmacy, and medical. We were provided with a completed template for tenants of the "quad" area of York, with estimates of gross revenue for about half of them. Some of York's lease arrangements require the tenant to disclose gross sales, so it was feasible to provide this to us on a confidential basis. We found significant ranges in gross sales per unit of area, relating to different types of food and business models, from as much as $1080/sf to a low of $11.80/sf. Missing sales data could be estimated, such as for a dental office. Our analysis confirmed the possibility of deriving this more broadly across the campus, but without additional information about tenants or area under retail leases across the campus, we could not estimate emissions within category 314.

315: Emissions from York investments including endowments

York earned about $37 million in revenue in fiscal 2020 from investments. Conceptually, scope 1 plus 2 emissions attributed to all York-owned investments could be proportionally attributed to York's scope 3 downstream emissions. However, this attribution would be quite challenging. Companies were not mandated to report those emissions. Furthermore, ownership tends to be fluid with investments mediated through managers that frequently re-allocate holdings within a portfolio, and over a year.

A further challenge of quantifying emissions for this project was apportioning the emissions appropriately between investors (earning dividends or interest) and consumers of the good or service. York was potentially a consumer of goods and services produced by companies that it partially owned as an investor. The same emissions from those companies ought to not be allocated to York's scope 315 and to other upstream scope 3 categories, otherwise emissions would be double counted. Conceptually a solution would be to apportion a company's emissions between its consumers and investors. Consumers would count emissions attributed to the goods or services they purchased as part of their upstream scope 3 total, while investors would account for their share as downstream scope 3 emissions. The total from consumers and investors would therefore equal to the company's scope 1 plus 2 emissions. If 10% of operating revenue were earned by the company as operating profits, and passed onto investors as dividends or interest, then it would seem to be reasonable to attribute 10% of the company's scope 1 plus 2 emissions to investors and the rest to its consumers. Various details could complicate the calculations including different ways of accounting for profits, whether to subtract taxes from profits, how to handle profits that were retained or used to purchase company stock, and handling losses which would presumably not count as negative emissions to the investor. Nevertheless, approximations could be made to generate a reasonable non-double-counted estimate. However, this approach would vary from a typical approach to allocate all scope 1 plus 2 emissions to investors in proportion to their share of ownership.

Emissions attributable to York's investments were assessed by the Board Investment Committee of the of the York University Endowment Fund (2021) and reported in its Sustainable Investing Report 2020. This report identified an estimated emission intensity of endowment fund equities at 114.5 tons of CO_2e per $1M USD of "revenue" (two summary tables reported this as "sales"). The intensity metric was derived from a weighted survey of investment managers who reported estimates as a one-time snapshot. Emissions attributable to fixed income investments were estimated at 461 tons of CO_2e per $1M USD. Together, these components accounted for about 88% of the holding of the endowment fund, with the balance in real estate funds that were more challenging to assess. Additional information was provided in confidence by York's Treasurer related to York's operational funds as balance sheet investments, with a spreadsheet attributing emission intensity to the market value of the company.

From our own assessment of this information, we assumed that benchmarks referred to emissions per unit of market value, which reflects the marginal price of the investment being exchanged within capital markets. If we were to follow the usual approach to distribute all emissions to investors (without any to consumers), and in proportion to an investor's share of ownership, this would generate a total equivalent to the emissions from York's reimbursement of "other travel expenses" (306). If we follow our recommended alternative approach to attribute emissions to investors in proportion to their share of operating profit, and apply a typical economy-wide operating profit ratio of 10%, this would generate an equivalence to the total emissions from student airfare paid by York in 2020. We recommend this latter approach so that emissions from investments including endowments could be summed with other scope 3 emissions. We recognize that the profit share of companies within York's investment portfolio is potentially not reflective of an economy-wide average; financial corporations tend to have a much higher profit rate, while retail trade, construction, and food and accommodation tend to be lower. With additional effort a more robust estimate could be derived, even with an expectation that this component of emissions would be relatively small compared to York's total scope 1 plus 2 plus 3.

Aggregations and integrated assessment

All components could be aggregated since we ensured that all components and scopes were distinct and mutually exclusive. The Greenhouse Gas Protocol (WBCSD and WRI, 2022) asserted that all organizations should quantify and report scope 1 and scope 2 emissions, whereas Scope 3 is an optional reporting scope that is still worth estimating. Therefore, Figure 26 stacks all scope 1 and scope 2 components to be consistent with minimum reporting under the protocol. This minimum trended down in 2017, then rebounded with a growth in emissions in 2018 and 2019, with a slight decline in 2020. This trend reflected the trend in emissions from co-generated electricity and heat (component 101).

Figure 26: Scope 1+2 emissions per fiscal year, by scope 1 and 2 components. Emissions are reported as thousands of tonnes (kilotonnes) of greenhouse gasses in units of carbon dioxide equivalent (CO2e).

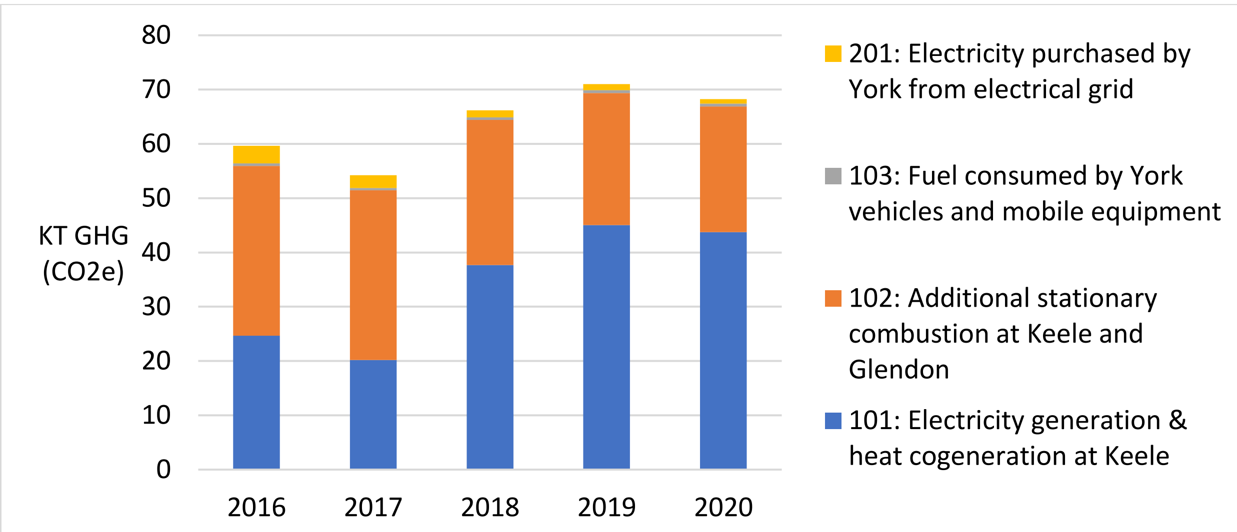


Figure 27: Scope 1+2+3 emissions per fiscal year, by scope. Emissions are reported as thousands of tonnes (kilotonnes) of greenhouse gasses in units of carbon dioxide equivalent (CO2e).

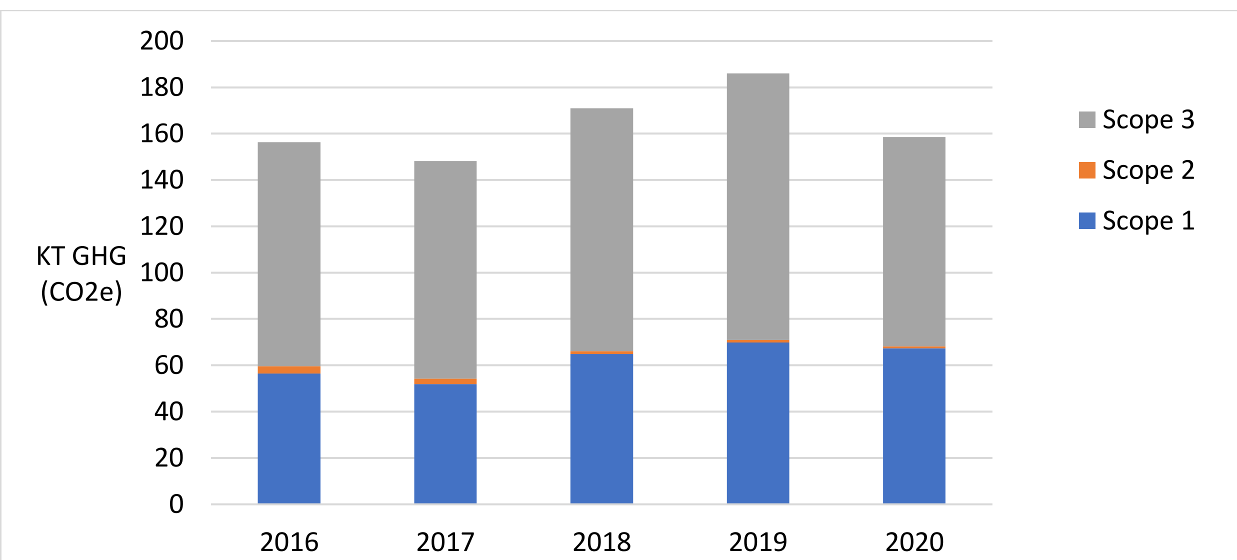


Figure 27 plots total emissions aggregated by scope, with the relative share of each provided in Figure 28 to reveal how the proportions trended over time. Generally, in all years, about 40% of quantified emissions were from scope 1 and 2, with the remaining 60% of emissions from scope 3.

Figure 28: Relative share of scope 1 versus scope 2 versus scope 3 emissions per fiscal year.

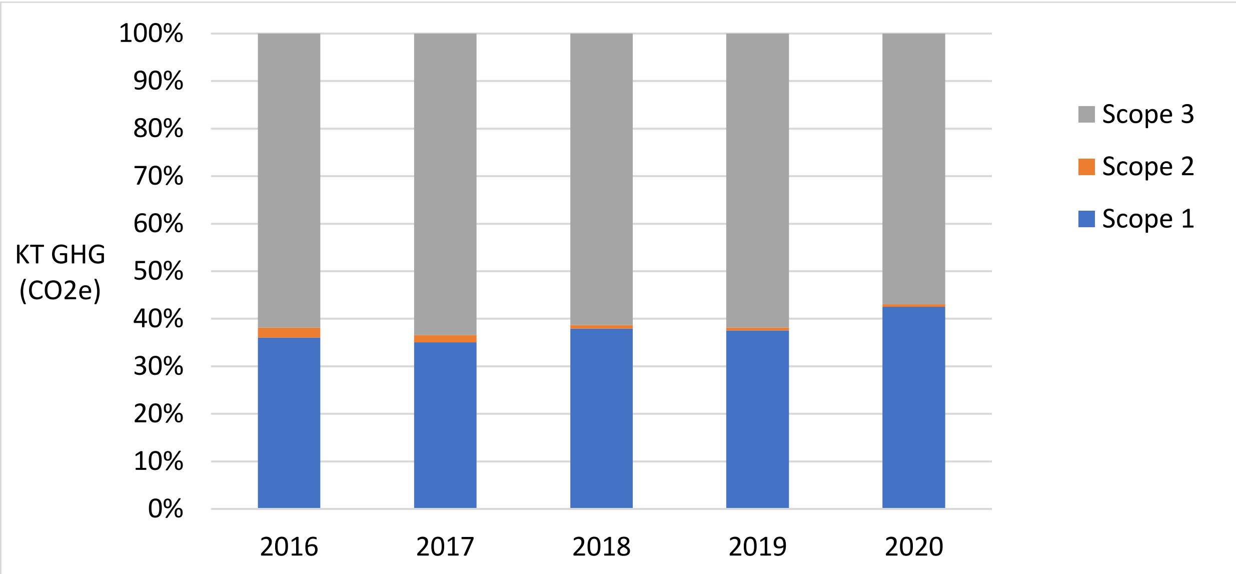


Figure 29 stacks all scope 3 components, revealing a peak in 2019, and negative emissions from scope 309 (offsets) in 2016, 2018, and 2019. The variability in scope 3 emissions mostly reflected the variability of annual capital expenses, which affected emissions attributed to component 301.

Figure 29: Scope 3 (upstream) emissions per fiscal year, by component. Emissions are reported as thousands of tonnes (kilotonnes). Component 309 is negative because it reflects emission offsets (in 2016, 2018, 2019).

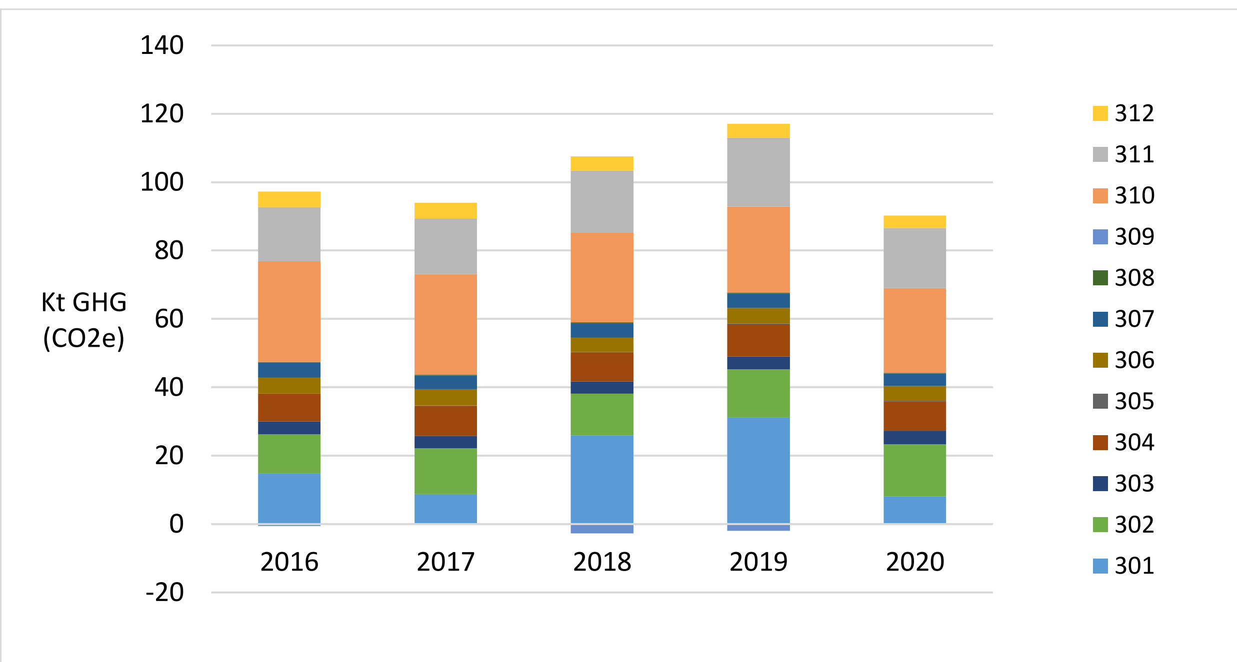


Figure 30 plots all components quantified in this report, with the greatest amount of detail of all the integrated graphs. The peak of scope 1 and scope 3 emissions in 2019 combined to peak aggregated emissions in that year, followed by a reduction in 2020 at a level that was below 2018 but above 2016. Figure 31 presents each component separately, with emissions in 2020 and its range from 2016-2020.

Figure 30: Scope 1+2+3 emissions by fiscal year, detailed by all scope 1 and 2 and 3 components. Emissions are reported as kilotonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).

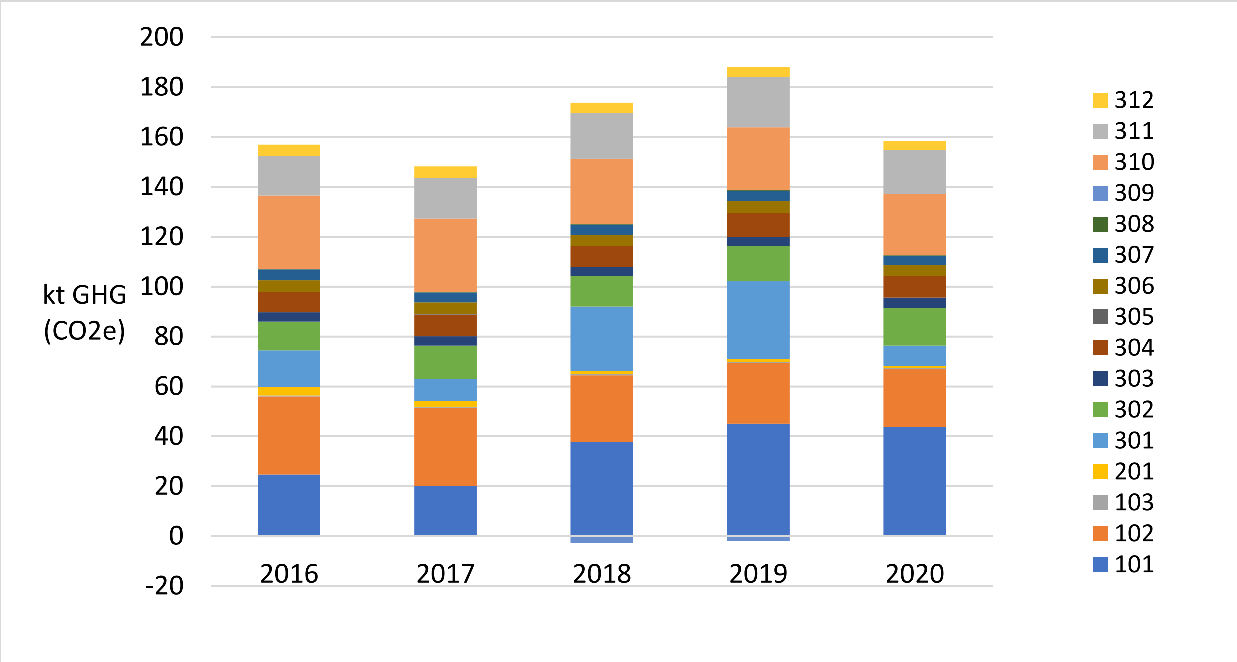


Figure 31: Greenhouse gas emissions in fiscal year 2020 and the 5-year range of each component.

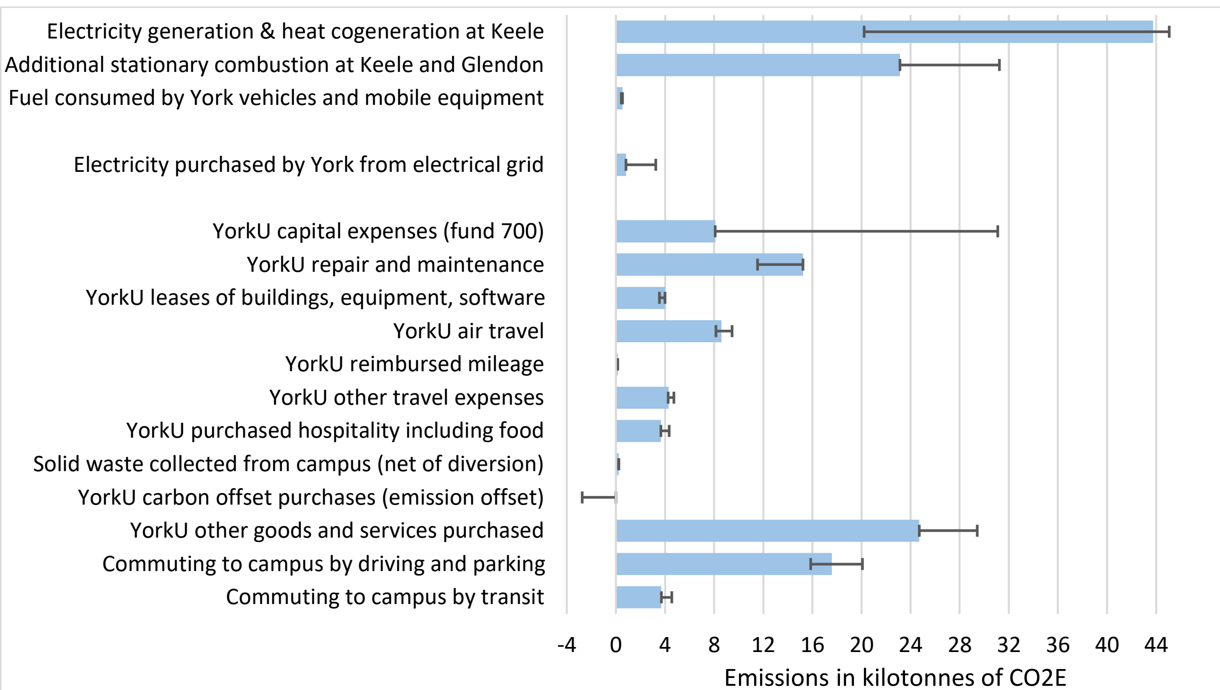
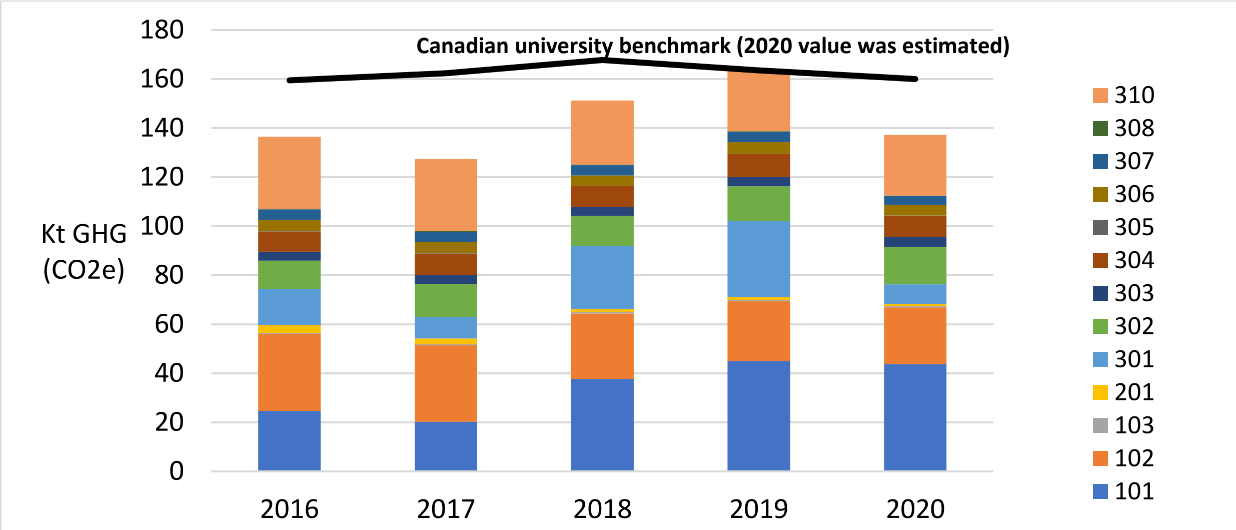
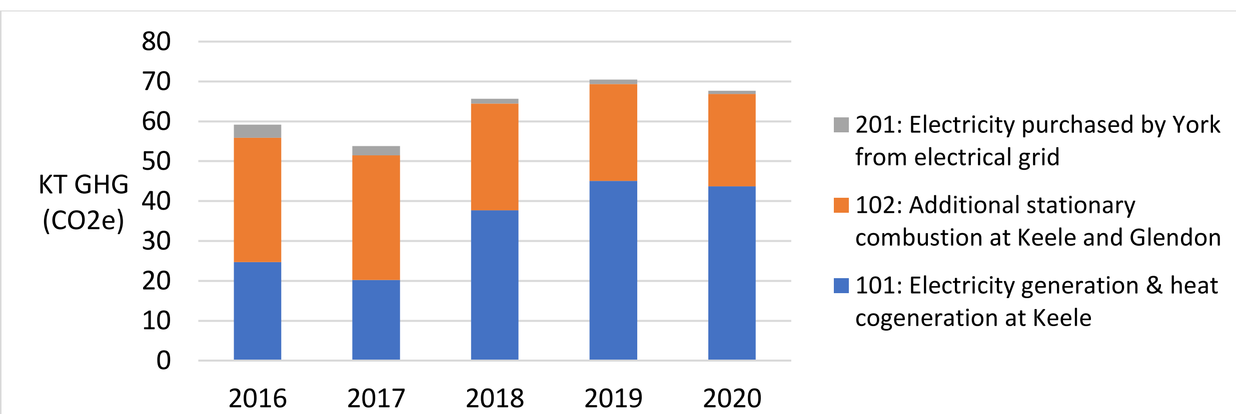


Figure 32: Emissions from York compared to Canadian university benchmark, which reflects scope 1 plus scope 2 plus most of scope 3 (omitting carbon offsets (309) and commuting (311 and 312)). Emissions are reported as kilotonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e) per York fiscal year.



With Statistics Canada reporting a national average emissions intensity of all universities, we could compare York to this national benchmark by including components that would have been reflected in the methodological approach used by Statistics Canada. Figure 32 plots this comparison by summing York's scope 1 + 2 + 3 (upstream) emissions, omitting carbon offsets (309) and commuting (312 and 313) since these would not have been included in the intensity calculation by Statistics Canada. The solid line which we call the Canadian university benchmark is an emission intensity per unit of output of the university, which changed slightly since 2015. Statistics Canada provided this benchmark's underlying parameters on an annual basis, with 2019 as the most recent calendar year of data when writing this report. We generated fiscal year equivalents as 2/3 of the prior calendar year plus 1/3 of the current calendar year. Fiscal 2020 was estimated as the value of calendar 2019. We applied the Canadian intensity to York's total expenses, which increased over time. From fiscal years 2016 to 2020, York's emissions were typically below the Canadian university benchmark. In fiscal 2019, York's emissions were 0.2% higher than the Canadian benchmark.

Figure 33: Emissions per fiscal year from heating and cooling and lighting York (scope 101 + 102 + 201). Emissions are reported as kilotonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).



Additional combinations of components can help to characterize broad aspects of York's activities and services, such as mobility and facilities and energy management. Figure 33 aggregates components that sum to emissions from heating and cooling and lighting buildings. This aggregation could be helpful to compare against trends in the useable, and used, floor space of buildings and their occupancy loads.

Figure 34 aggregates components that relate to "mobility" which is a key attribute of universities including York, which is also situated in the commuting-intensive Greater Toronto region. Toronto has intensified around York's Keele campus such that it feels less suburban nowadays as compared to historically. Nevertheless, York draws daily commuters from a broad geography, and York engages in significant local and global travel through its research and training initiatives. Mobility-related emissions trended around 25-26% of all emissions or about 40% of all scope 3 (upstream).

Figure 34: Emissions per fiscal year from mobility-related components of scope 3. Emissions are reported as kilotonnes of greenhouse gasses in units of carbon dioxide equivalent (CO2e).

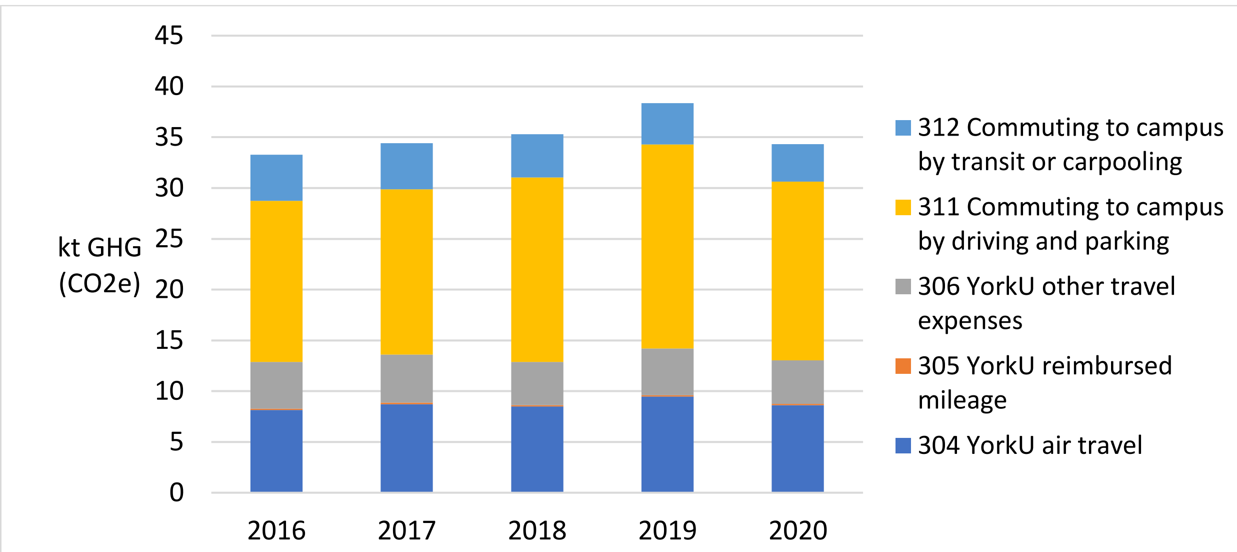
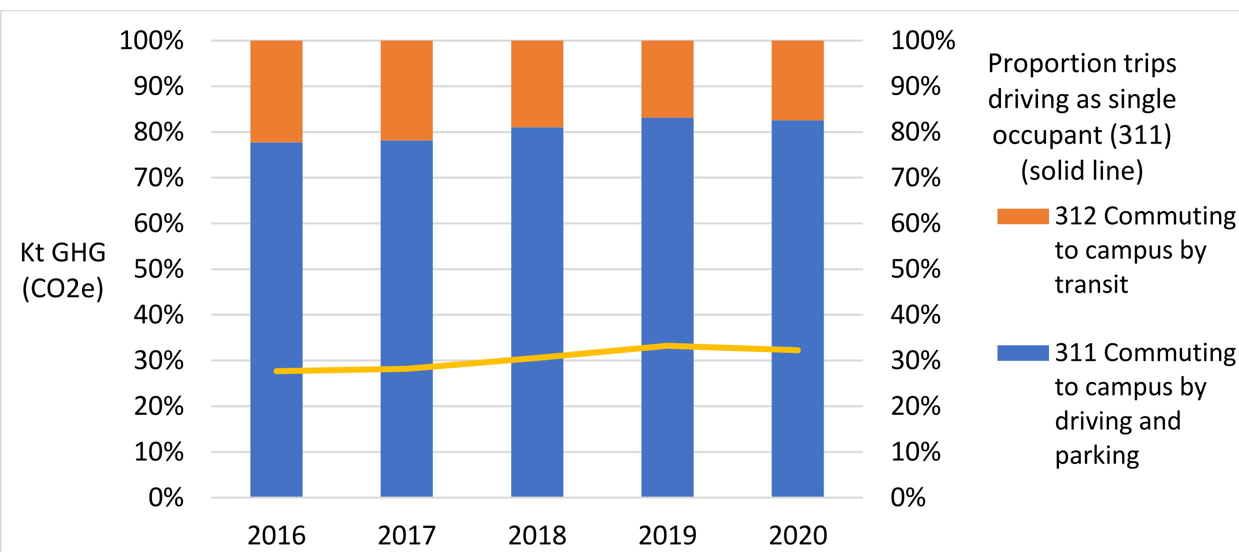
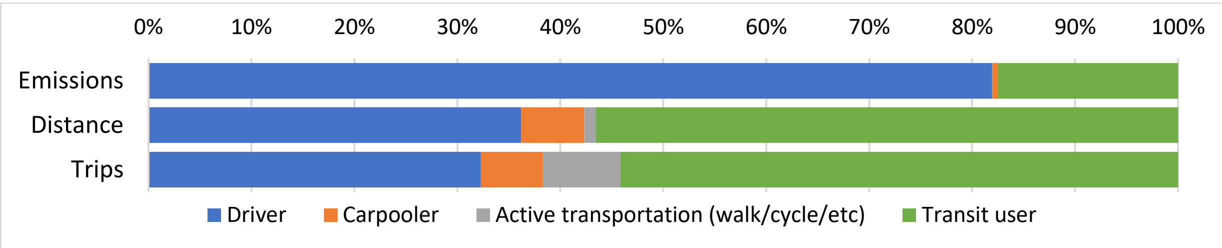


Figure 35: Commuting emissions by driving versus transit, compared to proportion of trips by driving.



Commuting emissions are integrated in Figure 35, which reveals the relative inefficiency of driving from an emissions perspective. This figure juxtaposes that 30% of commutes to York by driving accounted for about 80% of commuting emissions. From 2016 to 2020, the proportion of trips driven as a single occupant trended upwards with a decline in the proportion using transit. Trips, distance, and emissions can be split by modal share, by year, and by campus; Figure 36 plots the modal share for 2020.

Figure 36: Modal share of commuting to York's Toronto campuses in 2020.



Ecological footprint related to York's activities within scope 1 and 2 and 3

We integrated into the database a suite of parameters that were used to derive Ecological Footprint, and its components (defined in Table 2), from the activities identified within scope 1 and 2 and 3. Since our team was also involved in producing the National Ecological Footprint and Biocapacity Accounts, we could apply the parameters from the latest 2022 edition to account for the area of land needed to biologically sequester York's emissions. To account for the five other (non-carbon) components of Ecological Footprint, we needed coefficients that relate a dollar of expenditure to units of footprint components. This would allow us, as an example, to translate York's expenditures on paper to the area of forest land needed to generate that value of product. We derived these coefficients from a prior project for the Ontario Ministry of Natural Resources and Forestry (Miller et al., 2021). In that project, we related Canada's Ecological Footprint to categories of final-demand goods or services, such as footwear and apparel consumed by households, through a Consumption Land Use Matrix (CLUM). For the present project, we used the same CLUM but allocated its final categories to the economic sectors with emission intensities from Statistics Canada. Since we already matched York's accounts to those same economic sectors, we could effectively relate a dollar of spending from any of York's accounts to a fraction of a global hectare of forest land, or crop land, etc.

Figure 37: Components of York's Ecological Footprint in 2020, which totalled 74,328 global hectares. Each component is sized in relation to its contribution to the total.

Figure 37 illustrates York's estimated Ecological Footprint in 2020 to be 74,328 global hectares from scope 1 plus scope 2 plus upstream scope 3 activities. About 80% of the Ecological Footprint was comprised of the forested area needed to sequester caron emissions, representing 59,255 global hectares of forest lands needed to fully sequester those emissions. Those hectares would be needed to sequester 70% of York's 159 kt of greenhouse gas emissions, considering that about 30% of all anthropogenic emissions were sequestered by the world's oceans in 2019. The second-largest component at 11,172 gha was the footprint of forest products, representing the area of forests needed to provide timber and pulp-derived products. York's activities therefore required about 70,428 global hectares of forests to generate the flow of goods and services used by forests in fiscal year 2020.

We directly converted greenhouse gas emissions into the land area needed to biologically sequester those emissions, and we added this to other footprint components that would have been consumed by the activities that generated emissions. Intuitively, York's purchase of paper and books generates emissions from their production and transportation to York while also necessitating forested land to generate the pulp. Somewhat less intuitively, the production and transportation of paper products also relies upon cropland through complex supply chains that connect various economic sectors. Our prior work generating a CLUM for Ontario revealed these interrelationships which we applied to York. As a result, our calculation of Ecological Footprint reflected these interrelationships.

The 2022 edition of the National Ecological Footprint and Biocapacity Accounts had a final data year of 2018 and the CLUM from our prior project was calibrated to multi-regional input-output statistics from 2014. Nevertheless, we weighted the matrix to account for changes from 2014 to 2018, and we extended the trend further to 2019 by noting that that Canada's Ecological Footprint of consumption has been flat on a per-capita basis since 2014. Despite these coarse assumptions, the breadth of the Ecological Footprint and its relationship to areas of land and water make it a useful addition to the measurement of emissions. It can help to contextualize the relevance and significance of economizing on emissions and the use of lands and waters either directly or indirectly through scope 3 relationships.

York's lands at its Keele and Glendon campuses, plus its 167.5 hectares in Costa Rica, provided about 858 global hectares of biocapacity using coefficients from the National Ecological Footprint and Biocapacity Accounts related for Canada and Costa Rica. This meant that just over 1% of York's Ecological Footprint could be provided by the lands managed by York University, with the rest dependent upon lands and waters around the world beyond York's boundaries and direct management.

On a global basis, humanity's Ecological Footprint has been above Biocapacity in every year since 1971. This "overshoot" means that humanity's greenhouse gas emissions were above the amount that could be biologically sustained by the lands and waters used to generate food and renewable fibres and building materials, and which were not occupied by built-up infrastructure in settled areas. Most recently, Ecological Footprint was about 75% greater than Biocapacity. Only 34% of carbon emissions in recent years could have been sequestered by forests which were not concurrently used to provide forest products. This presents a challenge to York and to the world.

The global overshoot of humanity's Ecological Footprint could be remedied through Canadian and global commitments to reach "net zero emissions" since this emission target translates into an Ecological Footprint being no larger than Biocapacity. Ecological Footprint and Biocapacity accounting can help the world to strategize about options for net zero emissions since the "net" component of zero emissions involves using lands and waters to sequester emissions which cannot be reduced on a gross basis. Ideas abound about "nature-based solutions" to the climate challenge such as replacing fossil fuels with biofuels, afforesting non-forested lands, and increasing the proportion of renewable building materials in new construction and renovations. These solutions involve using lands and waters differently, and potentially in competition with each other or with other competing uses of lands for food and settlements. Area-based accounting of Ecological Footprint and Biocapacity can help the world to reconcile these trade-offs and to account for how footprint relates to global trade-flows.

Conclusion and future possibilities

This project generated the first comprehensive assessment of emissions and Ecological Footprint related to York's activities. This included scope 1 emissions from combusted fuels on York's Keele and Glendon campuses, scope 2 emissions embodied within York's purchase of electricity, and scope 3 emissions embodied within York's expenses on goods and services and from the commutes of faculty and staff and students. From fiscal years 2016 to 2020, the sum of scope 1 plus 2 emissions trended upwards while scope 3 (upstream) trended downwards. Emissions from York's self-generation of electricity were significant within scope 1, while procurement and commuting emissions were significant within scope 3. Some components were highly variable, such as capital expenses. York's non-commuting emissions were below a Canadian university benchmark in all years except in 2019 when it was 0.2% above. Beyond this comparison, the authors of this report have not yet seen a comparably broad scope 1+2+3 assessment of another Canadian university.

This report draws its analytics from an MS Access database that was created to facilitate the integration and reconciliation and cleaning of data. The database and its associated code and queries were developed for this project in a way that would facilitate future updates and expansion.

Opportunities abound to build on this work to enhance the accounting of past emissions, and to explore scenarios of the future course of emissions. One opportunity would be to integrate emissions data with other output- and outcome-oriented performance measures to help understand trends in York's ecological economic efficiency. For example, quantitative performance measures associated with externally-sponsored research could be compared with emissions attributable to Fund 500 expenses. Even as York works to reduce its total greenhouse gas emissions, it is helpful to understand how those emissions are trending relative to York's outcomes of research, training, and impact. This could be especially useful since York has grown its outcomes, and at this point still intends to grow further, with a new campus in Markham and a proposed School of Medicine and Vaughan Healthcare Precinct.

As we engaged with York colleagues throughout this project, we were routinely asked how the Covid-19 pandemic would be considered. Colleagues accepted that a 2016-2020 period was a reasonable pre-pandemic baseline even though the pandemic affected the last two months of the fiscal year ending on April 30, 2020. Since then, many wondered if and how emissions trended. This could be answered by incorporating more recent years of data, possibly in combination with adding a component to account for energy used by home offices and online networking during the lockdown. It would be instructive to add additional years of data to understand how emissions varied as the York community reduced its mobility and on-campus activities while shifting to an online format of engagement and communication from home-office setups. Even with lower occupancy, we were told that buildings on campus remained heated and cooled with enhanced ventilation during the pandemic. As people question the future of office-versus-home arrangements for work, education, and research, the emission implications of scenarios and policy prescriptions could be assessed using data from this project.

York provides globally significant leadership in the measurement of Ecological Footprint and Biocapacity through its Ecological Footprint Initiative which produces the National Ecological Footprint and Biocapacity Accounts. Since 2019, the accounts have been produced through an experiential education arrangement between EUC and FODAFO to offer MES students the opportunity to be trained in sustainability informatics as part of their customized Plan of Study. As the initiative grows to become more recognized across York, and embodied withing broader clusters of data-oriented and sustainability-focussed research, there grows a need to broaden the scope of actionable data-oriented research projects. The database developed for this project, and its data, could be used to support training in data analysis, informatics, metrics, and data visualization. This project could also help to inform other universities which are equally challenged to assess their broad scope of emissions. This project could also help to inform CAUBO with its interests in supporting university-level emission assessments. York has an opportunity build upon its global recognition of Ecological Footprint and Biocapacity accounting to include enterprise-wide emissions accounting. Ideally results of this project could be shared with the world by mobilizing this research through presentations and publications.

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