Greenhouse Gas Inventory: 2015 Emissions

Project Report

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Disclaimer

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Executive Summary

The reporting of greenhouse gas emissions by large businesses, organizations and institutions is becoming more common as environmental law and regulations change to create a more environmentally stable economy. As of 2004, Environment and Climate Change Canada began requiring these business and educational entities to accurately report on their annual carbon emissions (Environment Canada, 2010). In 2015, Western signed onto the Paris Pledge to help with global climate change, committing to reducing Westerns carbon footprint and greenhouse gas emissions over the next decade. This 2015 Greenhouse Gas Inventory was conducted to understand Western's carbon footprint since 2009 and benchmark their progress in greenhouse gas reduction.

Western University created their first Greenhouse Gas Inventory report in 2009 that covered emissions under three scopes. Scope 1 represents direct emissions such as natural gas combustion; Scope 2 represents emissions from purchased electricity and Scope 3 represents indirect emissions such as travel and commuting habits. Direct emissions are defined as emissions Western would have operational control over while indirect emissions are defined as emissions Western may not have operational control over. Using the Campus Carbon Calculator developed by Clean Air-Cool Planet Western quantified their Scope 1, 2 and 3 emissions from a variety of sources. In total, Western's 2009 emissions were equivalent to 96, 550 tonnes of CO_2e. Scope 1 emissions accounted for the largest portion of total emissions, followed by Scope 2 and 3, respectively. 2009 emissions calculation was designated to become the baseline for future inventories. It should be noted that Western is only mandated by environmental law to report their scope 1 emissions. Reporting on the other two scopes is done to ensure a holistic understanding of source emissions attributed to the main campus.

Since 2009, Western has successfully reduced their carbon emissions by 12% as a result of energy conservation initiatives and demand management strategies. Example of projects include: LEED certification of 9 buildings, LED lighting building retrofitting and the creation of the energy dashboard that helps Western manage energy demand across campus.

The 2015 Greenhouse Gas Inventory shows an overall decrease in total emissions since 2009. In the same fashion as the 2009 inventory project, the Campus Carbon Calculator was used to quantify emissions. However, the calculator had been updated since 2009 and created some challenges for comparison purposes. Nevertheless, annual emissions for the calendar year 2015 were calculated to equal 90209.493 tonnes of CO_2e. Of this, the largest contributor of emissions was Scope 1 followed by Scope 3 and Scope 2, respectively.

To understand emissions reductions, an analysis between 2009 and 2015 emissions was conducted but challenges were noted. During the analysis, it was found that the updated calculator used for 2015 data was more accurate than the 2009 version. This was due to the fact that some data was not accurately input into the 2009 calculator and discrepancies in emissions

factors for source categories were present. As a result, a recalculation was made to the 2009 baseline in order to accurately compare 2009 and 2015 data.

Using the recalculated baseline, comparisons between 2009 and 2015 were made. The recalculation of 2009 emissions was now equal to 97,521.7 tonnes of CO_2e. Notable increases were associated to emissions from landfilled waste, faculty and staff commuting and paper purchasing. A full display of the recalculated data for 2009 can be seen in Appendix 1.

In comparison, 2009 emissions were higher than 2015 despite the increase in population and operations. The main reason for 2015 decreases was from purchased electricity emissions. In 2014, Ontario successfully phased out coal as an electricity generation source. As a result, 2015 emissions for purchased electricity were 79% lower than 2009. Other noteworthy differences in the data between 2009 and 2015 were the increase in emissions from student commuting habits, the decrease in paper purchasing emissions and the inclusion of study abroad student travel emissions for 2015. Student commuting accounted for 16% of total 2015 emissions and study-abroad travel accounted for 6%. Overall increases in travel, transportation and commuting habits were prominent, accounted for 31% of total emissions for 2015.

Recommendations were made from the analysis under five categories: inventory process, energy, travel, transportation and commuting, waste and purchasing and supply chain. The following are examples of recommendations Western could pursue for future inventories:

Create a Greenhouse Gas Data Collection System- Standard data storing system for source categories across campus to eliminate inaccurate data collection

Create Western Specific Carbon Calculator for Scope 1, 2, and 3 emissions – Eliminate uncertain information sources for emission factors and limitations form third-party sourced carbon calculators.

Continued Investment into Long-Term Energy Conservation Projects – Investments into building retrofitting, LEED certifications, occupancy sensors and replaced inefficient equipment

Renewable Energy Technology Investments – Research and feasibility study into implementing renewable energy technology to reduce reliability on purchased energy

Offer Discounted Bus Pass Rates to Staff and Faculty – Reduce the personal vehicle commuting

Encourage and Invest in Telecommunications Technology – Increase online-education and phone/video conferencing

Expand Organics Programs – Collect organics campus wide and pilot on-campus composting

Move from Dual Stream to Single Stream Recycling – Make recycling more convenient to the average campus community member and increase diversion rates

1. Background

In 2004, Environment and Climate Change Canada began requiring greenhouse gas emissions reporting for companies, organizations and institutions. Using the Intergovernmental Panel on Climate change (IPCC) approach, organizations are required to determine their emissions yearly by using the most accurate information and methods available (Environment Canada, 2010). Reporting emissions defined in the Scope 1 category, is required by law and must be third party verified while Scope 2 and 3 reporting is voluntary (Ontario Ministry of the Environment and Climate Change, 2009). Western University reports emissions in all three categories in order to understand the impact it has on the environment and to take responsibility for its carbon footprint.

1.1. Paris Pledge

The 2015 UN Climate Change Conference announced an ambitious target of limiting the global temperature rise to less than 2 degrees Celsius with the global help of business, institutions and cities. Western University was one of these institutions to sign the Paris Pledge for Action alongside many other global communities. This pledge is a commitment to reducing Western's carbon footprint and greenhouse gas emissions. The goal is to meet or surpass the targets that were set out in the COP21 conference. While Western is already a leader in this commitment to lowering greenhouse gas emissions, the motion to sign the pledge is just one more step in meeting these climate goals. Since 2009, Western has achieved a 12% reduction in emissions despite the growth of the campus community and infrastructure. This is the result of impressive energy conservation projects such as the achievement of LEED certified buildings and an energy dashboard to help manage energy demand on campus (Hughes, 2016).

a. 2009 Quantification

In 2009, Western University created their first greenhouse gas inventory emissions report. In a response to the mandate of government regulations, Western enacted a project to determine their Scope 1, 2 and 3 greenhouse gas emissions (Figure 1). This emissions inventory was based on the Greenhouse Gas Protocol Initiative Corporate Standard (GHG Protocol) which is a policy-neutral set of guidelines for designing a GHG inventory. Using Western's main campus as its geographical boundaries, the inventory consisted of an aggregation of different source categories and emissions that required data collection from different areas of campus. While not all data came from direct documentation, nearly 95% of the information was collected.

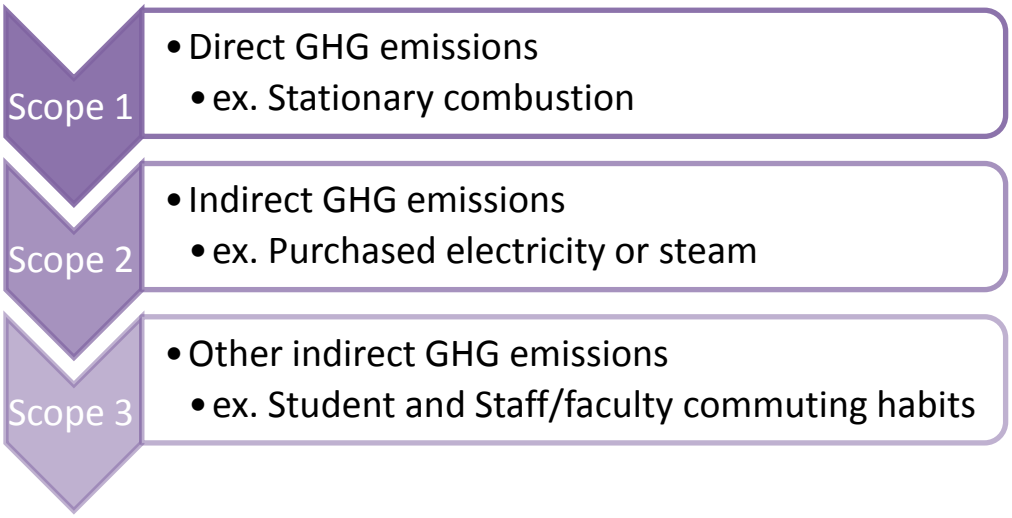

Figure 1. Definitions of Scope Emissions

Using the Campus Carbon Calculator (Canadian Version) that was created by Clean Air-Cool Plant the quantification of emissions was completed. This calculator considers indirect sources and purchased energy as part of the quantifications and was therefore used to offer Western a better understanding of their carbon footprint in all three Scopes. For the purpose of qualifying for AASHE, some modifications were made to calculator and two quantification tools were developed to meet the requirements under the GHG Protocol. Under the Campus Carbon Calculator version 6.0, the resulting emissions were 96, 550 tonnes of CO_2e emissions, the majority contributed by Scope 1 emissions (Figure 2).

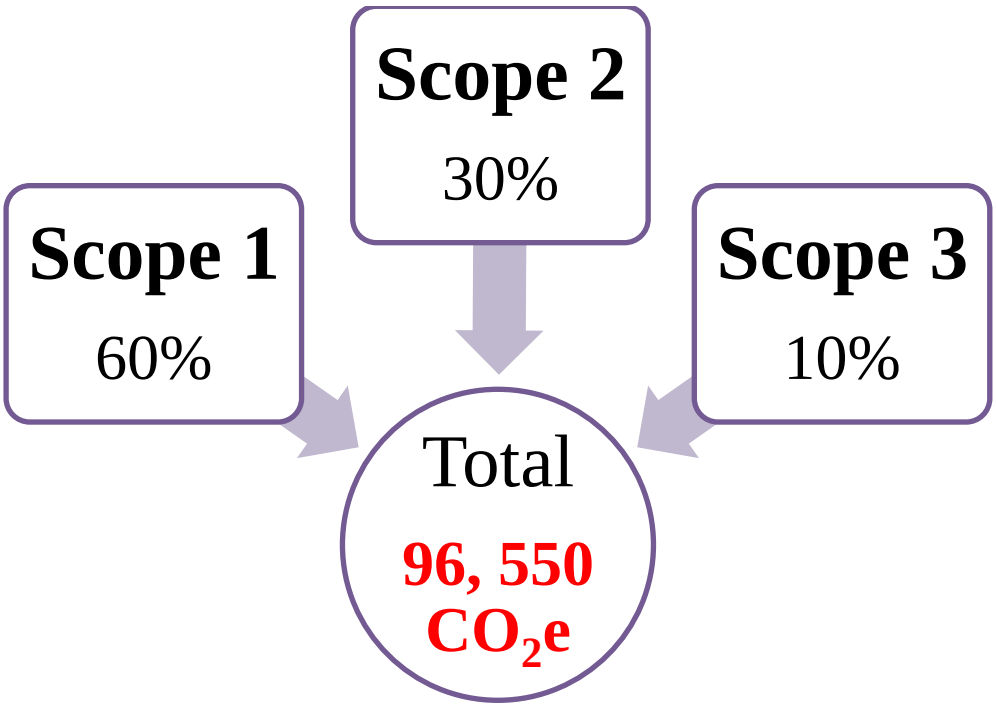

Figure 2. Scope Emissions as a Percent of Total Emissions for 2009

It was found that natural gas use had increased by 48.89% on Main Campus since 1990 and total emissions had increased by 53.57%. It was concluded that Western should be at 32,630 tonnes of CO_2e by 2014 in order to meet the targets set by Ontario's Climate Change Action Plan that was in action in 2010. Below Figure 3 shows the results of the 2009 emissions broken down by each Scope.

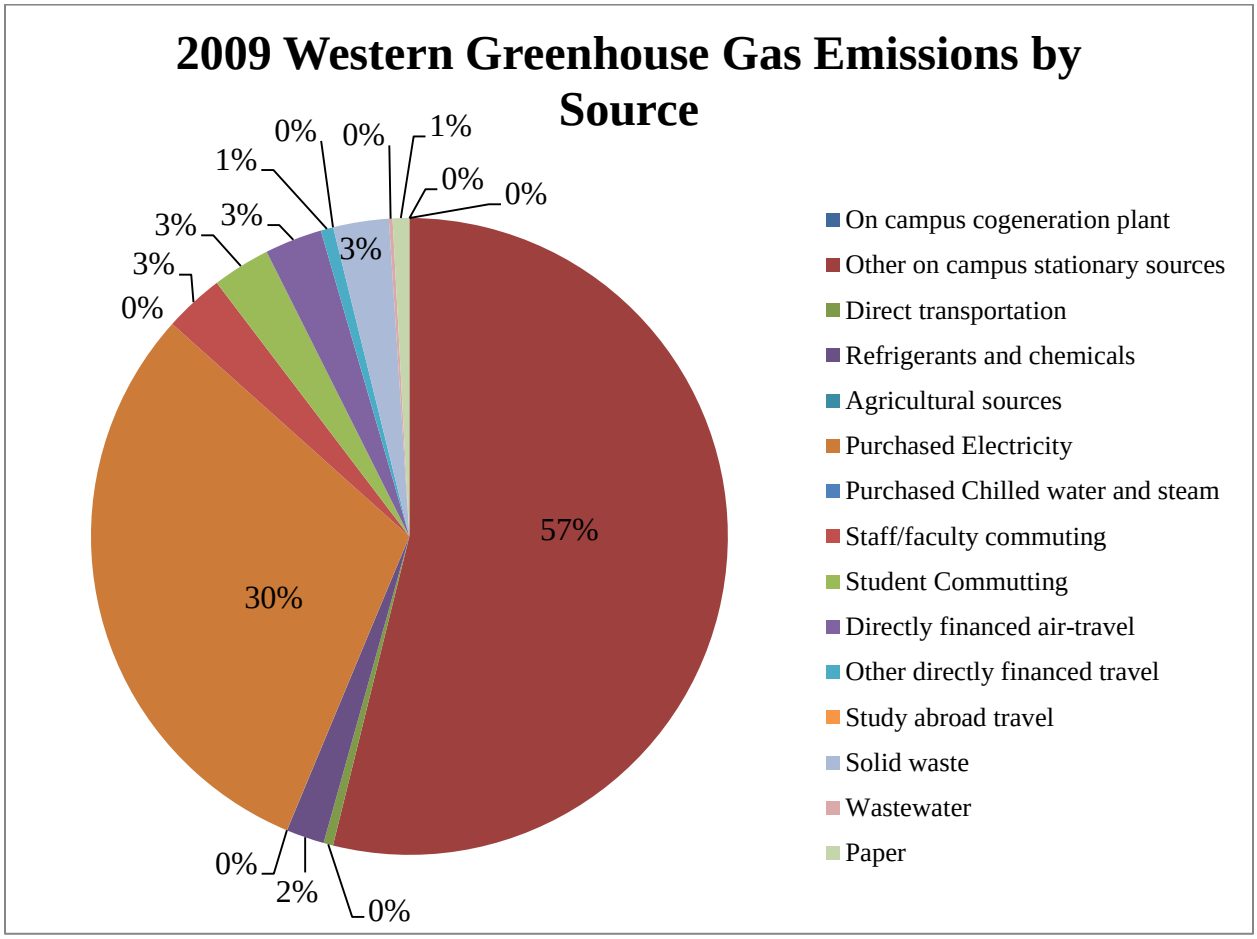

Figure 3. 2009 Western GHG Emissions by Source Category Before Recalculation

b. Project Goals and Objectives

Since 2009, Western has made a commitment to reporting on Greenhouse Gas Emissions in order to better understand their environmental impact and to comply with government regulations. The purpose and goals of the 2015 Greenhouse Gas Inventory project is to benchmark the success of Western's energy and emission conservation efforts, identify issues and challenges associated with carbon emission sources and make recommendations for greenhouse gas reduction strategies. This will help Western reach future institutional, provincial, federal and global targets.

With the intention of reaching these goals, specific objectives were achieved to complete this project. The objectives for the project were to:

1. Create Greenhouse Gas Inventory of Western's Scope 1, 2 and 3 emission sources
2. To identify challenges, limitations and opportunities to greenhouse gas reporting strategies
3. To create recommendations on how Western can reduce their greenhouse gas production in operations, purchasing etc.
4. To collaborate across internal and external stakeholders and make them aware of the impact the Western community has on a global scale by providing them with the results of the inventory.
5. Gather a complete inventory of Scope 1, 2 and 3 GHG emissions to be used as part of Western's 2017 STARS submission

2. Geographical Boundaries and Scope

The geographical boundaries to create the inventory were determined to be Western's Main Campus property in North London, Ontario. Western's Main Campus was determined in 2009 through meetings with facility engineers and managers. Western's three affiliated institutions (Brescia College, Huron College and King's College) and other facilities (Perth Drive Complex, Eight Level Parkade and the Research Park) were not included because Western has no operational control over any of these facilities.

3. Emissions Sources

Western is a large and diversified institution that has many different types of operational activities and processes taking place such as building construction, research and maintenance that are sources of greenhouse gas emissions. In 2009, a screening process was done to determine the possible emission sources for Western University facilities. The emission sources were identified as:

1. Direct emission
2. Purchased Energy emissions
3. Indirect emissions

According to the GHG Protocol, direct emissions are defined as "emissions from sources that are owned or controlled by the reporting entity (Greenhouse Gas Protocol, 2012). This would include anything that the University owns and operates such as the Power Plant. Indirect emissions are emissions that come from sources that are not controlled by the reporting entity and are a consequence of the activities conducted by the entity (Greenhouse Gas Protocol, 2012). For Western, this would include activities such as business travel, water use and waste production.

4. Inventory Scopes

Emission sources that were identified were classified under three different scopes: Scope 1, Scope 2 and Scope 3 (Table 1). The emissions that are considered direct emissions, such as stationary sources of energy on campus, were classified under Scope 1. Scope 2 emissions included sources of purchased energy such as electricity and indirect emissions were classified under Scope 3.

Table 1. Explanation of Source Emissions by Scope

Scope 1: Direction emissions	
Source	Includes
Stationary Combustion	-Natural Gas combusted on campus -Diesel combusted on campus -Propane combustion
Refrigerant and Chemicals	HFCs (R-134, R-404A) -HCFs (R-22, MP-39, R-141B) -SF_6
Direct transportation	-Gasoline -Diesel -Electric Vehicle
Fertilizers	-Organic and synthetic

Scope 2: Purchased emissions	
Source	Includes
Purchased electricity	-Electricity in kWh use on campus

Scope 3: Indirect Emissions	
Source	Includes
Faculty/ Staff Commuting	-Automobile, bus commuting to campus
Student Commuting	-Automobile, bus commuting to campus
Directly financed outsource travel (Air)	-Air travel sponsored by the university
Directly financed outsource travel (Train)	-Train travel sponsored by the university
Study Abroad Travel	-Air travel by students complete academics abroad in a foreign country
Solid Waste	-Incinerated Waste (not used for on campus) -Landfill waste in tonnes with no CH4 recovery -Landfill waste in tonnes with CH4 recovery and Flaring -Landfill waste in tonnes CH4 recovery and electric generation
Wastewater	-% of wastewater treated aerobically -% of wastewater treated anaerobically
Paper	-% Recycle content of paper
Offsets	-Green Power Certificates

5. Emissions Data

5.1. Data Management

A data management system was developed and used to help manage the information in an organized way and help keep records for reporting bodies. The system includes four parts:

1. Consultation
    a. This has the files, activites and documents that were used as reference for the data collection and management
2. Control
    a. This involves the activites and files to help keep track of the information and the data that was requested and received.
3. Information Sources
    a. The actutal files that were received, additional research and reference to sources and paper records. Paper sources were transcribed into electronic files and was used as raw data.
4. Processing and collection
    a. This inclues the relevant information that was processed from the received data that could be used in the calculator.

5.2. Data Collection and Processing

Information sharing at Western can be quite difficult due to the size and departmental diversification of the organization. For this reason, the information and data that was used for the quantification of 2015 emissions inventory was conducted in a variety of ways. Through emails, phone calls, personal communication and surveys information was collected from internal coworkers and external partners. Data that was collected was presented in a variety of forms that include email responses, phone calls, personal communication, hard-copy bills and paper records, electronic files and survey responses. Table 2 lists the sources of the information attained to complete this project.

In addition to collecting emission source specific information for quantification, research was conducted to update the CA-CP Carbon Calculator. The CA-CAP Carbon Calculator was taken over by the University of New Hampshire's Institute of Technology and was last updated in the year 201 to version 6.85. As a result, changes to emission factors needed to be made to ensure accurate information was being calculated for the inventory using 2015 emissions factors.

Table 2. List of the source of data and information for 2015 GHG inventory by scope

Scope	Data/Information Collected	Source of Information
1	Distillate Oil (#1-4)	Physical Plant
1	Natural Gas	Facilities Engineering
1	LPG (Propane)	Physical Plant
1	Fleet diesel use (total volume)	Stores and Transportation
1	Fleet gasoline use (total volume)	Stores and Transportation
1	Diesel (total use for generators)	Physical Plant
1	Refrigerants (types)	Stores
1	Fertilizer (total amount used organic and synthetic)	2009 GHG Inventory
2	Electricity (amount used)	Facilities Engineering
3	Student Commuting (survey)	Qualtrics Survey Platform
3	Staff Commuting (survey)	Qualtrics Survey Platform
3	Student (number or full-time, part-time)	Office of Institutional Planning and Budgeting
3	Staff (number or working people on campus)	Office of Institutional Planning and Budgeting
3	Directly Financed Outsourced Travel (train-total distance travelled)	Financial Services, Procurement, VIA Rail
3	Directly Financed Outsourced Travel (airplane-total distance travelled)	Financial Services, Procurement, FCM Travel Solutions
3	Paper Use (% recycled & total amount purchased)	Procurement
3	Solid Waste (sent to landfill and produced on campus)	City of London
3	Solid Waste (landfill flared and gassed)	City of London
3	Wastewater Treatment (% aerobic and % anaerobic)	City of London
3	Green Power Certificate (purchased)	Facilities Engineering
3	Study Abroad Travel (students Alternative Spring Break-- total distance travelled one-way)	Student Success Center
3	Study Abroad Travel (students ABS-- total distance travelled one-way)	Western International

5.3. Challenges and Limitations

As with any large project challenges and limitations were posed while creating the 2015 inventory of greenhouse gas emissions. Since much of the system and inventory design was set out in 2009, there were no issues that were present during this stage. The challenges and limitations presented itself during the data and information collection stage. Identified emissions sources occurred in a variety of operations across campus and off-campus that were managed differently. Therefore collecting information was quite difficult because every area of operations had a different way of storing data. These varied forms of information and data often made it hard to extrapolate data or verify the accuracy of information which could mean gaps in the information being collected.

Table 3. Summary of Challenges and Limitations of Data Collection Process

Challenges and Limitations of Data Collection	
Challenges	Limitations
-Variability of received data **- Difficulty finding correct information source**	-Data availability -Data collection timeline -Quality of emission source data -Differing data storing systems

Another challenge that was present during data collection was the response rate of internal and external contacts. For instance, emails and phone calls to respective operations managers were made in June 2016 and some information and data for quantifying emissions was not received until August 2016. This could be attributed to the months the inventory was conducted as many Western staff often takes vacation during the summer months. However, this made it quite difficult to create the inventory in a timely manner and slowed down the process of quantification.

6. Quantification

In 2009 quantification of the GHG emissions on campus was completed using three different calculation tools. However, the 2015 data was only quantified using the Canadian Versions Campus Carbon Calculator.

6.1. Campus Carbon Calculator

Developed by the Clean Air-Cool Plant (CA-CP), this calculator is a tool for universities to document and report on greenhouse gas emissions as accurately and transparent as possible. In 2014, the University of New Hampshire's Sustainability Institute (USNH, 2016) took over the Campus Carbon Calculator and offers it in downloadable Excel Format spreadsheet on their website. This calculator has default values that can be used for Canadian quantifications of emissions that were used to help quantify Western's emissions. The carbon calculator is a widely

used GHG quantification tool for educational institutions and it used by more than 90% of the U.S. universities and colleges that report their emissions publically (USNH, 2016).

As previously mentioned, the Campus Carbon Calculator includes scope 1 2 and 3 that has been tailored toward educational greenhouse gas emissions requirements for educational institutions. This document is very intricate and includes instructions, troubleshooting, emissions projections and emissions graphing tools and is pre-programmed to perform all necessary calculations. It is based on workbooks by the Intergovernmental Panel on Climate Change and the GHG Protocol calculators. The most recent Canadian version, 6.85, includes specific values for emission factors that are often province specific and indicates the units that the data must represent in order to quantify the emissions properly. It should be noted that when a source category was not applicable Western it was coloured grey and left empty on the 'Input' Worksheet. This was to ensure that there was no missing data for the inventory. The cells that were coloured red represented emissions information that was not available at the time.

The information for emissions was presented in many different spreadsheets that all corresponded to specific CO_2 equivalence calculations. For the purpose of creating a complete inventory, the final emissions totals used were the ones calculated under the "S_eCO_2_Sum" tab and spreadsheet.

6.2. Challenges and Limitations

While UNHS took over the calculator in 2014, the Canadian default values have not been updated since 2012 or since version 6.85. Therefore important updates were made to accommodate changing emissions factors. As well, some manipulation of the Excel document was made in order to include the 2015 year in the calculator. This was because the 'Input' tab in the calculator did not go past 2012. Additional lines could not be added to include the 2015 emissions due to the fact that the calculator projected emissions from 2013 on. Therefore, 2015 emissions factors were input into the 2010 emission factor tabs for factors that had changed since 2012.These cells were then labelled as 2015 instead of 2010. Figure 4 shows how this change is displayed in the calculator.

Other challenges included the lack of communication offered by UNHS. When the previous issue with the calculator presented itself, UNHS calculator information desk was contacted with no answer back. This stalled the inventory process as we had to manually figure out how to update the calculator without corrupting the pre-calculation tools.

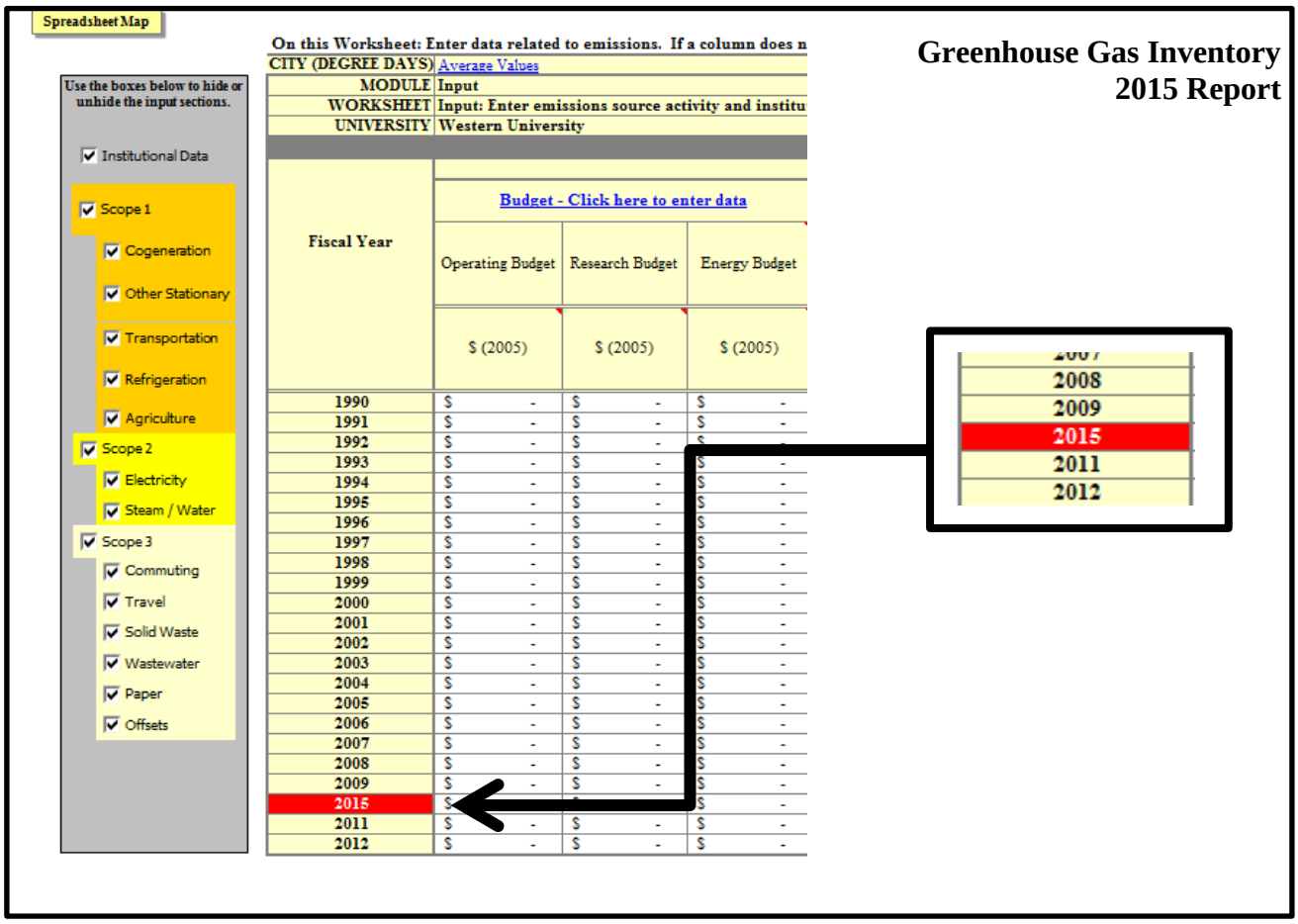

Figure 4. Changes made to version 6.85 of the Campus Carbon Calculator

7. Results

The follow section presents all the data and findings from the 2015 emissions inventory. Information presented was retrieved from the Campus Carbon Calculator quantification tool's default calculations.

7.1. Scope 1 Emissions

As defined in previous sections, Scope 1 emissions include the direct emissions produced on Western's central campus. This includes emissions of fuel consumed from the power plant, campus fleet and emergency generators. It also includes emissions from refrigerants and chemical use and agricultural product use. Table 4 shows all of Western's stationary combusting emissions, presented in $CO2_e$. The largest contributor of emissions is from "other on-campus stationary sources" that include propane and natural gas use, diesel used in emergency generators and distillate oil. Any gasoline or diesel consumed by the campus fleet is represented in the direct transportation source category. This is fleet fuel use from all campus vehicles over the 2015 year. Since Western does not have a co-generation station on campus, emissions from the category "on- campus cogeneration plant" was not produced.

Table 4. Scope 1 Emission by Source for 2015

2015 Scope 1 Emissions	
Source Category	Tonnes CO2e
On campus cogeneration plant	0
Other on campus stationary sources	51308.5
Direct transportation	529.6
Refrigerants and chemicals	1208.433
Agricultural sources	4.6
Total	**53,051.133**

In total there are six refrigerants and chemicals used on campus. Most of the chemicals fall under the Hydrochlorfluorcarbons (HCFCs) which have 2-5 percent of ozone-depleting substances and have a ban in effect on the use of the substance (ECCC, 2016). The only source captured under "agricultural sources" was fertilizer use. Due to the fact that information was not available for the amount used in 2015, values from 2009 fertilizers usage were applied to the 2015 values.

7.2. Scope 2 Emissions

The following information represents Scope 2 emissions (Table 5). The only purchased emissions associated with Western's main campus come from electricity. This is because no chilled water or steam is purchased because it is produced in the on-campus Power Plant.

Table 5. Scope 2 Emissions by Source for 2015

2015 Scope 2 Emissions	
Source Category	Tonnes CO2e
Purchased Electricity	6040
Purchased Chilled water and steam	0
Total	**6,040**

7.3. Scope 3 Emissions

The 2015 year GHG inventory was focused on capturing Scope 3 emissions data. These are often the hardest emissions to capture since they are indirect emissions that Western does not have any operational control over. These include financed staff and faculty travel, commuting habits, waste production, wastewater treatment, paper purchases, and study abroad travel. Efforts to capture as many sources from these emissions resulted in more data being quantified for the 2015 year. Table 6 displays all the Scope 3 emissions sources captured in the 2015 GHG inventory. Note that the purchase of Green Energy Certificates resulted in a greenhouse gas emission reduction for 2015.

Table 6. Scope 3 Emissions by Source for 2015

Source 3 Emissions	
Source Category	Tonnes CO2e
Staff/faculty commuting	2846.36
Student Commuting	14410.7
Directly financed air-travel	4975.7
Other directly financed travel	12.7
Study abroad travel	5316.1
Solid waste	3065.9
Wastewater	203.6
Paper	380
Green Certificates	-92.7
Total	**31,118.36**

Commuting habits of staff, faculty and students was the most challenging emissions source to determine. Using the program Qualtrics, surveys were administered to faculty, staff and students to help determine the commuting habits of the Western community. The highest CO_2e quantity is attributed to student commuting at 14,410.7 CO_2e, while study abroad travel is the second highest at 5316.1 CO_2e. Following behind these sources was directly financed-air travel, solid waste and staff/faculty commuting contributing 4,975.7 tonnes CO_2e, 3,065.9 tonnes CO_2e and 2,846.36 tonnes CO_2e, respectively.

8. Analysis of Results

In 2015, the total greenhouse gas emissions were equal to 91,439.593 tonnes CO_2e. The largest contribution came from Western's Scope 1 emissions, totaling 54,281.233 tonnes of CO_2e. These direct emissions accounted for 57% of Western's total CO_2e emitted. The second largest greenhouse gas contribution comes from indirect sources under Scope 3 emissions. In fact, 31,118.36 tonnes of CO_2e came from Scope 3 emissions accounting for 34% of total emissions. Scope 2 emissions only accounted for 7% of the total CO_2e emitted and was equal to 6,040 tonnes of CO_2e (Table 7).

Table 7. Summary of total emissions by Scope for 2015

Total 2015 Emissions	
Scope	Tonnes CO2e
Scope 1	53051.133
Scope 2	6040
Scope 3	31118.36
Total	**90,209.493**

Analyzing Scope 1 further, it appears that about 97% of the 53,051.133 tonnes CO_2e came from the use of natural gas, propane and oil on campus. Scope 1 emissions have been the largest contributing factor to Western's carbon footprint in the past; therefore it is no surprise the data presents itself this way again. This is a result of the amount of energy Western needs to run its daily operations. Western supplies all buildings on campus with chilled water during the summer and steam during the winter, resulting in a significant use of energy to meet the demand. A complete breakdown of Scope 1 emissions can be seen in Figure 5 The other 3% of emissions under Scope 1 stem from refrigerants and chemicals (2%), direct transportation fuel consumption (approximately 1%) and fertilizer use (0.008%). It should be noted that there was no change in the emissions associated with fertilizers. No data was found for fertilizer use in 2015 and therefore it was assumed that fertilizer used for 2009 would have remained relatively the same for 2015.

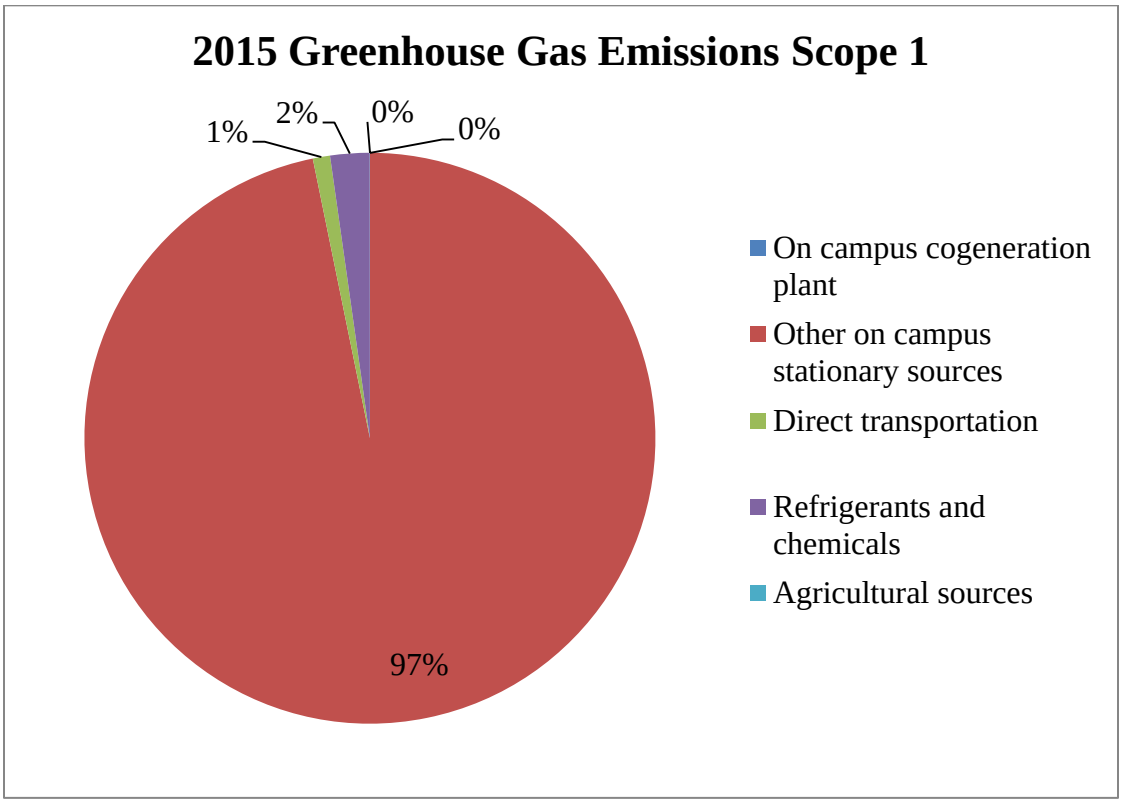

Figure 5. Percent of Scope 1 Emissions by Source Category for 2015

Scope 2 emissions were only comprised of purchased electricity emissions. Western does not purchase any chilled water or steam since they produce it in the Power Plant. On the other hand, it seems that Scope 3 emissions come from a variety of sources. Student commuting contributes the most emissions under Scope 3 accounting for 46% of the 31,118.36 tonnes CO_2e. This is a large contribution of emissions coming from students commuting back and forth to class. In fact, student commuting makes up 16% of the total 2015 emissions (Figure 6). It should be noted that these numbers are based on the assumption that students are making one-way trips to campus 5 days a week for three academic terms.

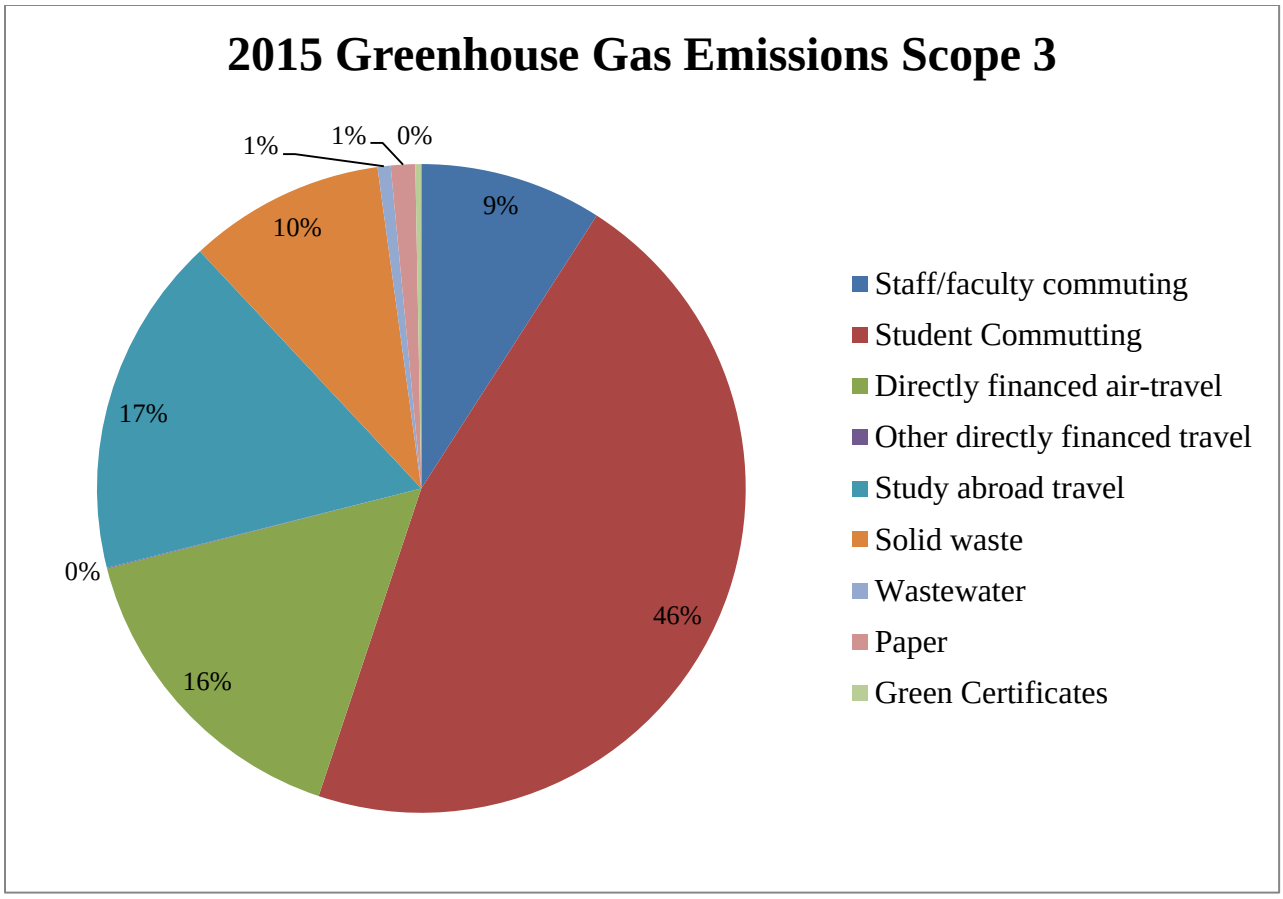

Figure 6. Percent of Scope 3 Emissions by Source Category for 2015

Another large contributor to the 2015 emissions under Scope 3 is the study-abroad travel. These emissions are a result of students traveling abroad to complete course work or participate in international exchange programs. While this is a large portion it should be noted that some data collected was inadequate and was excluded from the inventory. Therefore emissions from study abroad travel may increase in future inventories as a result of more accurate information being stored for international travel destinations.

In 2015, 'other on-campus stationary sources' accounted for the most greenhouse gas emissions at Western. As mentioned, 57% of total emissions come from the use of natural gas, oil, diesel and propane for energy to provide Western with essential services such as heating and air conditioning, as well as back-up energy in case of emergencies. Student commuting contributed the second highest amount of CO_2e at 16%. This could becoming an increasingly bigger issue as Western continues to grow as an institution. Unexpectedly, purchased electricity overall only accounted for 7% of the total emissions. The lowest contributions of greenhouse gas emissions at Western include fertilizer use, other directly financed travel, wastewater, paper purchases, and direct transportation fuel use accounting for 0.005%, 0.014 %, 0.223%, 0.42 % and 0.6%, respectively (Figure 7).

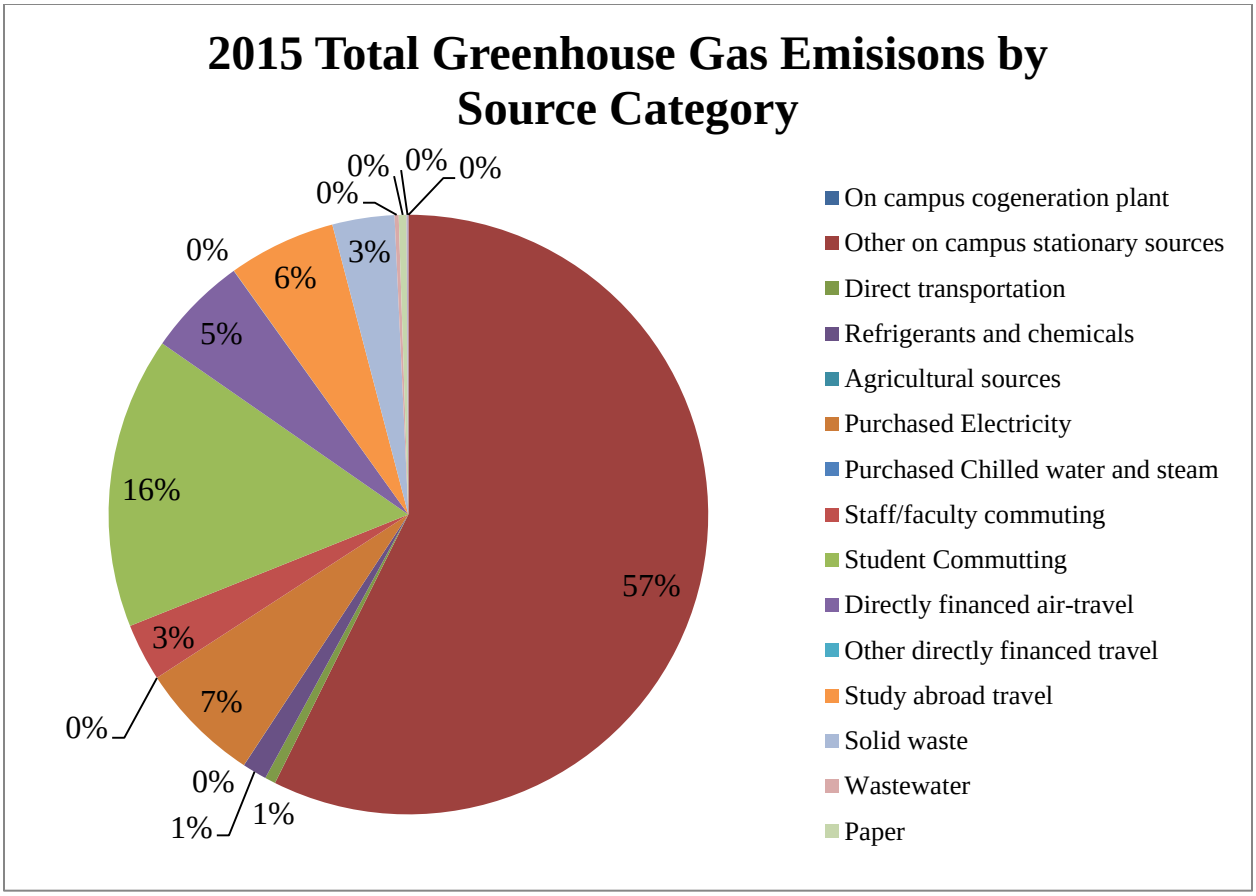

Figure 7. Percent of Total Emissions for 2015 by Source Category

9. Comparisons with 2009 Results

In order to make a direct and more accurate comparison between the 2009 and 2015 data, changes to the baseline were made. After initial comparisons with the 2009 data, there were many discrepancies within the data as a result of major changes in the new version of the Campus Carbon Calculator and some inaccurate data recorded in 2009. While a few changes in emissions could be explained, such as the change in purchased electricity emissions, some data needed to be manipulated to make a proper comparison. As a result a recalculation of the 2009 baseline was made using version 6.85 of the Campus Carbon Calculator. This made a comparison more accurate for the following analysis and corrected errors on the previous 2009 baseline for future benchmarking purposes.

The year 2009 is used as the baseline for benchmarking progress on Western's greenhouse gas reductions. The total greenhouse gas emissions in 2009 using the Campus Carbon Calculator was 96, 550.35 tonnes of CO_2e and was recalculated to be 97, 251.7 tonnes of CO_2e using the updated version of the calculator. In 2015, this total is equal to 90, 209.493 tonnes of CO_2e. Overall, according to the Campus Carbon Calculator, Western has reduced its greenhouse gas emissions by 7.2% since 2009. Table 8 compares 2009 and 2015 emissions by Scope and source category.

Table 8. Comparison of Recalculated 2009 Baseline and 2015 Total Emissions by Source Category

2009		2015	
Scope 1 Emissions		Scope 1 Emissions	
Source Category	Tonnes CO2e	Source Category	Tonnes CO2e
On campus cogeneration plant	0	On campus cogeneration plant	0
Other on campus stationary sources	52378.3	Other on campus stationary sources	51308.5
Direct transportation	471.6	Direct transportation	529.6
Refrigerants and chemicals	1883.1	Refrigerants and chemicals	1208.433
Agricultural sources	4.6	Agricultural sources	4.6
Total	**54737.6**	**Total**	**53051.133**
Scope 2 Emissions		Scope 2 Emissions	
Source Category	Tonnes CO2e	Source Category	Tonnes CO2e
Purchased Electricity	29507.7	Purchased Electricity	6040
Purchased Chilled water and steam	0	Purchased Chilled water and steam	0
Total	**29507.7**	**Total**	**6040**
Source 3 Emissions		Source 3 Emissions	
Source Category	Tonnes CO2e	Source Category	Tonnes CO2e
Staff/faculty commuting	2951.6	Staff/faculty commuting	2846.36
Student Commuting	2859	Student Commuting	14410.7
Directly financed air-travel	2830.9	Directly financed air-travel	4975.7
Other directly financed travel	622.6	Other directly financed travel	12.7
Study abroad travel	0	Study abroad travel	5316.1
Solid waste	2740.7	Solid waste	3065.9
Wastewater	183.6	Wastewater	203.6
Paper	818	Paper	380
Green Certificates	0	Green Certificates	-92.7
Total	**13006.4**	**Total**	**31118.36**
Total 2009 Emissions	**97251.7**	**Total 2015 Emissions**	**90209.493**

9.1. Purchased Electricity

The 2009 purchased electricity CO_2e amounts are much higher than the 2015 emissions despite the increases in electricity consumption at Western. In 2009, emissions from purchased electricity accounted for 29,507.7 tonnes of CO_2e or 30.45% of the total emissions. However, the emissions from purchased electricity in 2015 are only equal to 6,040 tonnes of CO_2e or 6.69% of total emissions. This major difference is attributed to the change of the CO2e emissions factor

for electricity in the Campus Carbon Calculator from 0.000197001 CO_2e in 2009 to 0.000040011 CO_2e in 2015. This 2015 emissions factor was provided by the Ministry of Energy and is a direct reflection of the change in the generation of electricity in Ontario. In 2014, Ontario became the first jurisdiction in North America to eliminate coal combustion as a source of electricity generation (IESO, 2016). This elimination of coal saw the single most reduction in carbon emissions in North America and explains the major reduction in emissions from Western's electricity purchases (Ontario Ministry of Energy, 2016).

9.2. Traveling and Commuting

In comparison with 2009 data it would seem that traveling, whether that is internationally or to and from campus, has increased over the past few years. Emissions in the source categories for staff, faculty and student commuting, international and study abroad travel and directly-financed travel all show increased for 2015. The inclusion of study-abroad travel emissions in the 2015 inventory is also a major difference from 2009 totals. This source category was not included in the 2009 inventory but made up a large portion of the 2015 emissions at 5,316.1 tonnes of CO_2e or 6% of total emissions. Including study-abroad travel in Western's GHG inventory is therefore quite important for future inventories. As previously mentioned, there was a large portion of the data that was unusable that could have seen a larger emissions total from this source. As well, Western International plans to increase study-abroad travel from 1% of students to 10% by 2019 (Western International, 2014). Therefore, it is very likely that emissions from international travel will increase in future inventories.

The increase in student commuting to campus is quite large. The respondents for 2015 student commuting survey only represented 11% of the student population but accounted for 46% of all Scope 3 emissions and 16% of total emissions. In comparison with the survey results in 2009 that represented 15% of the student population, there was still an increase in emissions by 16% in 2015. Western's student population has grown by approximately 4,000 students over the past 6 years and it would seem that more students are using personal vehicles to get to school. In fact, the number of students who are driving to school has increased by 4% since 2009. It was found that the average number of kilometres travelled by students to get to campus was 25 kilometres in 2015 compared to 3 kilometres in 2009. Therefore student are willing to travel from nearby towns to campus for lectures and exams. The rise in living expenses could be a contributing factor to this increase in students commuting by personal vehicle. The cost of university often include many living expenses such as rent, food and utility bills that can considerable add to student debt loads. According to Statistics Canada, student debt creates a lot of pressure on future net worth, ability to buy a home and ability to create savings (Hsieh, 2014). Thus, living at home may help students take off the extra stress of money problems. Explanations into why this may be occurring should be pursued in the future. Understanding the reasoning for this further would benefit future campus planning. If this tends to be a trend in the future, then planning for more parking would be needed.

Lastly, directly financed air-travel has almost doubled since 2009. The system for recording financed air-travel now comes from an outsourced travel vendor, meaning data was more accurate. FCm Travel Solutions and VIA Rail provided the 2015 kilometres travelled by

university staff and faculty travel and were therefore more accurate because they track and record travel data for their customers (FCM, 2014).

Staff and faculty commuting seems to remain relatively the same in terms of emissions. It is possible that faculty and staff commuting habits are more constant because they are often long-term employees of Western. As well, survey comments placed attention on the fact that Western staff and faculty are not offered a discounted price in public transit which could change the way this population commutes to campus. This may also be a factor for why personal vehicles are used more to arrive to campus.

9.3. Waste Production and Water Use

As a result of Western's growing community and operations, the demand for necessary services on campus has increased thus increasing the GHG emissions associated with these services. Waste on campus has always been a major challenge for Western but with new goals and programs in place, such as the recycling of coffee cups and organics, Western is sure to decrease their waste production on campus. Waste tonnage for original baseline 2009 was less than half of the totals for 2015. However, 2009 waste data may not have been accurate as the "Greenhouse Gas: 2009 Emissions, Appendix I, Emission Sources" states that a mistake in the original source data resulted in a corrected data input for the Campus Carbon Calculator. It should also be noted that reported methane recovery in 2009 saw discrepancies from the data in the calculator and what is explained in 2009 Emissions Appendix I. The calculator shows that no methane was recovered whereas notes in the section 'Scope 3" under solid waste explains that CH4 recovery occurred at the City of London Landfill. This inconsistency in the data also made it difficult to compare emissions from waste generation as half of the methane produced by the waste was recovered through flaring and not documented. This inconsistency could also be supported by the fact that data management systems have changed drastically over the past few years due to changes in technology. This means that with an improved data management system, managers and businesses are better able to track and measure their performance and make improved decisions operations (McAfee and Brynjolfsson, 2012).

By using the recalculated baseline data, waste emissions were more accurate to compare. To make the data more comparable, a calculation was made to the 2015 waste tonnage to reflect the size of the campus population during 2009. As a result, the waste tonnage was changed from 521 tonnes to 1,736 tonnes, therefore making a more accurate comparison to the 2015 waste totals (1942 tonnes). This was done by taking the waste totals from 2015, dividing them by total population to get a quantity of waste per person. This quantity was then multiplied by the population in 2009 to get the new waste tonnage. As mentioned, waste production on campus goes up as the population increases and this will continue to rise in the future. Strategies to address waste challenges more decisively will help decrease emissions and waste produced for the future. Overall, waste emissions in 2015 have increased since 2009 as a result of more waste being produced on campus.

When it comes to wastewater, the slight increase in emissions totals is seems to be attributed to the change in population and wastewater treatment system N_2O emissions factor from 6.69 kg

N_2O/person per year in 2009 to 9.43 kg N_2O/person per year. Both references for emissions factors came from the Canadian National Inventory Report's for 2008 and 2012, respectively.

9.4. Paper and Green Certificates

While there were many notable increases in emissions for source categories over the years, there are also some areas that saw a decrease. For instance, paper purchasing emissions for 2015 decreased by almost 53% since 2009. Not only is this a result of less paper being purchased across campus, but also less paper being purchased at only 0% recycled material.

Table 9. Comparison of 2009 and 2015 Paper Purchased by Percent Recycled Content

2009 and 2015 Paper Purchasing Comparison			
2009		**2015**	
% Recycled	Total kg	% Recycled	Total kg
0%	217, 724	0%	123, 069
30%	0	30%	3, 216
50%	0	50%	2
75%	0	75%	0
100%	0	100%	125
Total Emissions	**619.44**	**Total Emissions**	**380**

The 2015 GHG inventory included an emissions reduction from the purchasing of Green Power Certificates. Purchased certificates secured Western 2,316,000 kWh and saved them 92.7 tonnes of CO_2e for the 2015 year. This opportunity to lower emissions was not explored during 2009 and therefore is not present in the results. Western should continue to explore the option of purchasing green energy credits for the future to help reduce emissions created at campus.

Overall, Western's 2015 emissions were 7.2% lower than 2009. However, most source categories saw an increase in emissions. The reduction from 2009 is reflective of Ontario's decision to eliminate coal as a source of electricity generation which drastically changed the amount of emissions created for this category. Nonetheless, Western's efforts to keep their emissions relatively stable while the campus continues to grow is a great achievement.

10. Recommendations

Despite some minor discrepancies between 2009 and 2015 GHG inventory data, it would seem that Western is becoming more transparent and more accurate in the emissions data reporting. There are many initiatives that Western has done to reduce, not only their emissions over the years, but also their impact on the natural environment. These includes the achievement of LEED certification in 9 buildings on campus, installation of energy meters, the energy dashboard and water meters, the creation of important systems such as the energy dashboard and management system as well as pursuing energy conservation projects (sustainability.uwo.ca). While these initiatives have allowed Western to reduce their emissions and environmental impact over the

years, there are still many programs and initiatives to be explored to help accelerate these reductions.

The following are recommendations based on the 2015 Greenhouse Gas Inventory Emissions results and the data collection and processing procedures of the project. These recommendations are made with the intention to help Western understand their emission sources better and to meet mandatory requirements for compliance purposes.

10.1. The Inventory Process

10.1.1. Creation of a Western Greenhouse Gas Data Collection System

This GHG Inventory project could benefit from the creation of a Western wide GHG inventory collection system. The creation of a standard data storing and report procedure for emission sources would greatly increase the rate at which the inventory can be completed as well as the accuracy of the data being used for quantification. One of the main challenges for the inventory was collecting accurate and pertinent data for each source category, specifically for Source 3 emissions. Therefore, having an integrative system in place where information pertaining to each source category can be input into a single, GHG database. Not only will this make data collection more efficient but also could be used for long-term information storing and comparison of numbers annually. This system would allow the managers or staff involved in the source category data to input the key information for the inventory and could eliminate wait times in data collection.

10.1.2. Creation of a Western Specific Carbon Calculator for Scope 1, 2 and 3 Emissions

With the new Ontario Climate Change Action plan, emissions reporting and reduction strategies are only going to increase in the future. Western will be reporting on their greenhouse gas emissions for years to come and creating a unified and Western specific carbon calculator will be beneficial for the GHG Inventory Process. The Campus Carbon Calculator that is being used for current emissions quantification is useful but was found to have some limitations. Not only was it created by a United States company, but its Canadian version has not been properly updated since 2012. As well, the spreadsheet information used to quantify the emissions is limited to large, metropolitan areas and therefore is not current to the City of London. The creation of a Western specific GHG calculator would eliminate uncertain information sources for emissions factors and ensure that data reported is as accurate as possible because thorough examination of these sources would be conducted by Western staff, specifically, and not be entrusted to a third party organization. This unique calculator would also eliminate inconsistent data for future comparisons as all information for calculations could be updated years if necessary. This would also help drastic data changes to be justified.

10.1.3. Create a Greenhouse Gas Inventory Committee

The process of creating a greenhouse gas inventory at Western could be a lot easier if conversation around source emissions and solutions for minimizing them could be facilitated. The creation of a greenhouse gas inventory committee could allow for a better understanding of

where departments stand in terms of the goals and objectives in order to better address emission values in these areas. This opportunity may allow for open communications of emissions in operations are campus and could facilitate a discussion around carbon emissions reduction strategies for the future. It is recommended that this idea be brought to the attention of the President's Advisory Council on Environment and Sustainability (PACES) in order to explore the feasibility of this committee in the future.

10.2. Energy

By far, stationary combustion is the largest source of carbon emissions for Western University. It accounted for 57% of the total emissions for the 2015 year. Natural gas combustion and electricity use has increased since 2009 as a result of the Western's growth in both population and building space. As well, Western is a research intensive educational institution and runs a lot of important research equipment that consumes large amounts of energy and is often not energy efficient. For these reasons, energy consumption remains high here at Western. Growth at Western is expected to continue as educational programs, research opportunities and operations expand. Therefore, to reduce energy emissions it is vital to conserve energy here at Western. The follow are recommendations to conserve energy.

10.2.1. Continued Investment in Long-Term Energy Conservation Projects

Over the past few years, Western has invested in a variety of energy conservation projects that have been successful in reducing environmental impact and economic cost. Therefore, it is recommended that Western continue to pursue energy conservation projects to help reduce energy consumption on campus. These could include continued efforts to retrofit buildings with more energy efficient technologies such as LED lighting and light sensors, continued efforts to pursue LEED certification in new building projects and upgrading inefficient equipment on campus. These types of projects would be beneficial in helping Western reduce their energy consumption and consequently their emissions. For instance, LED lighting has the potential to save as much as 75% of energy compared to a standard incandescent light bulb and emits less heat than both an incandescent and compact fluorescent light bulb (IESO, 2016). Therefore, pursuit of these projects has the potential to save Western energy in the long-term. While some projects could be costly to implement, there are many opportunities offered by London Hydro and government assistance programs that help support important projects for energy conservation. These energy assistance programs should be pursued to help alleviate economic cost of projects.

As well, to assist in this initiative it is recommended that research be conducted on energy conservation initiatives occurring in universities around the world, not just in Canada, to explore unique opportunities for reducing energy consumption. This would allow for a better understanding of energy consumption challenges faced in educational institutions across the world and may lead to great ideas for conserving energy.

10.2.2. Increased Purchasing of Green Energy Credits and Carbon Offsets

In 2015, over 9 million kWh of renewable energy credits were purchased that offset Western's carbon emissions by 92 tonnes of CO_2e. This may seem small but every ton of emissions saved is a positive impact on total greenhouse emissions and environmental impact. Electricity generation is one of the largest sources of GHG emissions and purchasing renewable energy credits (RECs) can help offset Westerns emissions (Suzuki, 2016). While the elimination of coal has already seen a large reduction in GHG emissions attributed to electricity generation, purchasing these offsets will improve this reduction in the short-term. Not only does this offer opportunities to Western but it also offers support to renewable energy producers and provides financial incentive for developers to create more opportunities for renewable energy generation projects (Suzuki, 2016). It should be noted that this is not a long-term solution to energy consumption patterns and trends and is not counted in the emissions that are reported to the provincial and federal governments.

10.2.3. Invest in Renewable Energy Technology for Electricity Generation and Energy Conservation

The production of energy on campus using renewable resources would be highly beneficial to Western University. Across Ontario, 10 university campuses have installed renewable energy technology such as solar, geothermal, wind and hydroelectric (COU, 2009). Of these 10 campuses, 5 of them reported that between 1% and 10% of their energy comes from their renewable energy source and one campus reported that 31%-40% of their energy is derived from these sources (COU, 2009). As a large educational institution with high energy consumption, Western has the potential to invest in renewable energy technology and follow those campuses that are using this technology to reduce their electricity purchases and consequently, their emissions. It is recommended that Western create a feasibility study to invest in renewable energy technology for the purpose of electricity generation and energy conservation. For instance, a full case study should be done that outlines potential government incentives and the business case in order to present all options to explore the feasibility and benefits of this project.

10.3. Transportation, Travel and Commuting

When combined, transportation, travel and commuting emissions were these second largest emission sources in 2015, accounting for 31% of total emissions. This includes campus fleet, out-sourced travel, student, staff and faculty commuting and study-abroad travel (Table 10). As a result, addressing the transportation, travel and commuting habits of Western's community is necessary to reduce emission from these sources.

Table 10. Total Emissions from Travel, Transportation and Commuting by Source Category

Travel, Transportation and Commuting	
Source Category	**Tonnes of CO2e**
Direct transportation	529.6
Staff/faculty commuting	2846.36
Student Commuting	14410.7
Directly financed air-travel	4975.7
Other directly financed travel	12.7
Study abroad travel	5316.1
Total Travelling Emissions	**28091.16**
TOTAL 2015 EMISSIONS	**90209.493**
Percent of Total Emissions	**31%**

10.3.1. Improve Systems for Collection Study-Abroad and International Student Travel Data

Study-abroad travel contributed 6 % of the CO_2e emissions in the 2015 inventory. This is a noteworthy source of GHG emissions that needs to be explored for future inventories. As mentioned, a significant portion of the international student travel data was unusable as a result of travel destinations not being recorded properly. This unusable information would have increased the amount of kilometres being travelled and therefore gave a better representation of travel abroad emissions. To address this data limitation, efforts to improve the international student travel data collection system for programs such as the "Safety Away Database" should be pursued. To gather more accurate information mandatory input of the city that the student is travelling to should be implemented. This would result in more accurate travel data for the GHG inventory and would allow Western International to benchmark and record trends or destination "hotspots" for international travel programs. It is also highly recommended that study-abroad travel is included in future GHG inventories for a more holistic understanding of Western emissions from all possible sources.

10.3.2. Offer Discounted Bus Pass Rates to Staff and Faculty

Staff and faculty working at the university are often long-term employees that come to campus every day to make a living. It was found that 66% of the staff and faculty are using personal vehicles to get to and from campus and only 12% are taking the bus Table 11. If Western was to offer a discounted bus pass rate, it may persuade staff and faculty who currently drive to campus to start taking the bus to campus, especially for those who live within 10 kilometres from the campus. Therefore, it is recommended that Western pilot the discounted bus pass rate for a year to assess the interest in using this alternative transportation program. Benefits to offering this program could include a reduction in the cars near the university during rush house traffic, a reduction in GHG emissions annually attributed to commuting habits and a reduced demand on the parking services from staff and faculty.

Table 11. Summary of Staff and Faculty Commuting by Method of Transportation

Summary Chart of Staff/faculty Commuting			
Method of Transportation	**# of staff/faculty**	**Average km**	**% of total**
Drive a vehicle	1582	15.22647	66.58249
Carpool	68	10.36765	2.861953
Average km for vehicle (GHG Calculator)		12.79706	N/A
Take a bus	286	6.108014	12.03704
Ride a bike	214	4.948837	9.006734
Walk or jog	191	3.085492	8.038721
Live on campus	8	8	0.3367
Other	27	30.833	1.136364
Total	**2376**	**11.4208154**	**100**

10.3.3. Promote, Encourage and Motivate Others to Carpool

Carpooling could significantly reduce the numbers of cars coming onto campus daily. It was found that only 3% of both faculty and staff and students took advantage of carpooling in 2015. This presents an opportunity for Western to encourage carpooling has an alternative to commuting. While carpooling information is included on all Wester Green Boards around campus, there is more that could be done to encourage this commuting practice. For instance, Western could create some sort of benefit program to those who choose to commute with 1 or more people. These could include preferred parking spots, discounts on parking passes and gas mileage incentives.

Furthermore, the use of a rideshare matching app for staff, faculty and students would allow those looking for carpooling opportunities to find what best works for them. The Comovee App is fully customizable software that helps businesses promote carpooling. A program similar to this could be developed and used across Western to promote more carpooling (Sysware GMBH, 2016). It is recommended that options such as using a rideshare matching app be explored for motivating carpooling as an alternative form of commuting to and from campus.

10.3.4. Further Conduct a Study on Student Commuting Habits

A noteworthy result of the 2015 GHG inventory was student commuting habits. Accounting for 14410.7 tonnes of CO2e of the total emissions, student commuting habits have increased by 17% since 2009. Specifically, personal vehicle travel has increased quite significantly. In 2009, student reported travelling 3 kilometres to campus on average. In 2015, the average kilometres travelled by students in a personal vehicle were 8.3 times higher, equaling to 24.5 kilometres. It was found that some students were travelling from cities such as Toronto meaning they would drive as much as 200 kilometres to get to campus daily for classes. While speculation can be made for reasons behind students commuting in from outside cities, it would be beneficial for Western to truly understand this change in commuting habits. An investigation into the reason behind this could lead to be a better understanding of how to address reducing the emissions from this source category. It is suggested that Western conduct another survey in order to gather

information on reasons why more students seem to be commuting to campus from outside of the city. This will allow Western to address these emissions properly and give an insight into why students choose to commute rather than live in London. A complete breakdown of student commuting by travel method is displayed in Table 12.

Table 12. Summary of Student Commuting Data by Method of Transportation

Summary of Commuting Data			
Method of Travel	**# of Students**	**Average KM**	**% of Total**
Drive a vehicle	671	18.02980626	19.75853946
Carpool	92	31.14673913	2.709069494
Personal Vehicle Average (For GHG Calculator)		24.58827269	
Take the bus	1526	6.351245085	44.9352179
Bike	571	3.295096322	16.8138987
Walk or Jog	147	4.166666667	4.328621908
Live on campus	352	0	10.36513545
Other	37	9.202702703	1.089517079
Total	**3396**	**10.31317945**	**100**

10.3.5. Encourage and Invest in Telecommunications Technology

Where possible, alternatives to travelling should be encouraged through the use of telecommunication technology. Advancements in technology are allowing businesses and educational institutions to expand their operations and enhance their global communication. By offering more opportunities via telecommunications, Western may be able to reduce their emissions from travelling in a few source categories such as directly financed air-travel, other directly financed travel and student commuting. It is recommended that Western offer more online-learning opportunities. This has the potential to reduce the number of students commuting from cities outside of London who has no other option but to live at home. Some benefits of online-learning include: continuous access to multimedia learning experiences and tools, increased communications between the student and the professor and cost-effective solutions to scheduling issues and building space for holding exams and lectures (Mammani, 2015). This would also allow Western to expand their provincial and continental partnership with other universities by being able to offer important or specialized classes in collaboration with programs.

It is also suggested that telecommunications be encouraged when conducting meetings with external stakeholders. Technologies such as Webinars, Skype, and video and phone conferencing should be used where possible as alternatives for travelling to meet with external partners and stakeholders. This could reduce the amount of emissions from directly financed travel by air and train. Opportunities for telecommunications present itself for follow-up meetings, check-ins and updates on projects and AGMs for organizations that staff and faculty are involved in that directly relate to their work.

10.4. Waste

One of the main sustainability goals of Western is to become Zero-Waste by 2022. This ultimately means diverting at least 90% of the waste produced on campus from going to landfill, whether that be through reducing, reusing or recycling programs. Working towards this goal is beneficial for Western for both their sustainability goal and for reducing GHG emissions associated with waste production.

10.4.1. Expand Organics Program on Campus

According to the 2016 Waste Audit results, 64% of what were are sending to landfill could actually be diverted through recycling programs. Of the 64% of recycling going to landfill, 58% is comprised of organics. Organics is by far Westerns biggest waste challenge. Addressing how to eliminate organics from going into the waste stream will reduce the amount of waste being sent to landfill and therefore the emission associated with this. Expanding the program to reach across campus would greatly increase the chance of food scraps and organics being sent to the composting programs as opposed to landfill. Expanding the organics program also presents opportunities to explore the feasibility of a small composting operation here at Western. On-site composting occurs at many schools across Canada such as University of British Columbia, University of Victoria and Queens, and McGill (Gray and Boyd, 2013). These universities use a variety of composting programs such as vermi-composting, outdoor composters (backyard style) and Earth Tubs. Noting the feasibility of these operations in other universities across Canada, it is recommended that Western conduct a feasibility study for on-site composting opportunities. Incorporating on-campus composting into Western operations is also beneficial for the purpose of the GHG inventory. In fact, under Scope 3 emissions on-campus composting is counted as a carbon offset. Therefore, composting on campus will lead to a carbon reduction through the offsets and from a reduction in waste going to landfill.

10.4.2. Move from Two-Stream Recycling System to Single- Stream Recycling

Currently at Western general recycling is separated into two-streams: paper and containers. The separation of recycling into these streams is often found to confuse students and deter them from separating their waste properly. Students come from different municipalities all over the country and internationally that have differing recycling facilities than found here in London, Ontario. Moving from two-stream recycling to single-stream on campus would be easier for those at Western to make the decision to recycle. A study conducted by Waste Diversion Ontario noted that single stream recycling has the potential for increased program participation and increase diversion rates whereas two-stream recycling may seem less convenient to the average participant and lead to lower diversion rates (Niagara Region, 2013). Therefore in a place where the largest portion of the population is comprised of busy and fast paced individuals, single stream recycling seems to be the more efficient option for recycling. This move has the potential to increase diversion and participation rates and decrease the amount of waste being sent to landfill. Thus, it is highly suggested that Western explore the option of switching to single-stream, recycling campus wide to help meet sustainability goals and reduce landfilled waste on campus.

10.5. Purchasing and Supply Chain

10.5.1. Establish Sustainability Expectations for Purchasing and Supply Chains

Western should work with suppliers to find ways to be more sustainable by establishing sustainability expectations for supply chains. This could include establishing codes of conduct to manage expectations for both suppliers and customers. These codes of conduct with a supplier could address issues such as material toxicity and chemicals, raw material use, greenhouse gas emissions, energy use, recyclability of the materials, product packing in shipping, air pollution, biodiversity and water use of all products purchased (UN Global Compact Office, 2010). This code of conduct could lead to better relationships between Western and supply chains and increase the responsibility suppliers have over the products purchased for Western. Establishing expectations would allow Western to fully understand the environmental impact of products. Being more aware of carbon emissions associated with certain products would allow Western to explore more sustainable options for the GHG reporting.

11. Conclusion

The previous recommendations are at Western's discretion to pursue for reducing greenhouse gas emissions on campus. It should be noted that many of the recommendations have been made based on an amalgamation of the 2015 GHG Inventory results and observed trends in data between 2009 and 2015 totals. A few of the recommendations address opportunities for Western to pursue pilot projects or long-term programs to reduce emissions over time and should be explored in the next few years. Overall, Western will continue to grow as an institution and should address emission sources and how to reduce them in order to reduce their overall carbon impact.

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