Office of Sustainability
Environmental Sustainability Plan 2018
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Introduction

Objective of the Plan

This Environmental Sustainability Plan (ESP) outlines a path for McMaster University to contribute to the Ontario Climate Change Action Plan (CCAP) green house gas (GHG) emissions reduction target of 37% below the 1990 level by 2030 and 80% by 2050. This plan outlines the reduction of the Scope 1 GHG emissions on campus which include burning of fuels to produce electricity, steam and heat on campus.

The following section of this plan presents the GHG emissions historic trend and the 1990 level baseline. The remaining sections present the forecasted future emissions, the path to reduce these emissions which include various possible scenarios to implement both for the 2019-2030 and 2030-2050 periods. Each scenario outlines the GHG reductions measures, the associated cost and implementation timeline.

McMaster University Profile

Founded in 1887, McMaster University is home to more than 30,000 students, and almost 7,500 employees.

McMaster University offers a unique educational experience featuring state-of-the-art research facilities, a world-renowned medical program and innovative student services. Like most Canadian universities, the academic year runs from September until late April, and during this period, approximately 3,700 students occupy the university’s 12 residence buildings. In the summer months (May-September) many of the residence buildings and classrooms remain unoccupied. Campus occupancy decreases significantly to around 10,000 including summer students, campus maintenance staff and conference guests. However, this presents a unique challenge to energy management as the buildings that are partially occupied must have access to heating, lighting and ventilation, thus increasing energy costs, even with lower occupancy.

Figure 1 below is a schematic map showing the location and relative size of the campus buildings.
Figure 1: McMaster University Schematic Map of Campus Buildings (2017-18 academic year)
Table 1 below presents the size and usage of each of the buildings of Figure 1. This supported the creation of an energy profile for the university.

<table>
<thead>
<tr>
<th>Building Name</th>
<th>NSM¹</th>
<th>Primary Usage</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthur N. Bourns Building</td>
<td>23,319</td>
<td>Classroom &amp; Research</td>
<td>1968</td>
</tr>
<tr>
<td>Alumni House</td>
<td>487</td>
<td>Administration</td>
<td>1930</td>
</tr>
<tr>
<td>Alumni Memorial Hall</td>
<td>1,071</td>
<td>Hospitality</td>
<td>1949</td>
</tr>
<tr>
<td>Applied Dynamics Lab</td>
<td>1,773</td>
<td>Research</td>
<td>1967</td>
</tr>
<tr>
<td>Bates Residence</td>
<td>13,514</td>
<td>Residence</td>
<td>1971</td>
</tr>
<tr>
<td>Biology Greenhouse</td>
<td>702</td>
<td>Research</td>
<td>1967</td>
</tr>
<tr>
<td>Brandon Hall</td>
<td>9,206</td>
<td>Residence</td>
<td>1968</td>
</tr>
<tr>
<td>Campus Services Building</td>
<td>4,519</td>
<td>Administration</td>
<td>1968</td>
</tr>
<tr>
<td>Charles E. Burke Science Building</td>
<td>15,379</td>
<td>Classroom &amp; Research</td>
<td>1953</td>
</tr>
<tr>
<td>Chester New Hall</td>
<td>6,913</td>
<td>Classroom</td>
<td>1964</td>
</tr>
<tr>
<td>Commons Building</td>
<td>4,659</td>
<td>Administration &amp; Hospitality</td>
<td>1965</td>
</tr>
<tr>
<td>Communications Research Laboratory</td>
<td>2,480</td>
<td>Research</td>
<td>1983</td>
</tr>
<tr>
<td>David Braley Athletics Centre</td>
<td>12,918</td>
<td>Athletics</td>
<td>2007</td>
</tr>
<tr>
<td>DeGroote School of Business</td>
<td>6,855</td>
<td>Classroom</td>
<td>1990</td>
</tr>
<tr>
<td>Divinity College</td>
<td>3,002</td>
<td>Grad Studies</td>
<td>1959</td>
</tr>
<tr>
<td>E.T. Clarke Centre</td>
<td>4,618</td>
<td>Administration</td>
<td>1954</td>
</tr>
<tr>
<td>Edwards Hall</td>
<td>1,930</td>
<td>Residence</td>
<td>1929</td>
</tr>
<tr>
<td>Engineering Technology Building</td>
<td>12,280</td>
<td>Classroom &amp; Research</td>
<td>2009</td>
</tr>
<tr>
<td>Gilmour Hall</td>
<td>7,467</td>
<td>Administration</td>
<td>1959</td>
</tr>
<tr>
<td>General Sciences Building</td>
<td>4,778</td>
<td>Classroom &amp; Research</td>
<td>1962</td>
</tr>
<tr>
<td>H. G. Thode Library of Science &amp; Engineering</td>
<td>7,752</td>
<td>Library</td>
<td>1976</td>
</tr>
<tr>
<td>Hamilton Hall</td>
<td>3,758</td>
<td>Classroom</td>
<td>1929</td>
</tr>
<tr>
<td>Health Sciences Centre</td>
<td>105 363</td>
<td>Health Services</td>
<td>1972</td>
</tr>
<tr>
<td>Hedden Hall</td>
<td>8,327</td>
<td>Residence</td>
<td>1989</td>
</tr>
<tr>
<td>Information Technology Building</td>
<td>10,311</td>
<td>Classroom &amp; Research</td>
<td>1955</td>
</tr>
<tr>
<td>Institute for Applied Health Sciences</td>
<td>8,914</td>
<td>Classroom</td>
<td>2000</td>
</tr>
<tr>
<td>Ivor Wynne Centre</td>
<td>17,957</td>
<td>Athletics &amp; Research</td>
<td>1964</td>
</tr>
<tr>
<td>John Hodgins Engineering Building</td>
<td>22,851</td>
<td>Classroom &amp; Research</td>
<td>1958</td>
</tr>
<tr>
<td>Kenneth Taylor Hall</td>
<td>10,028</td>
<td>Classroom</td>
<td>1971</td>
</tr>
<tr>
<td>Les Prince Hall</td>
<td>8,239</td>
<td>Residence</td>
<td>2006</td>
</tr>
<tr>
<td>L.R. Wilson Hall</td>
<td>14,195</td>
<td>Classroom &amp; Research</td>
<td>2016</td>
</tr>
<tr>
<td>Life Sciences Building</td>
<td>8,769</td>
<td>Classroom &amp; Research</td>
<td>1970</td>
</tr>
<tr>
<td>M.G.D. Centre for Learning and Discovery</td>
<td>24,976</td>
<td>Classroom &amp; Research</td>
<td>2004</td>
</tr>
<tr>
<td>Mary E. Keyes Residence</td>
<td>11,252</td>
<td>Residence</td>
<td>2002</td>
</tr>
<tr>
<td>Matthews Hall</td>
<td>4,867</td>
<td>Residence</td>
<td>1964</td>
</tr>
<tr>
<td>McKay Hall</td>
<td>6,003</td>
<td>Residence</td>
<td>1964</td>
</tr>
<tr>
<td>McMaster University Student Centre</td>
<td>12,388</td>
<td>Hospitality</td>
<td>2002</td>
</tr>
<tr>
<td>Mills Memorial Library</td>
<td>19,620</td>
<td>Art Gallery/Library</td>
<td>1950</td>
</tr>
<tr>
<td>Moulton Hall</td>
<td>4,807</td>
<td>Residence</td>
<td>1959</td>
</tr>
<tr>
<td>Nuclear Reactor</td>
<td>1,648</td>
<td>Research</td>
<td>1957</td>
</tr>
<tr>
<td>Nuclear Research Building</td>
<td>5,020</td>
<td>Research</td>
<td>1950</td>
</tr>
<tr>
<td>Preliminary Laboratory (T13)</td>
<td>2,015</td>
<td>Classroom</td>
<td>1967</td>
</tr>
<tr>
<td>Psychology Building</td>
<td>8,098</td>
<td>Classroom &amp; Research</td>
<td>1970</td>
</tr>
<tr>
<td>Refectory</td>
<td>1,516</td>
<td>Hospitality</td>
<td>1929</td>
</tr>
<tr>
<td>Ron Joyce Stadium</td>
<td>3,719</td>
<td>Athletics</td>
<td>2008</td>
</tr>
<tr>
<td>Scourge Building (TB26)</td>
<td>184</td>
<td>Administration</td>
<td>1989</td>
</tr>
<tr>
<td>Tandem Accelerator</td>
<td>2,827</td>
<td>Research</td>
<td>1966</td>
</tr>
<tr>
<td>Togo Saloon Hall</td>
<td>11,654</td>
<td>Classroom</td>
<td>1965</td>
</tr>
<tr>
<td>University Hall</td>
<td>3,669</td>
<td>Administration</td>
<td>1929</td>
</tr>
<tr>
<td>Wallingford Hall</td>
<td>1,835</td>
<td>Residence</td>
<td>1929</td>
</tr>
<tr>
<td>Whidden Hall</td>
<td>5,594</td>
<td>Residence</td>
<td>1959</td>
</tr>
<tr>
<td>Woodstock Hall</td>
<td>5,039</td>
<td>Residence</td>
<td>1968</td>
</tr>
<tr>
<td>Temporary Portables (T32)</td>
<td>500</td>
<td>Classroom</td>
<td>2013</td>
</tr>
<tr>
<td>Temporary Portables (McMaster's Children's Centre T33)</td>
<td>631</td>
<td>Daycare</td>
<td>2013</td>
</tr>
</tbody>
</table>

Note 1: NSM = Net Square Metres
Source: Database and Master Inventory
Note: the scope of this Environmental Sustainability Plan does not include off-campus buildings (Halton Family Health Care Centre, McMaster Automotive Resource Centre, One James North).

Figure 2 shows the uses of assigned space on campus. It should be noted that building and residence occupancy during the summer months and building occupancy during the evening and night also poses challenges to energy management, as buildings that are partially occupied for evening classes still require heating, lighting and ventilation. Libraries, labs and classrooms often remain occupied until midnight or later, and do not run on a predictable schedule, which stresses the University’s energy management systems. Caretakers and custodial staff in buildings later in the night and early in the morning also increase energy usage.

Figure 2: Uses of Assigned Space on Campus
**Campus Energy Consumption Historical Trends**

Before we can set meaningful and realistic energy reduction targets, it is first necessary to evaluate the current energy consumption of the university and examine trends in consumption over the past fifteen years.

For the purposes of this energy profile, “energy” will be considered from a water, electricity and gas consumption perspective. Figures 3 - 5 show the consumption trends from the 2002-03 academic year to the 2017-18 academic year. These figures show the complete McMaster campus energy consumption excluding the McMaster portion of the on-campus hospital (Health Sciences Centre), and off-campus Halton Family Health Centre in Burlington, McMaster Automotive Resource Centre, One James North in downtown Hamilton, and Ron Joyce Centre in Burlington. The same applies for all remaining energy figures in this section.

It is worth noting here that a combined heat and power Co-generation (Cogen) plant was completed during the 2017/2018 fiscal year which contributed to the increase in GHG emissions on campus.

![Campus Natural Gas Consumption (2002-2018) With Cogen](image)

**Figure 3: Gas Consumption Trends (With Cogen)**
Figure 4: Gas Consumption Trends (Without Cogen)

Figure 5: Electricity Consumption Trends
The above graphs show that the consumption on a per student basis has dropped significantly from 2002/2003. Electricity consumption per student has dropped by 42%, natural gas by 47% (without factoring in the increase in gas consumption due to Cogen) and water consumption by 59%.
Campus Energy Intensities

Figures 7 - 10 present the energy (electricity, water, gas) usage per m$^2$ over different periods of time at McMaster University.

Figure 7: Electricity Intensity trends 2002-2018

Figure 8: Gas intensity trends (With Cogen) 2002-2018
This data shows a significant energy commodity intensity decrease across all commodities over the 2002-2018 period. Table 2 shows a comparison of consumption in 2002 and 2018 and summarizes the data in Figures 7-10.
**Table 2: McMaster energy use 2002-2018 comparisons**

<table>
<thead>
<tr>
<th></th>
<th>Net Consumption</th>
<th>Consumption/student/year</th>
<th>Consumption/m²/year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2002-03</td>
<td>2017-18</td>
<td>2002-03</td>
</tr>
<tr>
<td><strong>Electricity</strong></td>
<td>79,411,402 kWh</td>
<td>82,623,183 kWh</td>
<td>4,307 kWh/student/yr</td>
</tr>
<tr>
<td><strong>Gas (with Cogen)</strong></td>
<td>11,491,093 m³</td>
<td>17,934,436 m³</td>
<td>623 m³/student/yr</td>
</tr>
<tr>
<td><strong>Gas (Without Cogen)</strong></td>
<td>11,491,093 m³</td>
<td>10,759,055 m³</td>
<td>623 m³/student/yr</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>690,230 m³</td>
<td>500,239 m³</td>
<td>37 m³/student/yr</td>
</tr>
</tbody>
</table>

**Review and Analysis of McMaster GHG Emissions from 1990 till Present**

Assessment of McMaster’s Scope 1 emissions in this Plan is based on:

a) a Physical Plant Equipment Study that McMaster University conducted in 2003 which included McMaster’s on-campus fuel consumption from 1989/90 till 2001/02, and

b) McMaster’s gas consumption records for the period from 2002/03 till present.

Based on the above study, McMaster’s Scope 1 emissions was 27,795 tonnes of CO2e in 1990. The target of this plan is to reduce these emissions by 37% from the above 1990 baseline by 2030, which correlates to lowering the emissions to 17,511 tonnes of CO2e by 2030. The last section of this plan outlines reducing these emissions by 80% from the 1990 baseline by 2050, which correlates to lowering the emissions further to 5,560 tonnes of CO2e by 2050.

Utilizing the data from the above study (1989/90 – 2001/02) and from McMaster files (2002/03 – 2016/17), Figure 11 was developed to present the Scope 1 CO2e emissions historic trend on campus. It also shows the target reduction levels by 2030 and 2050.

![Figure 11: Carbon Dioxide Emission Trend 1989-2017](image-url)
Forecast of McMaster Campus GHG Emissions till 2030

Based on McMaster Capital plan, the forecasted GHG emissions increase related to new planned buildings till 2030 is presented in Figures 12 and 13 below, which includes the historic C02 emissions trend.

Figure 12: Forecasted Carbon Dioxide Emissions (Without Cogen) 1989-2030

Figure 13: Forecasted Carbon Dioxide Emissions (With Cogen) 1989-2030

C02e emissions increased significantly during the fiscal year 2017/18 due to implementing the cogeneration project. On the other hand, various other C02e emissions increase forecasted till 2025 are due to new buildings planned to be built on campus.

This part of the plan outlines the various scenarios and ways that can be adopted in the future to reduce McMaster’s Scope 1 emissions to meet the target reduction by 2030. The graphs below provide the estimated capital investment and the related CO2e reduction for each of the GHG reduction projects/initiatives. The timing of these projects has been coordinated with the planned renovations and retrofits on campus. Campus emissions in 2016/17 was 23,406 tonnes of CO2e, and it went up to around 36,757 tonnes in 2017/18 due to implementation of the Cogen plant during that fiscal year. The emissions are expected to rise to 40,474 tonnes of CO2e in 2018/19, which includes the emissions related to fully operating the Cogen plant and few new buildings.

The graphs below also present the net change in GHG emissions related to buildings under construction/planned (increase in GHG emissions) from 2018 – 2025, and planned GHG reduction measures (decrease in GHG emissions) from 2018 – 2029. These measures include projects which entail small GHG reduction such as steam traps replacement, solar water heating and window replacement in various buildings on campus and others which lead to considerable GHG reductions such as running the Cogen as a peaking plant and electric boilers.

**Under Scenario 1**, various gas consumption reduction projects that are either ongoing or planned (see Appendix A for details) between 2019 and 2028 are expected to lower the campus emissions down to 39,275 tonnes of CO2e in 2028/2029. This factors in the increase in emissions due to new planned buildings between 2019 and 2025. The major initiative planned after, is running the Cogen as a peaking plant in 2028/2029 followed by adding one electric boiler in 2029/2030 which will bring the emissions down to 14,475 Tonnes of CO2e (lower than the 2030 target level).

**Scenario 2** is basically the same as Scenario 1 but with the exception of having two electric boilers added in 2029/2030 instead of one and is expected to bring the emissions level down to 6,675 tonnes of CO2e in 2030.
Plan for Future McMaster GHG Reduction Initiatives (2030-2050)

This section outlines seven potential scenarios that can be adopted to further reduce McMaster’s emissions down to the 2050 target (80% below the 1990 level).

**Scenario A** starts from Scenario 1 in 2030 above and includes adding another electric boiler and the conversion of steam to hot water between 2030 and 2050. It can also start from Scenario 2 and add the steam to hot water conversion before 2050.

**Scenario B** starts from Scenario 2 in 2030 and includes having GHG reduction measures in the Health Sciences Centre to bring the emissions down to the 2050 target.
**Scenario C** starts in 2030 from Scenario 1 where another electric boiler is added in 2030’s lowering the emissions by 7,800 tonnes CO2e and then converting steam to hot water which will reduce the emissions by 5850 tonnes of CO2e thus bringing the emissions level to 825 tonnes of CO2e which is below the 2050 target.

**Scenario D** starts in 2030 from Scenario 1 where another electric boiler is added in 2030’s followed by GHG reduction measures implementation in the Health Sciences Centre in 2040’s which will lower the emissions by a total of 9,800 tonnes CO2e thus bringing the emissions level down to around 4675 tonnes of CO2e by 2050.

**Scenario E** starts in 2030 from Scenario 1 where the remaining gas boilers and the Cogen plant are run using biogas in 2040’s which will bring the emissions down to almost zero by 2050.

**Scenario F** starts in 2030 from Scenario 1. In 2040’s the remaining gas boilers will be replaced with new wood pellet boilers, thus bringing the emissions level down to around zero tonnes of CO2e by 2050.

**Scenario G** starts in 2030 from Scenario 2 where GHG reduction measures are implemented in the Health Sciences Centre in early 2030’s followed by retrofitting the Cogen plant to run it (either fully or as a peaking plant) on biogas in late 2040’s which will bring the emissions down to around 4625 tonnes of CO2e.

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**Figure 16**: Carbon Dioxide Emission Reduction Forecast Scenario A (2030 – 2050)
Figure 17: Carbon Dioxide Emission Reduction Forecast Scenario B (2030 – 2050)

Figure 18: Carbon Dioxide Emission Reduction Forecast Scenario C (2030 – 2050)

Figure 19: Carbon Dioxide Emission Reduction Forecast Scenario D (2030 – 2050)
Figure 20: Carbon Dioxide Emission Reduction Forecast Scenario E (2030 – 2050)

Figure 21: Carbon Dioxide Emission Reduction Forecast Scenario F (2030 – 2050)

Figure 22: Carbon Dioxide Emission Reduction Forecast Scenario G (2030 – 2050)
Appendix

Appendix: Overview of McMaster Energy Projects Completed, Ongoing and Planned

Projects Completed
Since developing the first Energy Management Plan in 2013, McMaster has implemented many energy efficiency projects that contributed to the GHG emissions reduction target set. Below is a summary of the completed projects to date:

- Building Exhaust Fans and Domestic Hot Water Pumps Controls in various buildings on campus
- Miscellaneous Control Systems which included:
  i. The University Hall Controls Retrofit
  ii. All building mechanical fan belt upgrade
  iii. All building heating systems set-backs after hours
  iv. Central plant / chilled water plant operational modifications
- A Demand Control Ventilation (DCV) – ABB Undergraduate Labs
- Fume Hood Retrofits and Upgrades Projects
- Indoor Corridors / Stairwells LED Lighting
- Conversion of city water cooling on process units to chilled water loop
- Demand Control Ventilation and Retro Commissioning - JHE and MDCL
- Lighting Retrofit – Student Residences
- Chiller Replacement– Art Gallery
- Chilled Water Loop Modifications

In addition to the above, a combined heat and power (Co-Generation) project was completed end of 2017.
Projects Ongoing
- Demand Control Ventilation (DCV) - ABB Chemistry Wing
- Water System retrofit on Life Sciences Building Fish Tank Lab (a recirculation aquaculture system)
- Chiller Plant Re-commissioning
- JHE Window Replacement
- Gilmour Hall Window Replacement
- McKay Hall Window Replacement

Projects Planned
- **Energy Efficiency Projects**
  - Demand Control Ventilation (DCV) – ABB Physics Wing
  - Steam Traps Replacement
  - Boiler Replacement with an Electric One
  - Demand Control Ventilation/Fume Hoods Upgrades in various buildings on campus
  - Lighting Retrofit – Office Space and Outdoors
  - Window Replacement in various buildings on campus

- **Renewable Energy Projects**
  - Solar Water Heating
  - Rooftop Solar PV

- **Potential GHG Reduction Measures in the Plant**
  - Running Cogeneration plant as a peaking plant
  - Boiler replacement with an electric one
  - Operating Cogen on Biogas
  - Operating Cogen on Hydrogen from Electrolysis (assessed but is not included in this plan due to its high cost compared to running the Cogen on biogas)
  - Running existing boilers on Wood Pellets