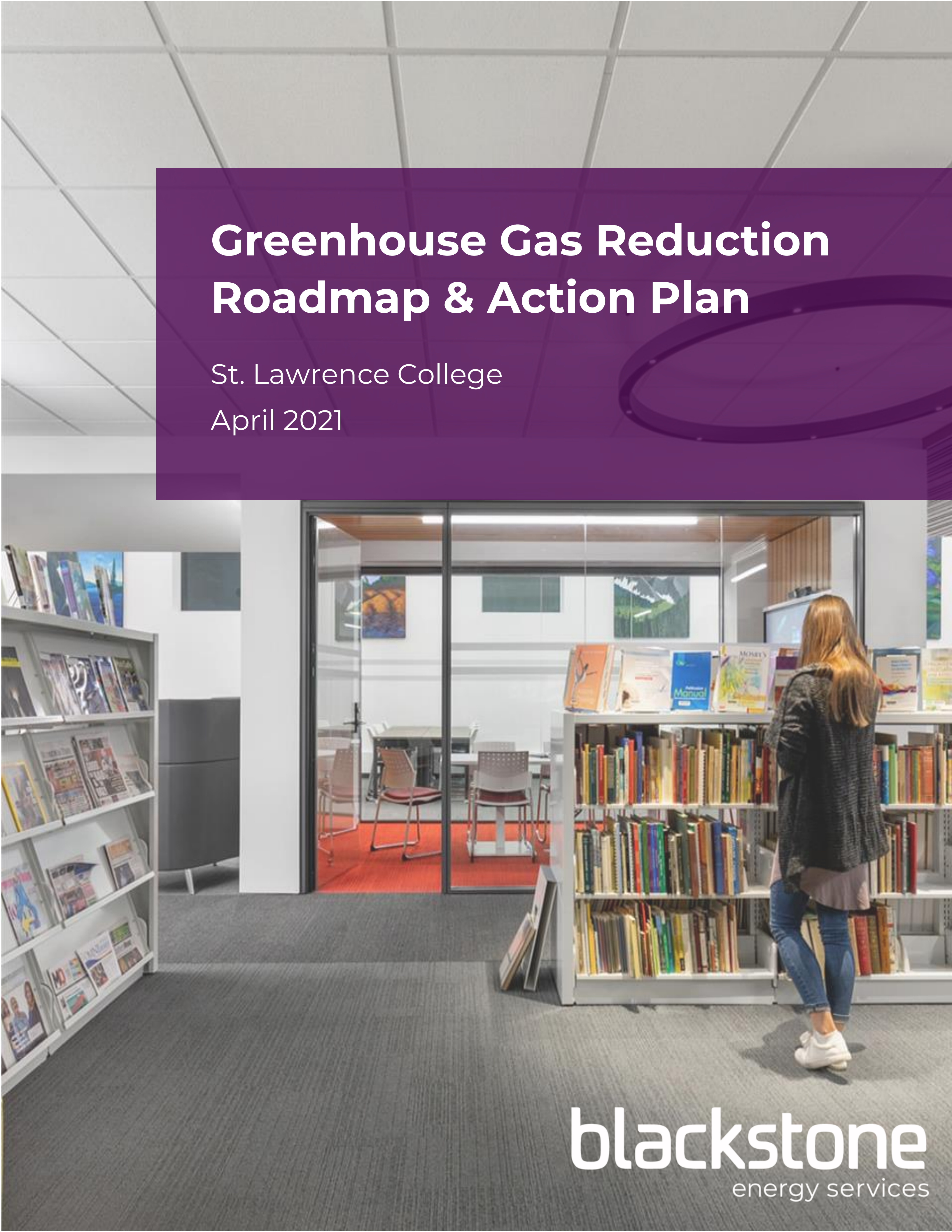
Greenhouse Gas Reduction Roadmap & Action Plan

St. Lawrence College

April 2021



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Introduction

The transition toward the decarbonization of your facilities and services is an opportunity for St. Lawrence College (SLC) to be a part of the growing activity around climate action initiatives. SLC has made significant strides in its sustainability standing and is on a path to being an institutional leader in the field. SLC’s Greenhouse Gas Reduction Roadmap & Action Plan (GRRAP) sets short-term and long-term strategies for greenhouse gas (GHG) footprint targets. It also sets SLC’s overarching sustainability goal of achieving carbon-neutrality and energy portfolio resiliency by 2050.

Compared to a baseline year of 2010, SLC has committed to:

- Reduce its GHG emissions by 40% by 2030
- Achieve net-zero carbon by 2050

This Greenhouse Gas Reduction Roadmap & Action Plan (GRRAP) aims to provide strategic direction and options required to reduce emissions at SLC over the next 30 years. In order to reach its GHG emission targets, SLC’s GRRAP must be reflected in its vision, planning and financial strategies. SLC policies and plans may include those listed below which may need to be adapted to fully realize their goals:

- Campus Master Plan
- Parking Master Plan
- Sustainability Action Plan
- Energy Management
- Five Year Strategic Plan
- Sustainability Policy

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Glossary of Terms

Word	Abbreviation	Meaning
Air Handing Unit	AHU	A device used to regulate and circulate air as part of a heating, ventilating, and air-conditioning system.
Baseline Year		A benchmark that is used as a foundation for measuring or comparing current and past values.
British Thermal Units	BTU	A standard unit of the heat content of fuels or energy sources.
Building Automation System	BAS	The automatic centralized control of a building's heating, ventilation and air conditioning, lighting, and other systems.
Business as Usual	BAU	Scenario if no actions are taken to mitigate or change.
Canada Green Building Council	CaGBC	SLC that certifies a Zero Carbon Building Standard that could be used as a guide for carbon free construction and operations.
Carbon Dioxide	CO_2	A greenhouse gas that results, in part, from the combustion of fossil fuels.
Coefficient of Performance	COP	A ratio of useful heating or cooling provided to work required.
Carbon Reduction Roadmap	GRRAP	Provides an in-depth look a facility's baseline, current, and forecasted Scope 1, 2 and 3 GHG emissions relative to their targets, and provides reduction strategies.
Direct Expansion	DX	A system that uses the vapor-compression refrigeration cycle to efficiently cool a building.
Environment and Climate Change Canada	ESLCC	Informs Canadians about protecting and conserving natural heritage and ensuring a clean, safe, and sustainable environment for present and future generations.
Electric Vehicle	EV	A vehicle that uses one or more electric motors for propulsion
Energy Conservation & Demand Management	ECDM	The installation of measures, or implementation of practices, to improve energy efficiency. This is a requirement of O. Reg. 507/18: Broader Public Sector: Energy Conservation and Demand Management Plans (ECDM).
Energy Storage		Typically refers to energy stored by battery.
Energy Usage Intensity	EUI	The amount of energy consumed relative to a buildings physical size, typically measured in equivalent kWh per square foot.
Engineering, Procurement and Construction	EPC	Engineering, procurement, and construction of infrastructure projects.
Electrification		The conversion of fossil fuel-based technologies to electric alternatives.
Equivalent Carbon Dioxide	CO_2e	A measurement of greenhouse gas emissions, relative to carbon dioxide.
Equivalent kilo-watt hours	ekWh	A standard unit of energy consumption used to compare energy sources.
Full Time Equivalent	FTE	A unit that indicates the workload of an employed person (or student) in a way that makes workloads or class loads comparable across various contexts.
GHG Protocol		The recognized international standards used in the measurement and quantification of greenhouse gases – The Scope 1 Standard, the Scope 2 Standard, and the Scope 3 Standard.
Greenhouse Gas	GHG	A gas that contributes to the greenhouse effect by absorbing infrared radiation, e.g., carbon dioxide and chlorofluorocarbons.

Global Warming Potential	GWP	A measure of how much heat is trapped in the atmosphere by a greenhouse gas up to a specific time horizon, relative to carbon dioxide.
Global Reporting Initiative	GRI	The GRI is an international independent standards organization that helps businesses, governments and other organizations understand and communicate their impacts on issues such as climate change, human rights, and corruption.
Heating, Ventilation and Air Conditioning +Lighting	HVAC+L	A system that provides heating, cooling, ventilation, and lighting to a building.
Hourly Ontario Electricity Price	HOEP	The wholesale price of electricity as determined in the real-time market administered by the IESO.
Independent Electricity System Operator	IESO	Crown corporation responsible for operating the electricity market in the province of Ontario.
SLC Energy Efficiency Project	EEP	SLC's program on improving energy efficiency and promoting energy conservation.
Leadership in Energy and Environmental Design	LEED	A green building certification program that is administered by the CaGBC.
Long Term Energy Plan	LTEP	Ontario's plan that outlines the province's energy demand, supply, and commitments.
Metric Tonnes	t	A unit of measurement of mass.
Mega Tonnes	MT	A unit of measurement of mass (1 MT = 1,000,000 t).
Photovoltaic	PV	The conversion of light into electricity using semiconducting materials.
Renewable Energy	RE	Generation of energy produced from sources that do not deplete.
Renewable Natural Gas	RNG	Biogas that is captured from decomposing organic waste.
Scope 1		Direct emissions from sources owned or controlled by the institution.
Scope 2		Indirect emissions from the consumption of purchased energy generated upstream from the institution.
Scope 3		Indirect emissions (not included in Scope 2) that occur in the value chain of the institution, including both upstream and downstream emissions, like waste, transport, food, and procurement.
Space Optimization	SO	Maximizing the effective use of the built environment.
Sustainability Campus Committee	SCC	SLC's committee of students, staff, and faculty, that works with the Sustainability Office, to increase awareness and understanding of on-campus sustainability challenges and opportunities.
Natural Gas/Traditional Natural Gas	TNG	Natural gas is a naturally occurring hydrocarbon, or fossil fuel, gas mixture consisting primarily of methane.
Variable Refrigerant Flow	VRF	A system that varies the *flow* of *refrigerant* to indoor units based on demand.
Zero Carbon Building	ZCB	Highly energy efficient building that is fully powered from on-site and/or off-site renewable energy sources and carbon offsets.

1. Executive Summary

St. Lawrence College (SLC) has made a commitment to achieve net-zero carbon by 2050. The path and transition to net-zero carbon by 2050 will be impacted by strategic planning, technology, government incentives, utility rate structures, grid emissions and societal impacts. It is recommended that SLC prepares and follows a strategy as envisioned through the GRRAP, performs annual inventory of energy and GHG emissions, regularly assesses their progress and identifies new programs that could help SLC reach a net-zero carbon presence in 2050.

There are **four key pillars** on the journey to achieving net zero carbon:

- **Pillar 1: Energy Conservation & Demand Management (ECDM)** – SLC has a documented ECDM strategy with estimated costs, benefits, and timelines. Pillar 1 supports the implementation and continued commitment to energy conservation, reduced waste, and optimum energy and GHG use intensities.
- **Pillar 2: Space Optimization (SO) & Zero Carbon Buildings (ZCB)** – Addresses how to minimize emissions from buildings by optimizing the use of existing building space and reducing emissions from renovations and new facilities through high performance design standards.
- **Pillar 3: Facility Electrification** – Focused on converting existing fossil fuel-based technologies to low carbon, electric, alternatives.
- **Pillar 4: Renewable Energy (RE) Generation** – On- and off-site renewable energy generation can support SLC's net-zero carbon targets. For SLC, renewable generation is focused on the installation of rooftop solar photovoltaics, carport solar photovoltaics and geo-exchange technologies (i.e., inter-seasonal ground energy storage).

To achieve carbon neutrality, it is recommended that SLC commits to implementing the strategies outlined in the GRRAP to support each of the four pillars.

Under Pillar 1, SLC should continue to create of a culture of ECDM. SLC's existing ECDM program has created a foundation for improvements to minimize energy use. ECDM technologies – including lighting, ventilation controls and upgraded building automation systems – have proven to be cost effective mechanisms for SLC. The ECDM Plan provides a short-term overview of projects, their estimated costs, and benefits. SLC should continue to fund ECDM to minimize energy usage and should review the ECDM plan on a five-year renewal schedule.

Under Pillar 2, it is recommended that SLC commits to undertaking a space use optimization study to further assess how to maximize the efficiency of existing spaces. For new buildings, SLC should commit that all new buildings and major renovations will be built to (at minimum) zero carbon standards. To build to the higher standard will cost approximately 7% more than building to the Ontario Building Code or LEED standards. However, buildings will have lower operational costs and be cost-effective over their lifespans.

Under Pillar 3, SLC commits to the electrification of fleet and facility equipment. Internal combustion fleet vehicles should be replaced with electric vehicles. When asset renewals are considered, facility equipment should be evaluated from a cost and carbon perspective. Installing electric systems may be more expensive and operating costs may increase. These are budget considerations SLC should assess with the knowledge that, the sooner the investment is made, the lower the carbon output of SLC's operations.

Under Pillar 4, it is recommended that SLC installs the maximum amount of solar photovoltaics (both rooftop and carport) and geothermal systems its campus can support to provide renewable energy. Onsite renewable potential was assessed to determine the feasibility of renewable energy projects and identify the best locations for installation at SLC.

The graph below depicts four scenarios for advancing towards net-zero, by depicting the GHG emissions under each scenario and the business as usual (BAU) scenario. The most significant differences between the scenarios to achieve carbon neutrality are the combinations in which the four pillars are implemented. The pillars implemented under each scenario are also listed in the figure below.

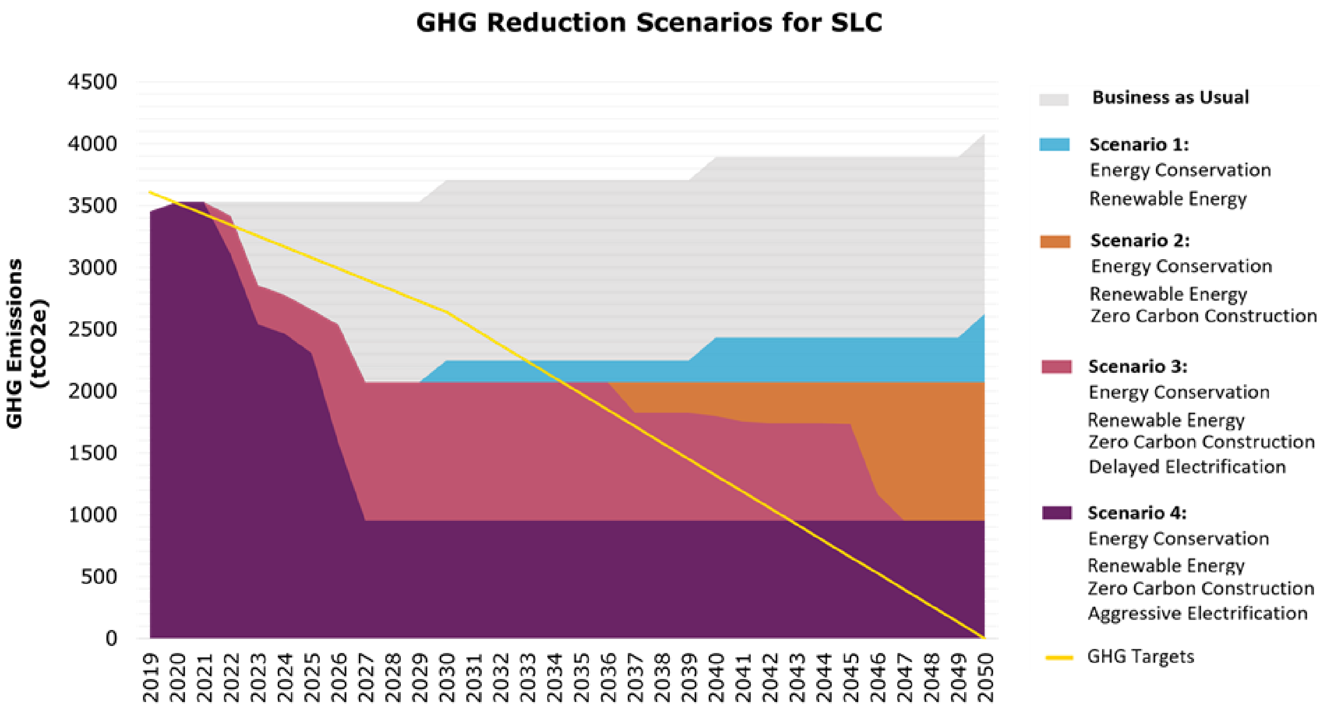


Figure 1. *GHG Reduction Scenarios for SLC*

2. Recommendations

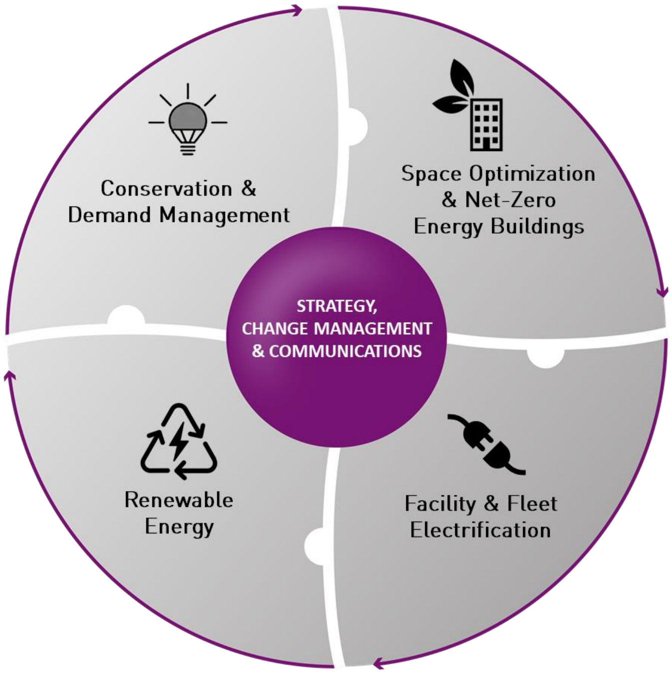


Figure 2. *Strategy, Change Management & Communications Wheel*

It is recommended that SLC moves ahead with the following actions items listed below, under all four pillars, to support the GRRAP.

Pillar 1. Energy Conservation & Demand Management

- At five-year intervals, update ECDM Plan and maintain commitment to energy management programs (as part of O. Reg. 507/18).
- Ensure budget allocation to support implementation of best practice ECDM standards.
- Identify opportunities for energy conservation and deep energy retrofits in alignment with deferred maintenance priorities.
- Review the state of building envelope items and facility condition reports on a regular basis.

Pillar 2. Space Optimization & Net-Zero Carbon Buildings

- Develop design and construction policies to ensure Net-Zero Carbon as minimum standard for new builds and major renovations.
- Develop space use policies to minimize underused space and maximize the space utilization rate on campus.
- Develop a campus master plan that has space optimization as a guiding principle.
- Allocate budget for conducting space use audits and implementing space optimization measures.

Pillar 3. Facility & Fleet Electrification

- Commit to electrification of facility equipment. Explore alternatives for fossil fuels for cooking equipment.
- Implement a Green Fleet Strategy to replace campus fleet with electric vehicles.
- Ensure parking lots have infrastructure to support solar panels, electric vehicles, and geo-loops, and enhance infrastructure for vehicle-to-grid in existing buildings.

Pillar 4. Renewable Energy

- Install maximum amount of solar photovoltaics, both rooftop and carport, and geothermal as the campuses will allow.

General Sustainability Initiatives

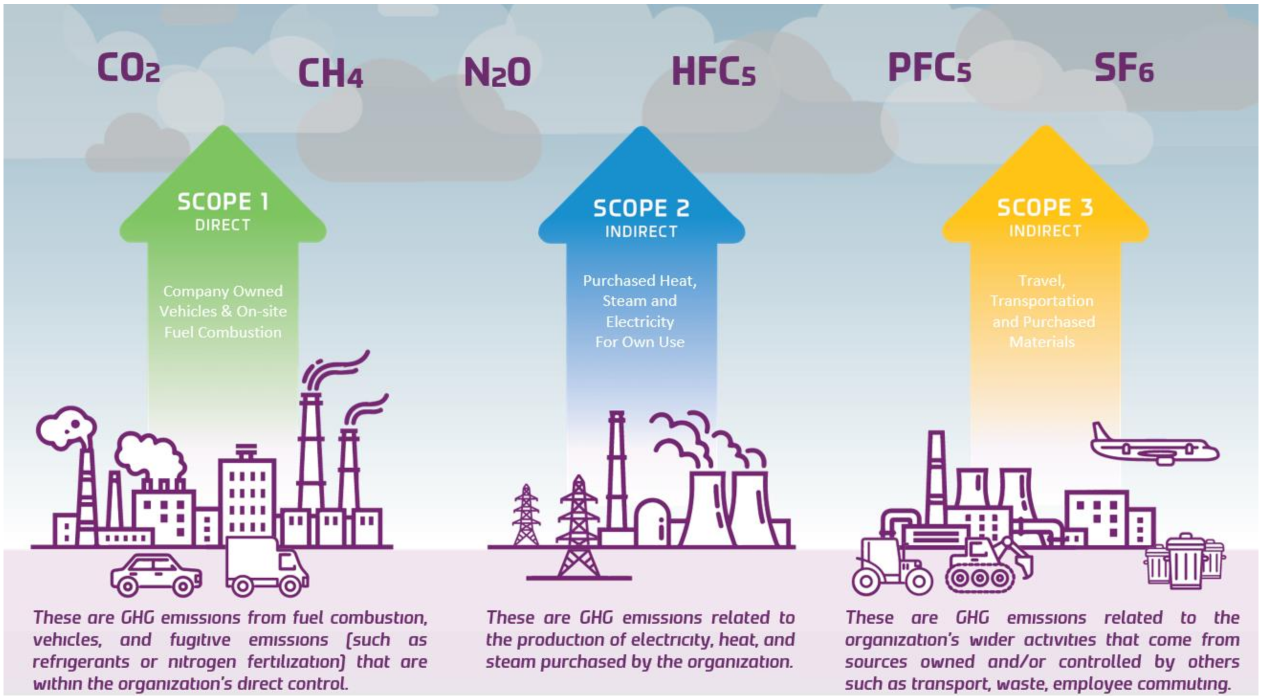
It is recommended that SLC continues to support a low carbon future and promotes sustainability on campus.

- Continue to monitor and achieve alignment between the sustainability plan and the College's GHG reduction targets.
- Ban single use plastics on campus.
- Limit food waste generation on campus.
- Strengthen awareness programs about waste management for employees and staff.
- Expand sustainable transportation options for SLC's community.

3. SLC's GHG Footprint

3.1. Scope of Emissions

SLC's GRRAP quantifies GHG emissions by source, outlines the scenarios for emission reduction and provides SLC with a roadmap to reach its reduction targets. GHG emissions are accounted for according to the GHG Protocol Standard, which is the global standardized framework to measure and manage greenhouse gas (GHG) emissions from private and public sector operations. GHG emissions considered for the GRRAP are categorized by three types of emissions: Scope 1, Scope 2, and Scope 3. This is explained in Figure 3 below.



Source: GHG Protocol[1]

Figure 3. GHG Emissions and Scopes

GHG emissions released from SLC's operations may include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Each gas has a global warming potential (GWP) that is expressed in terms of CO_2 equivalent or CO_2e. The GWP of GHGs is a measure of how much heat a greenhouse gas traps in the atmosphere. The GRRAP accounted for emissions from Scope 1, 2, and 3 and calculated the GWP relative to tonnes of carbon dioxide equivalent (tCO_2e). For example, for every tonne of methane released, about 25 tonnes of equivalent CO_2 is released as the GWP for methane is 25. Each GHG must be converted to equivalent CO_2 for calculations and reporting.

[1] Greenhouse Gas Protocol: http://ghgprotocol.org/about-us

The global warming potentials (GWP) associated with these six common GHGs are depicted in Figure 4 below.

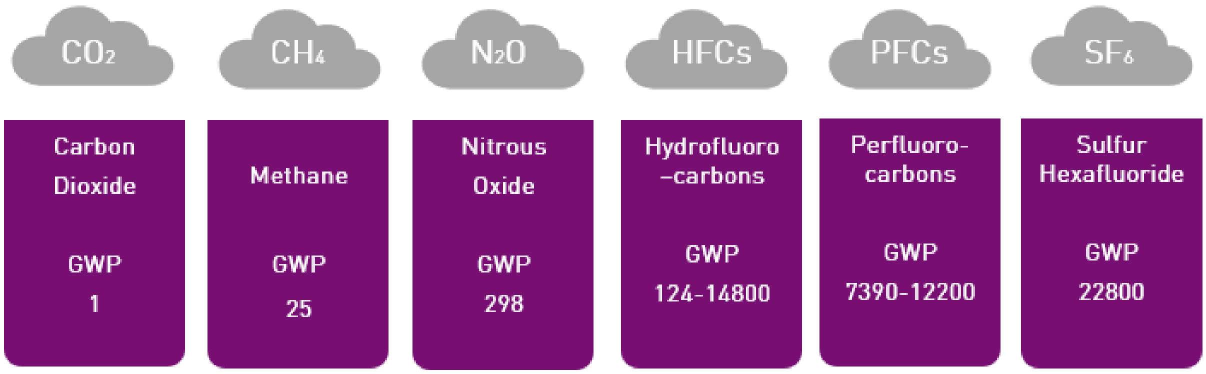


Figure 4. *Common Greenhouse Gases and Respective Global Warming Potentials*

The Scope boundaries, activities that were included in the GHG emissions calculations for SLC were selected based on the availability of data and discussions with the Sustainability Office and are summarized in Table 1 below.

Table 1. *GHG Emission Scopes & Sources*

Scope of Emission	Definition	Source of Emission
Scope 1	Direct emissions from sources owned or controlled by the institution	• Natural Gas • Refrigerants
Scope 2	Indirect emissions from the consumption of purchased energy generated upstream from the institution	• Purchased electricity

On-campus stationary sources such as oil (#1-4), natural gas, the use of refrigerants and organic fertilizers were all considered in the GHG emissions calculations for Scope 1. Scope 2 GHG emissions at SLC are solely generated from purchased electricity. The share of SLC's GHG emissions in 2019 is illustrated in Figure 5.

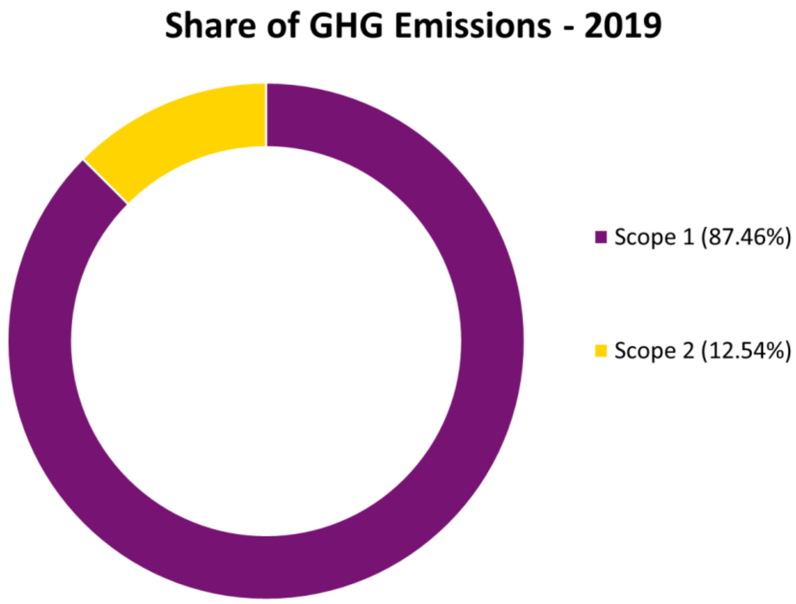


***Figure 5**. 2019 Share of Emissions for SLC*

The emissions were calculated for the three campuses – Kingston, Cornwall, and Brockville – this report mainly addresses Scope 1 and Scope 2 emissions. Scope 1 and Scope 2 emissions are directly under SLC's operational control as they are driven by energy use and facility management. Scope 3 emissions are dependant on human and social behaviour and can be addressed by awareness and policy implementation across the campuses. Hence Scope 3 emissions are dealt with separately in Section 9.

3.2. GHG Emissions Baseline

To set appropriate, ambitious yet achievable emissions reductions targets, and to set dates by which to achieve those targets, a baseline year of emissions must be set as a benchmark to measure the progress of the GRRAP. SLC has selected a baseline year of 2010, as established in its Sustainability Action Plan. The emission reduction targets for SLC are absolute numbers (versus an intensity-based value) as a percentage of SLC's emissions compared to the baseline year of 2010. The following table summarizes the GHG emissions in the baseline year and the resulting absolute targets set by SLC (in metric tonnes of carbon dioxide equivalent - tCO_2e).

Table 2. *Baseline, Current and Target Emissions for SLC*

GHG Emissions (tCO_2e)	2010 (Baseline)	2019 (Current levels)	2030 (40% reduction from baseline)	2050 (Carbon neutrality)
Scope 1	2,850	3,019	1,710	0
Scope 2	1,258	347	755	0
TOTAL	4,108	3,366	2,639	0

3.3. Historic Emission Trends

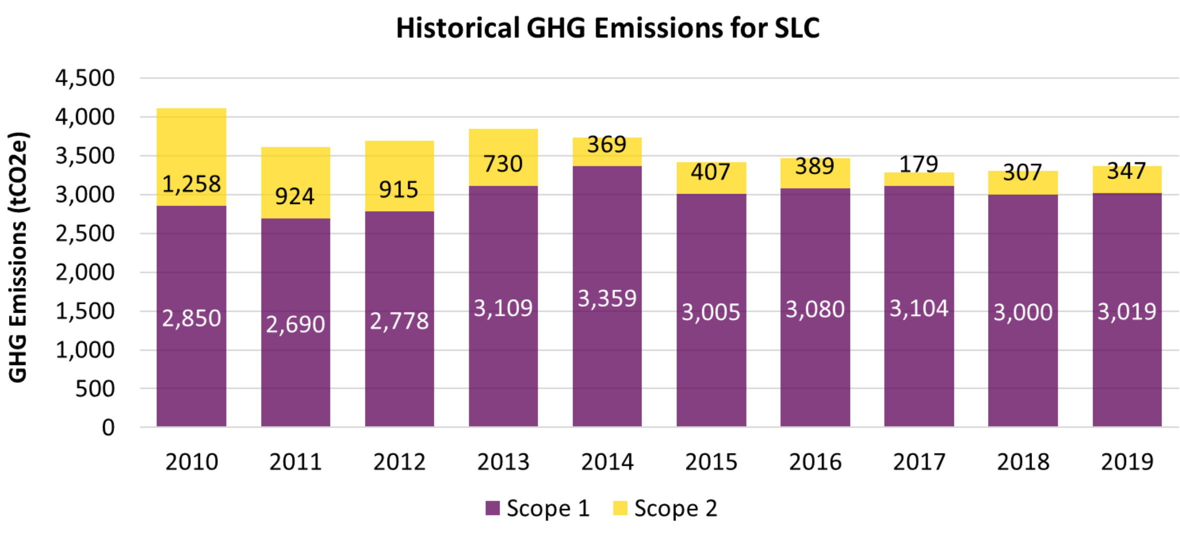


Figure 6. *Historical Emissions Trends for SLC*

Figure 6 above shows the annual GHG emission trends from the baseline year of 2010 through to 2019. The trends in the GHG emissions are broken down further between Kingston, Brockville, and Cornwall campuses. Factors affecting the GHG trends are explained on the following page by campus.

3.3.1. Kingston Campus

The Kingston campus is responsible for almost 65% of SLC's total GHG emissions. Scope 1 emissions have been relatively the same from 2010 to 2019. However, the implementation of energy conservation measures contributed to reducing the calculated Energy Utilization Index (equivalent kWh/sq. ft) across the campus. Scope 2 emissions from grid-supplied electricity were reduced when the coal-based power plants were closed in Ontario in 2014 and the carbon intensity of the grid was reduced. The Energy Conservation and Demand Management (ECDM) program also reduced Scope 1 & 2 emissions since 2010. The influence of campus growth (in both population and physical size) on GHG emissions is further explored in Section 3.5.

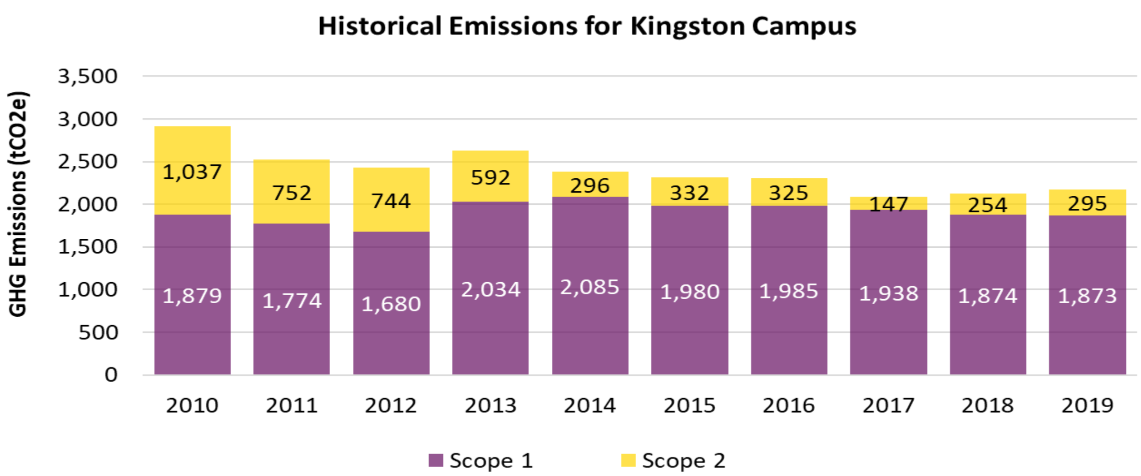


Figure 7. *Historic Emissions Trends for the Kingston Campus*

3.3.2. Cornwall Campus

The Cornwall campus accounts for 25% of SLC's overall emissions. The campus has fluctuations with GHG emissions since 2010. The rise in Scope 1 emissions can be attributed towards campus growth from 2010 to 2019. From 2010 to 2019 the population on campus has almost doubled. Scope 2 emissions from grid-supplied electricity were minimal as the campus procures electricity from Quebec. With mostly hydro power in the grid mix, Quebec electricity has a very low carbon content.

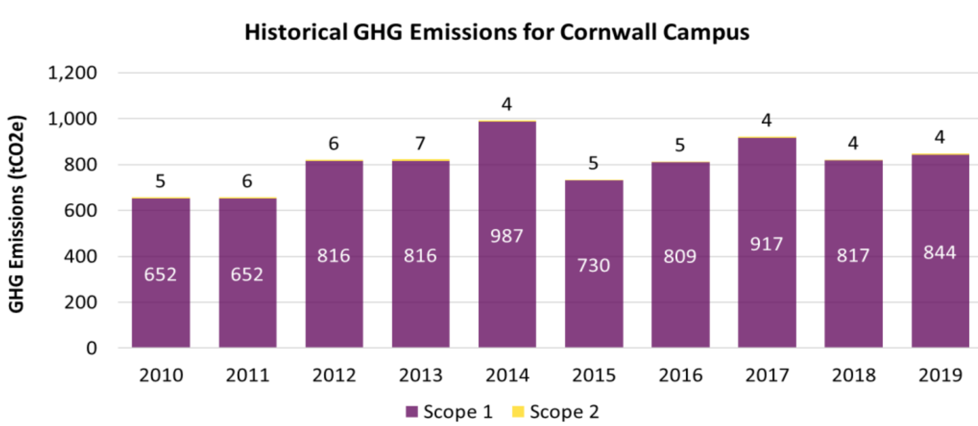


Figure 8. *Historic Emissions Trends for the Cornwall Campus*

3.3.3. Brockville Campus

The Brockville campus accounts for 10% of SLC's overall emissions. The GHG emissions have been relatively the same since 2010. The change in Scope 2 emissions from grid-supplied electricity were reduced when provincial coal-based power plants were closed in 2013.

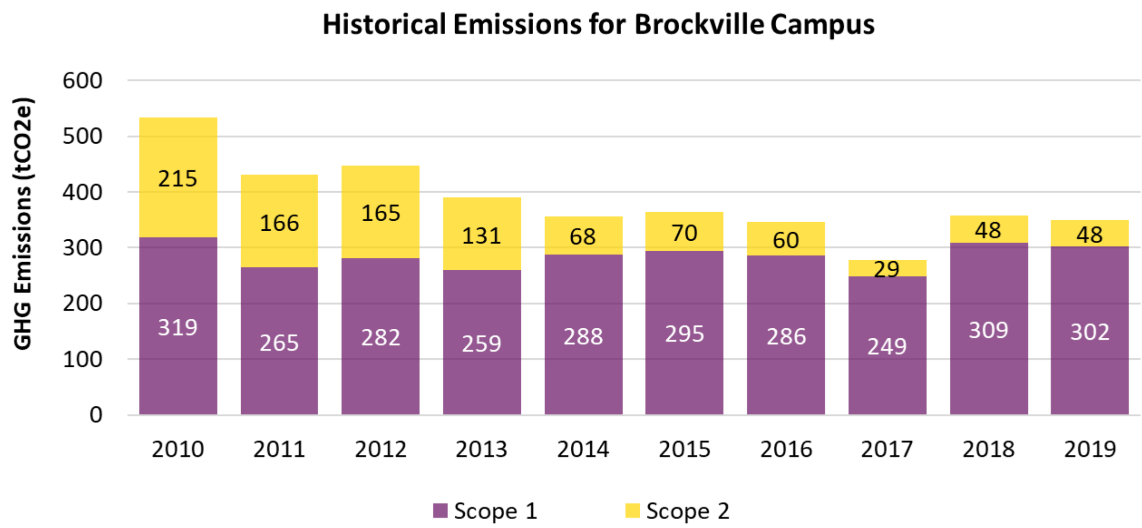


Figure 9. *Historic Emissions Trends for the Brockville Campus*

3.4. SLC GHG 2019 Inventory

LC's 2019 GHG footprint includes Scope 1 & 2 emissions. The breakdown of emissions by Scope is similar year over year. The highest contributors to SLC's GHG emissions are natural gas (Scope 1), and electricity (Scope 2). Figure 10 below illustrates the share of various GHG sources for all Scope 1 & 2 combined for the year 2018, aggregated for all campuses – Kingston, Cornwall, and Brockville.

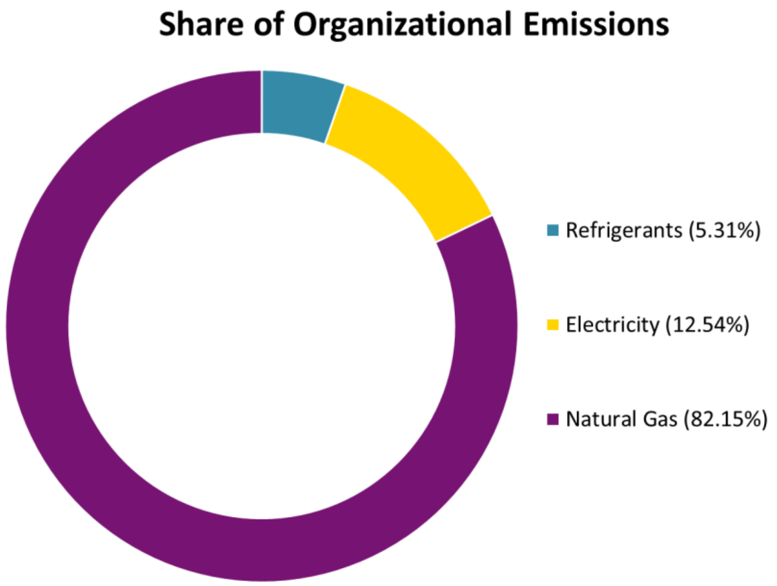


Figure 10. *2018 GHG Emissions & Sources*

Scope 1 represents most of total campus GHG emissions, which are primarily from natural gas as shown in Figure 11. Emissions reductions strategies that target the use of natural gas will result in the most significant decreases in Scope 1 emissions.

About 8% of Ontario's total power is generated from natural gas plants. This translates to 40 tCO_2e per kWh of electricity consumed. Thus, all Scope 2 emissions for SLC come from purchased grid electricity.

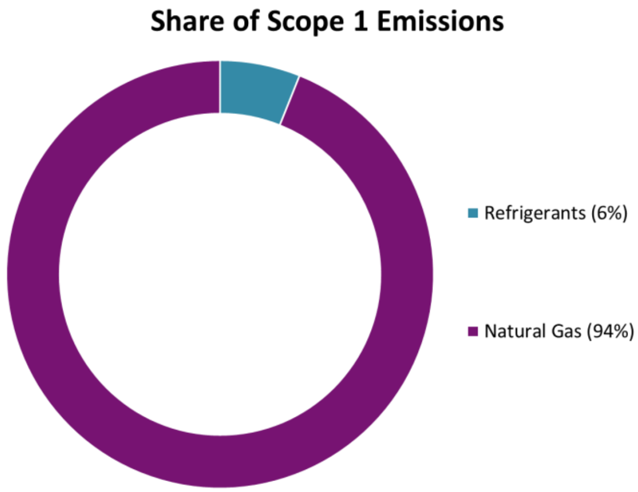


Figure 11. *2019 Scope 1 Emissions and Sources*

3.5. Growth

In 2010, SLC's total population across Kingston, Cornwall, and Brockville – including students, staff, and faculty – was 12,496 full-time equivalents (FTE). The total size of the SLC portfolio was 1,005,377 sq. ft. Since then, the population has increased by almost 39% to 22,725 FTE (in 2018). The annual growth trends are summarized in the graph below.

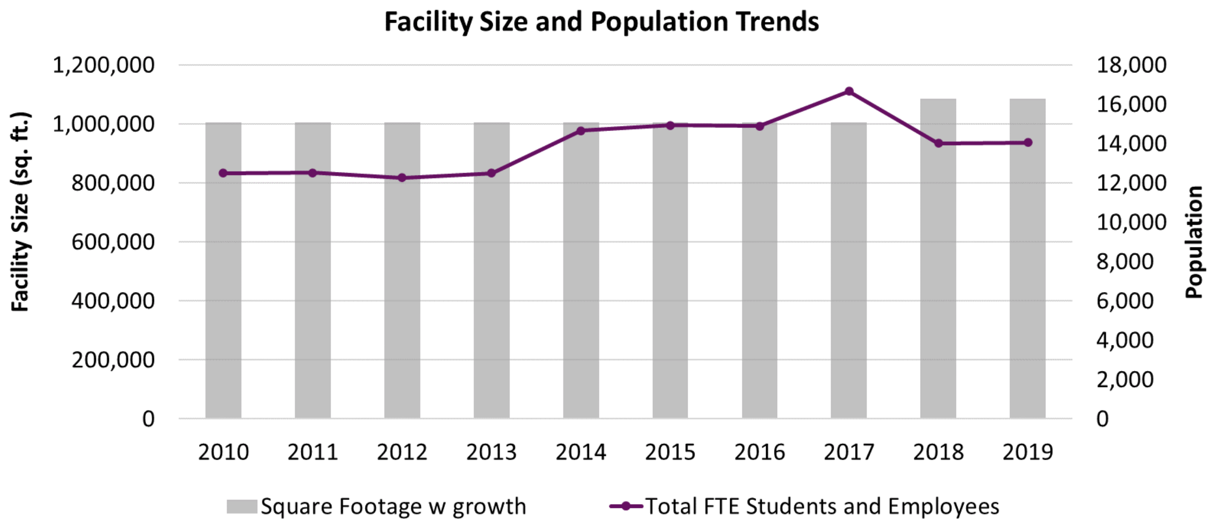


Figure 12. *Historic Growth Trends*

The enrollment growth estimates detail the expected campus growth in years to come. When analyzing data from the baseline year-to-date and forecasting trends to estimate SLC's expected campus and population growth by 2022, 2030 and 2050, there are two important factors to consider: 1) the increase in square footage and 2) the increase in population. As more students populate the campus, more faculty and staff will be necessary to support the growing enrollment. Expansions will be added to existing buildings, and new facilities will be constructed to accommodate the growing population. As these two factors increase, it is expected that total GHG emissions will increase as well.

For Scope 1 and 2 emissions, it is assumed that electricity and natural gas consumed per square foot is constant. As square footage increases to accommodate for growth, the emissions increase proportionally.

3.5.1. Campus Growth

Scope 1 and 2 emissions for the years 2010 to 2019 are modelled against the increase in square footage. Historically, increases in emissions and square footage follow an almost linear growth pattern. With efforts from energy conservation programs such as ECDM, the Scope 1 GHG emissions have mostly stayed the same despite campus growth. Scope 2 emissions have reduced in 2014 and is a result of coal plants being taken off-line in Ontario. While electricity use in all three campuses have stayed relatively constant, the fluctuations in scope 2 emissions from 2014-2019 can be attributed towards the change in grid carbon intensity year on year.

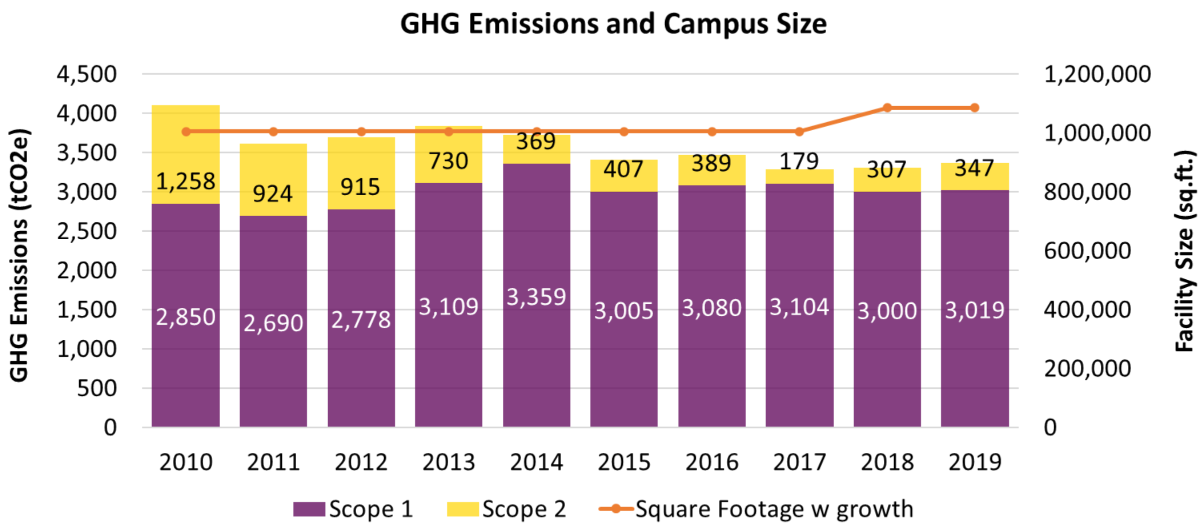


Figure 13. *Historic GHG Emissions Relative to Campus Size*

3.6. Business as Usual Emission Forecast

The following assumptions were considered to model SLC's forecasted emissions.

Table 3. *Growth Assumptions for SLC*

Annual Growth Assumptions	Kingston	Cornwall	Brockville
Campus Growth (sq. ft.)	5% every 10 Years		
Student Population (FTE)	1.5% annually till 2030 0.75 % annually from 2030-2050		
Employee Population (FTE)	1.5% annually till 2030 0.75 % annually from 2030-2050		

Figure 14 below demonstrates the business as usual (BAU) increase in SLC's total forecasted GHG emissions compared to SLC's target emissions level. It is expected that, by 2030, SLC's total emissions will be 3,705 tCO_2e, which is ~1,066 tCO_2e above its target for that year. Keeping with this trend, SLC's total emissions will be 4,085 tCO_2e in 2050 if no conservation or GHG mitigation strategies are implemented.

The Scope 1 and Scope 2 GHG emissions are estimated based on gross area. If no mitigation measures are adopted, then it is expected that by 2030 SLC's BAU total emissions will be 1,066 tCO_2e above target and by 2050 4,085 tCO_2e above target. These findings are further explained in the graph below.

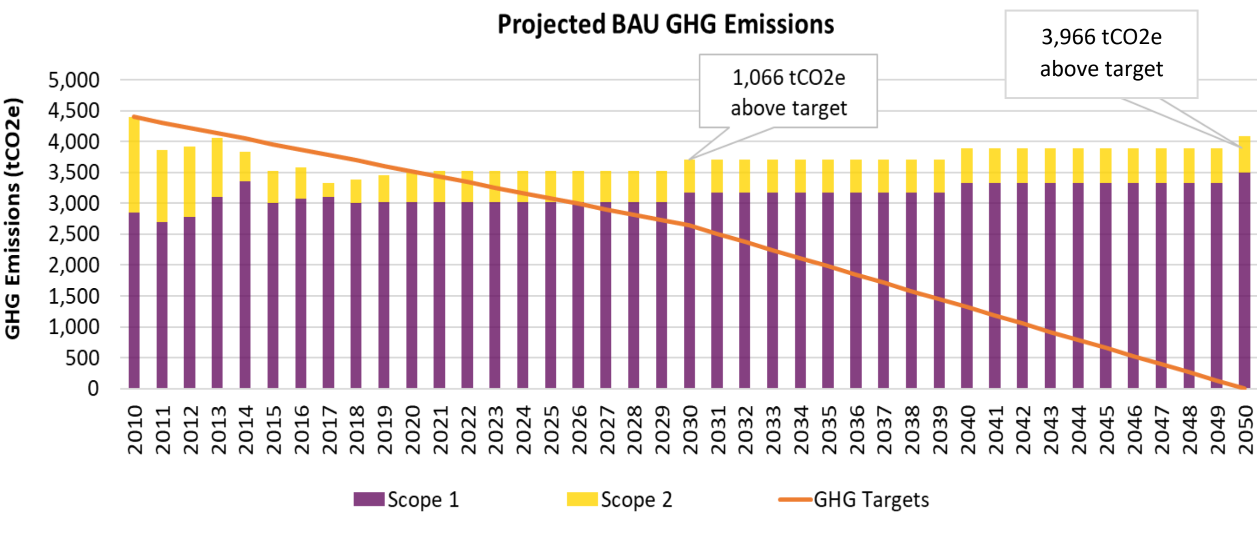


Figure 14. *Projected Business as Usual GHG Emissions*

4. Pillars of Carbon Reduction Roadmap

To reach SLC's net-zero carbon target, the following factors were analyzed in conjunction with a study of SLC's HVAC+L infrastructure, utility portfolio, campus growth plans, projected population increases and the potential for onsite renewable energy generation. To meet its 2030 and 2050 GHG emissions targets, SLC's GRRAP will be centred around the following four pillars, as previously mentioned:

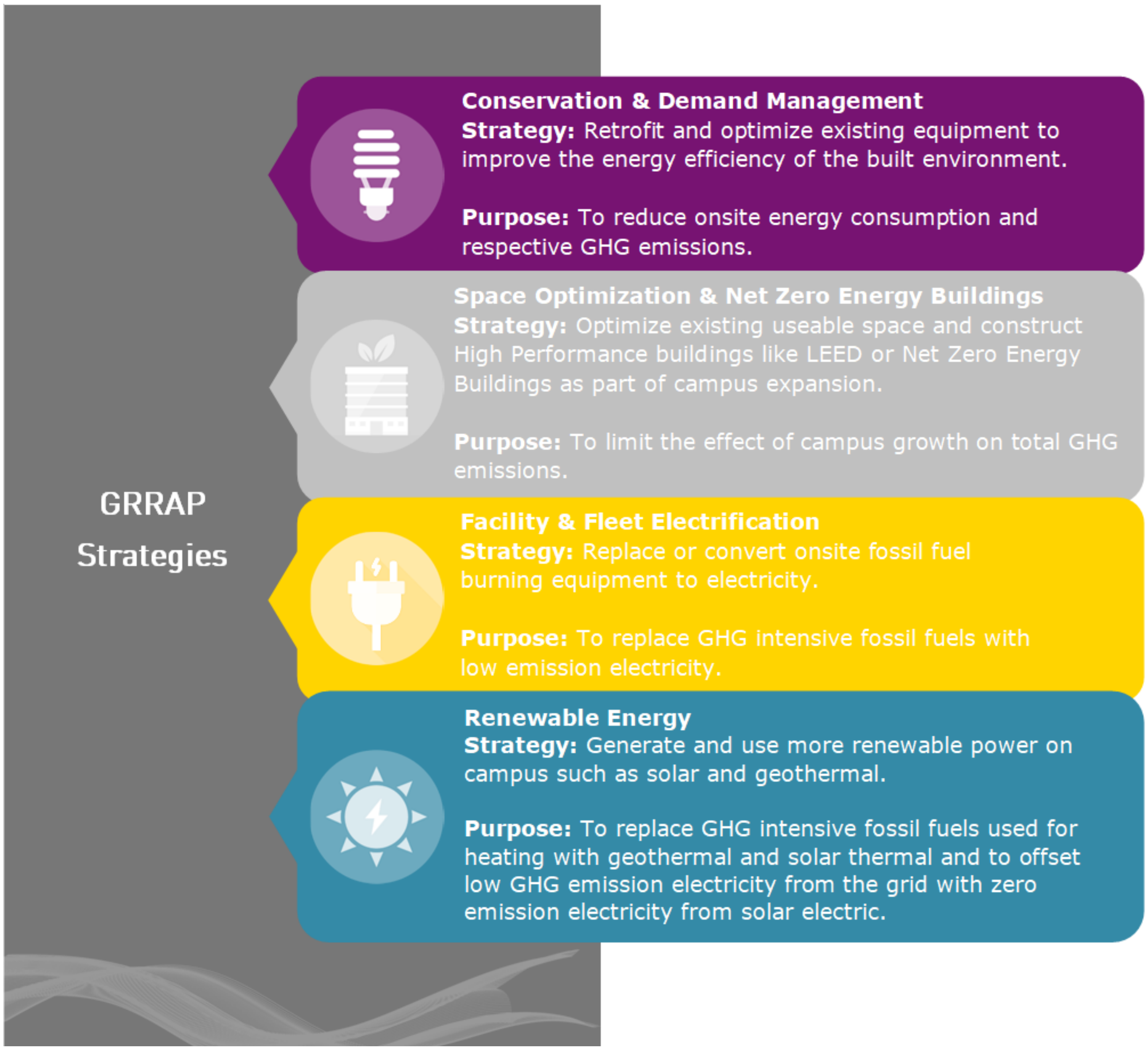


Figure 15. *GHG Reduction Pillars for the GRRAP*

4.1. Pillar 1: Energy Conservation & Demand Management

Energy Conservation and Demand Management (ECDM) refers to SLC's ongoing commitment to energy management and the improvement of campus-wide energy efficiency. ECDM measures reduce Scope 1 and Scope 2 emissions through facility upgrades and energy efficiency improvements and include renewable energy projects. The estimated savings and GHG reductions associated with the implementation of the ECDM, and measures and renewable energy generation planned from 2022 to 2035 are summarized in the table below. It is recommended that SLC fully execute the ECDM Plan by 2035.

Table 4. *Estimated Annual Savings from ECDM Plan*

ECDM Summary	2022 - 2025	2026 - 2035	Total
Total Investment in Conservation	$9,587,286	$21,355,760	$30,943,046
Electricity Savings (kWh)	2,377,280	328,197	2,705,477
Electricity Cost Savings	$316,891	$43,749	$360,640
Electricity Cost Savings Compared to 2019 Expenditure	18.7%	2.6%	21.2%
Gas Savings (m3)	150,489	544,020	694,509
Gas Cost Savings	$43,115	$155,862	$198,977
Gas Cost Savings Compared to 2019 Expenditure	10.0%	36.3%	46.3%
Total Utility Savings ($)	$360,007	$199,610	$559,617
GHG Reduction (tCO2e)	380	1,041	1,421

SLC should continue to be committed to creating a culture of ECDM and should update the ECDM Plan on a five-year renewal timeframe. To implement all measures identified in the EDCM Plan, SLC would need to invest $30,943,046 over 10 years. Once completed, the EDCM measures will save electricity and natural gas and reduce GHG emissions by ~1,421 tCO_2e annually.

4.2. Pillar 2: Space Use Optimization & Zero Carbon Buildings

The built environment is a crucial element in the academic experience of students, faculty, and staff. As such, it is important for SLC spaces such as classrooms, laboratories, and administrative spaces to be well maintained, to have flexibility to accommodate changes to enrollment and staffing, and to be able to support new institutional needs. Space use optimization and zero carbon buildings provide opportunities for SLC to meet the needs of its students and staff while remaining in alignment with GHG emission reduction targets.

4.2.1. Space Use Optimization

Space utilization analysis is a tool that can help SLC uncover which areas on campus are underused, why they are underused, and how to best move forward to improve space utilization. The average classroom in a North American post secondary institution is occupied less than 60% of the time during a typically scheduled day[2]. However, the classroom utilization rates for the Kingston, Brockville and Cornwall campuses are 82%,75% and 53% respectively.

Space utilization audits provide a data-centred assessment of the condition of building stock and the state of deferred maintenance. This is coupled with insights on how relocating certain offices could better centralize multiple departments. It can also help with the development of a capital allocation plan to achieve desired improvements.

Space utilization audits provide insights into wasted space and outlines how rethinking existing assets can achieve cost-savings goals previously thought to be out of reach. Educational institutions have spaces that are designated for "general use" (rooms that can be used for multiple academic purposes) and other spaces that are considered "owned-space" (classrooms, seminar spaces, laboratories that are controlled by departments). A space utilization audit would identify the potential positive and negative impacts, as well as barriers, to SLC implementing a policy to release "owned" spaces for general assignment.

Indoor space mapping, combined with real-time occupancy and schedule monitoring, determines how existing spaces can be better utilized. Space-sensing technology, combined with building automation systems (BAS), can support energy-saving lighting and HVAC optimization, further reducing total campus GHG emissions.

Space use optimization is a preventive measure against building new spaces. By maximizing the use of the existing built environment and underutilized spaces, and using technology and data analysis, space utilization can give institutions useful information to avoid unnecessary new construction projects. It is a useful tool to evaluate if campus expansion requirements can be met by effective utilization of existing spaces, avoiding the significant costs associated with new construction and operations and maintenance required for the new space.

[2] Sightlines, 2017: Space Utilization: Why it Matters to Find Negotiation Space on Campus

Case Study 1: Space Optimization – Compatible Technology

Cloud computing, artificial intelligence analytics and internet-connected sensors allow BAS to continually re-adjust temperatures. These adjustments are based on real-time data from occupancy and humidity sensors, commands from individual users via mobile or desktop applications, exterior temperature readings and predictions based on historical patterns of user behaviour, and time-of-use energy pricing policies in Ontario[3]. Smart heating, ventilation and air conditioning controls can limit energy consumption in unoccupied building zones, detect and diagnose faults and help reduce HVAC usage during times of peak energy demand.

As an example, the setup and functions of GE Current's smart office system are demonstrated below.

Figure 16. *GE Smart Office System*

[3] GE Current: How to build an intelligent office
https://www.currentbyge.com/ideas/how-to-build-an-intelligent-office

Case Study 1: Space Optimization – Compatible Technology

Integrating smart office technology in operations many advantages:

- Space availability and booking are dynamically adjusted based on occupancy and proximity.
- Hot-desking opportunities are created for remote workers, enabling effective use of underutilized space.
- Tracking equipment and furniture use can be implemented to improve logistics, facility operations and resource management.
- HVAC and lighting can automatically adjust to room occupancy.
- Up to ~20% annual utility cost savings can be achieved across typical office environments[4].
- Networked lighting control and BAS create energy management strategies that:
    - Create facilities that never forget to flip the switch when leaving a room.
    - Empower users to personalize their lighting and temperature controls.
    - Create facilities that coordinate lighting, heating, and cooling for optimum operational efficiency.

[4] Brasington, 2019: Smart Buildings – Innovation in Space Utilization
https://www.cleantech.com/smart-buildings-innovation-in-space-utilization/

4.2.2. Zero Carbon Buildings

The design, and operation of new and renovated spaces can have a significant impact on total campus GHG emissions for a long time. Environmental performance measures that promote sustainable new and retrofit development have a significant impact on the energy, GHG and comfort characteristics. Buildings in campus portfolio tend to be retained for long lives meaning a structure built today will still be in use past 2050 – designs now will impact carbon loads in a time when low to zero carbon buildings will be the norm. Low to zero carbon building (L-ZEB) designs will help SLC to reduce its carbon presence now and continue to keep GHG levels low as the building ages.

There are several existing L-ZEB standards and guidelines SLC can refer to and tailor to their own needs and circumstances. A dominant concept is to define absolute performance metrics for new builds and renovations. This refers to defining a fixed energy and GHG performance as units/m^2, such as kWh/m^2 and kg CO_2/m^2.

For example, the Toronto Green Standards, British Columbia Step Program and Canadian Green Building Council (CaGBC) have been shown to drive high performance construction without causing insurmountable incremental costs while yielding reduced energy and carbon costs. These are typically tied to the current Building Code requirements. In the case for SLC, this will mean setting standards that surpass the requirements of the current Ontario Building Code (OBC) including the Supplementary Bulletin 10, for example pursue zero carbon building standards for new builds.

These standards differ slightly but are all focused on designing high performance buildings that can be powered by renewable energy sources. The more energy efficient a building is constructed to be, the less energy is required to power the building.

Benefits of a L-ZEB design/renovation are:

1. Reduced energy and carbon costs
2. Improved thermal resilience
3. Improved thermal control
4. Attention to and use of daylighting
5. Improved ventilation efficacy
6. Improved and consistent comfort levels
7. More consideration for the impact on the surrounding environment – exterior lighting, bird impacts, water retention, heat island, public transportation

We recommend SLC develop and enforce low to zero carbon design standards for major renovations (this would be where the renovation addresses mechanical systems and envelope) and new buildings.

The New Buildings Institute studied the cost and savings from the construction and operation of ZCB. In the study, costs were separated into two categories: 1) the incremental costs for energy conservation measures and 2) the costs for purchase and installation of renewable energy systems. By increasing energy efficiency, the quantity of renewable energy systems (and therefore the cost) will be reduced. The Institute also extended the framework to retrofits and refurbishment of existing buildings to net-zero carbon by considering the design strategies listed in Figure 17 below.

***Figure 17**. Design Considerations for High Performance Buildings*

The average cost of construction in Ontario is an estimated $300 per square foot (sq. ft), compared to the average cost of a LEED building in Ontario, which was found to be ~$295/sq. ft. A ZCB is estimated to add approximately 8% to 13% to the cost premium of LEED buildings. The differences in cost for campus expansion is estimated in Table 5 below.

***Table 5.** Capital Cost Considerations for Zero Carbon Buildings*

Construction Type	$ / sq. ft.		Example Facility Expansion in 2028	Estimated Total Cost (2028 $)
	2018 $	2028 $		
Building Code	$300	$345	100,000 sq. ft	$34,500,000
LEED Gold Construction	$295	$339		$33,900,146
ZCB Construction	$320	$368		$36,800,000

Although construction of a ZCB comes with a cost premium of 7% to 13%, there are long-term financial savings in building to the Zero Carbon Standard. A typical ZCB has an annual utility and maintenance cost savings of approximately 20% to 26% when compared with a LEED construction project[5]. This is shown in Table 6 below.

***Table 6**. Comparing LEED & Zero Carbon Buildings*

	LEED Construction	Zero Carbon Buildings	Savings
Addition to Kingston Campus (sq. ft.)	100,000	100,000	
Estimated Construction Costs ($/sq. ft.)	$295	$320	
Estimated Construction Costs	$29,500,000	$32,000,000	-$2,500,000
Annual Natural Gas and Electricity Utility Cost ($/sq. ft.)	$1.49	$0.97	26%
Estimated Annual Utility Expense	$148,532	$96,546	$51,986
Simple Payback (Years)			48
Simple Payback with Utility Rate Escalation (Years)			34

Investing an additional $2,500,000 to construct a ZCB would generate an annual utility cost saving of $51,986 and would result in a 48-year payback based on additional construction costs and at current utility rates. However, when accounting for the escalation of utility rates, the payback for a ZCB goes down to 34 years.

[5] Canada Green Building Council & WSP, 2019: Making the Case for Building To Zero Carbon.

Case Study 2: Zero Carbon Buildings

Completed in Fall 2018, “evolv1” is a three-story, 110,000 sq. ft. commercial multi-tenant office building and one of 16 participants in CaGBC’s Zero Carbon Building pilot program.

Figure 18. *Evolv1 in Waterloo, ON*

Building highlights:

- Modelled as zero carbon balance for future operations.
- Incorporated a highly efficient energy and ventilation system to meet a defined threshold for thermal energy intensity.
- Designed onsite renewable energy systems capable of providing a minimum of five per cent of building energy consumption.

The building’s design includes elements aimed at maximizing its energy efficiency and producing more energy than it consumes:

- High-performance building envelope.
- Geo-exchange/variable refrigerant flow (VRF) HVAC system.
- Triple pane glazing.
- Solar wall for preheated ventilation.
- Combination of carport and roof-mounted photovoltaics producing 700kw of electricity for the grid.
- Three-story green wall to improve indoor air quality.

Estimated construction cost:

$318/sq. ft. (without interior fit-out)

4.3. Pillar 3: Facility & Fleet Electrification

To meet SLC's 2050 GHG emission target of net-zero, SLC must transition away from fossil fuel-based energy consumption and move towards low-carbon alternatives for its energy supply. Total facility and fleet electrification would entail the complete conversion of onsite equipment, including natural gas fired boilers and HVAC equipment, gasoline and diesel vehicles, and natural gas cooking equipment.

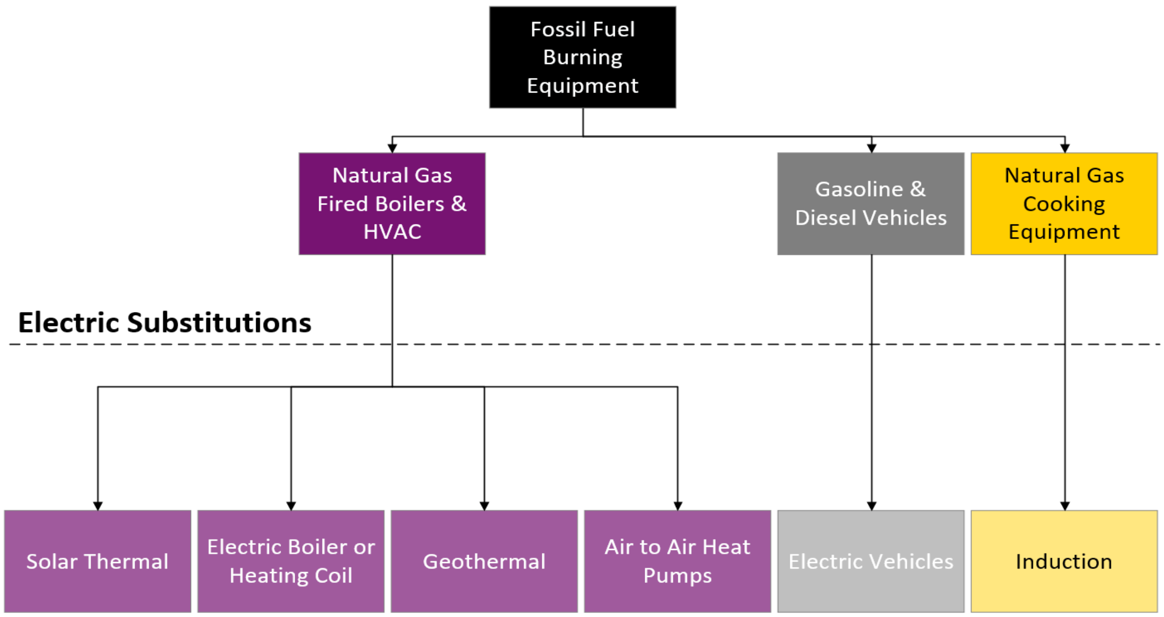


Figure 19. *Electric Equivalents for Traditional Equipment*

When comparing natural gas and electric systems, electrification produces fewer CO_2e emissions per kWh consumed. Comparatively, 1 kWh of electricity would emit 41g of CO_2 while 1 equivalent kWh (ekWh) of natural gas would emit 179 g of CO_2. The carbon content of various fuels converted to equivalent kWh is represented in Figure 20.

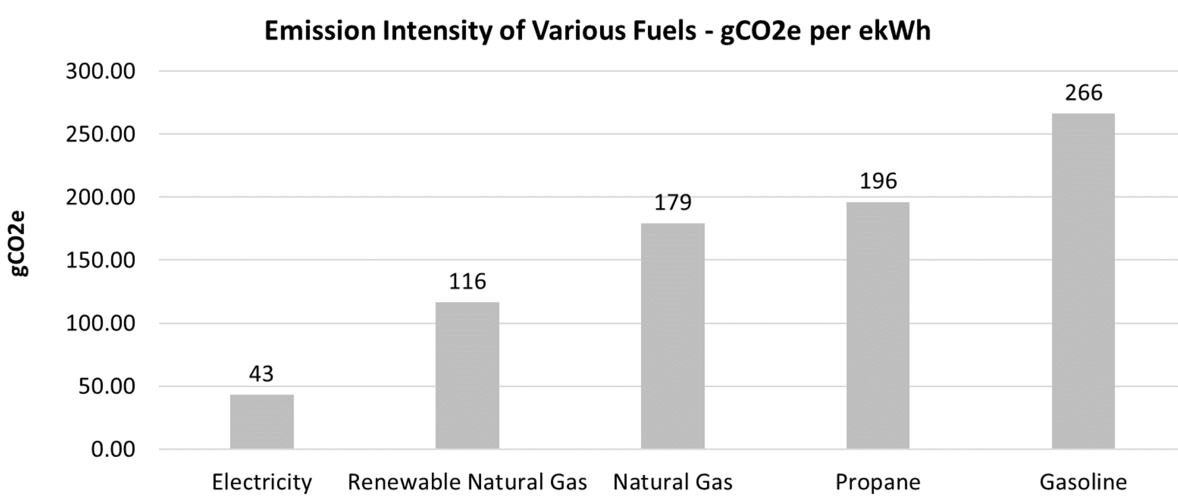


Figure 20. *Emissions Intensity of various Fuels for Equivalent Energy Output*

Based on the timeline and rate of electrification, two actions were developed: aggressive action electrification and delayed action electrification. Pillar 3 has the most cost and carbon impact that will shape SLC's journey to net zero carbon.

Under the aggressive and moderate actions, it is expected that SLC will fully implement the projects needed under Pillars 1, 2 and 4.

The actions were based on the expected asset end of life based on ASHRAE standards (see Table 8) and applied to SLC's equipment list. For example, as each natural gas-fired air handing unit (AHU) approaches end of life, the GRRAP considered the cost and carbon reduction associated with replacing it with an electric equivalent or high efficiency natural gas replacement. Depending on the current age of the equipment, it is possible it may be replaced ~two times with similar natural gas equipment prior to being replaced with low carbon electric equivalents, as shown in Table 7.

Table 7. *Sample Replacement Schedule for Fossil Fuel Equipment*

Campus	Location	Initial Installation Date	Estimated Replacement Schedule		
Kingston	A – Upper Roof	1996	2019	2034	2049
Potential Fuel Source →		Natural Gas	Natural Gas	Natural Gas	Electric

As part of Pillar 3, replacing equipment at the end of its life expectancy creates a decision point for SLC to assess whether the equipment should be replaced with electric equivalents or conventional natural gas systems. Under the aggressive action, SLC will replace fossil fuel burning equipment at the *first* end of life replacement cycle. Under the delayed action, it will defer electrification if possible and convert equipment at the final end of life replacement cycle before 2050.

The following table shows the life expectancy of equipment and the last date of potential installation for fossil fuel burning equipment.

Table 8*. Fossil Fuel Burning Equipment Expected Life Table*

Fossil Fuel Burning Equipment	Expected Life (Years)[6]	Last Date of Potential Installation / Replacement
Boiler	20	2030
Make-up Air Unit / Air Handling Unit – Interior Installation	25	2025
Make-up Air Unit / Air Handling Unit – Exterior Installation	15	2035
Cars / Trucks	10	2040
Cooking Equipment	15	2035

**Expected Life - ASHRAE Equipment Life Expectancy Chart*

[6] ASHRAE Equipment Life Expectancy Chart

Under the aggressive and delayed actions, SLC will increase its electrification and reduce its GHG emissions from natural gas-based equipment. The sooner SLC makes the investment in electric systems, the quicker it will reduce emissions. The following chart depicts the potential replacement (under each action) for fossil fuel burning equipment during the process of electrification (based on currently available technology). The group of equipment that make up these measures are: boilers, MAUs and AHUs.

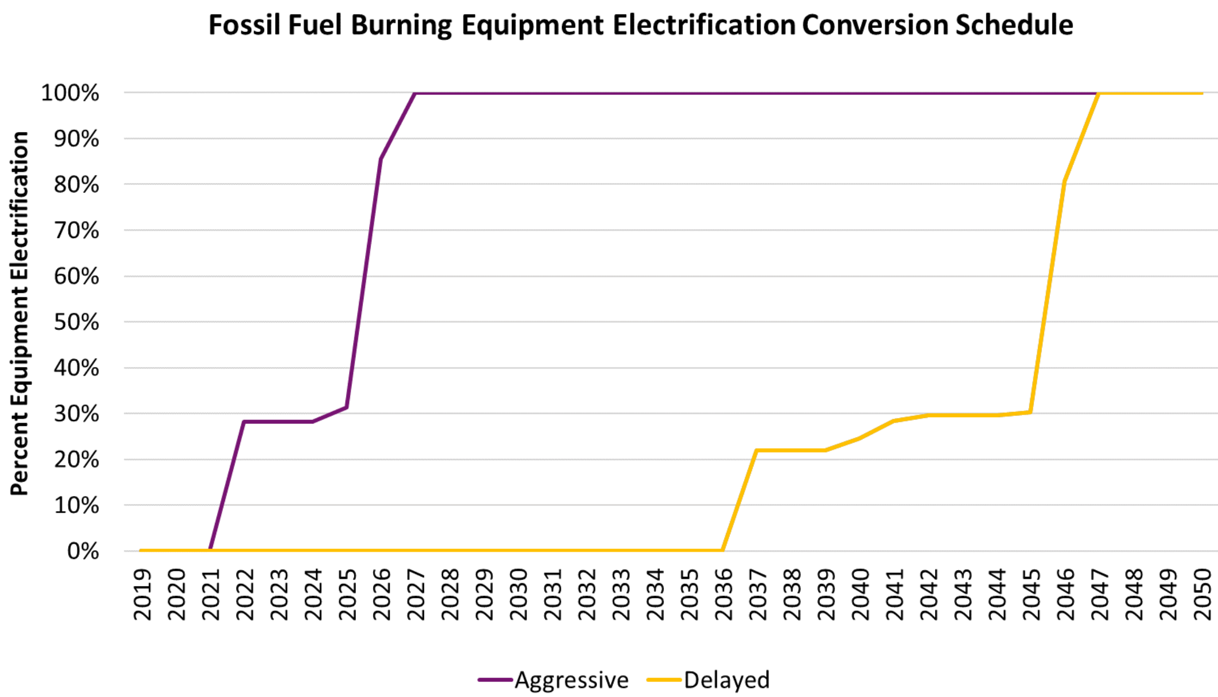


Figure 21. *Equipment Electrification Conversion Schedule*

4.4. Pillar 4: Renewable Energy Generation

Solar photovoltaic (PV) is a proven, low-maintenance and cost-effective form of renewable energy. It is currently installed on campus. Between the three campuses, SLC could install 2,695 kW or 2.695 MW of carport systems and produce 3.05 million kWh of renewable power. This estimate is based on the information available during the period of this study and actual number could vary depending on multiple factors such as changes to the campus master plan and parking plans.

Carports provide a great opportunity to produce renewable power when space constraints are a concern. Carport solar PV systems are a highly visual symbol of SLC's commitment to sustainability. The steel structures (or canopies) required to hold the solar panels typically make carport PV systems about twice as expensive to install as rooftop PV systems.

Maximizing SLC's solar potential on rooftops and carports would enable SLC to generate about 2,533 kW of solar power.

The limiting factor for renewable energy generation on SLC campuses is the space requirement per megawatt (MW) or kilowatt (kW) of solar installed. Based on the analysis of rooftop solar potential for SLC, using current solar technology efficiency estimates and evaluating rooftop space, the existing facilities can accommodate about 1,040 kW or 1.04 MW of rooftop solar PV at an estimated cost of ~$2,000 per kW. Solar PV is typically net metered to the provincial grid system. The amount produced would contribute to lowering SLC's Scope 2 emissions by reducing the amount of electricity it purchases from the grid.

Geothermal energy is a very effective way to reduce SLC's Scope 1 natural gas emissions. All three of SLC's campuses are optimal locations for the installation of geothermal systems. The projects identified in this study are expected to provide renewable heating to the campus buildings and reduce natural gas consumption by almost 461,000 cubic meters, which would reduce about 870 tonnes of GHG emissions annually.

Other forms of solar technology not considered in this report but still might be feasible for SLC are the building integrated and building applied photovoltaics more available (BIPV and BAPV). Case Study 3 on the following page elaborates on the BIPV and BAPV systems, their space and cost considerations.

Case Study 3: Building Integrated and Building Applied Photovoltaics (BIPV and BAPV)

Recent PV technology improvements are making building integrated and building applied photovoltaics more available (BIPV and BAPV). The difference between the two is that BIPV is when the PV is a part of the building such as embedded into the windows or forms the actual envelope, whereas BAPV is when the PV system is mounted on to the building such as the roof or vertical racking onto a wall.

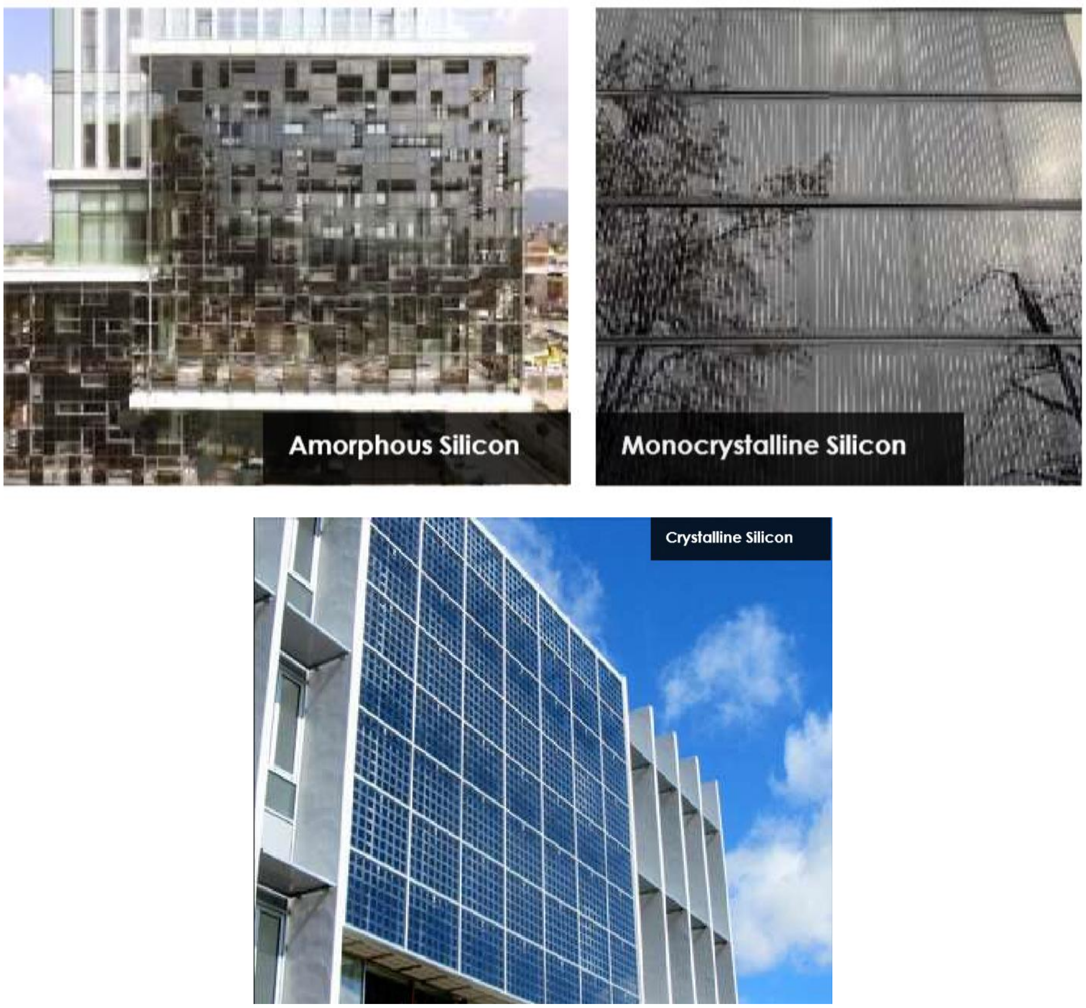


Figure 22. *Examples of BIPV & BAPV*

Some examples of BIPV – the PV modules are a part of the envelope. These can be customized with a range of transparencies and limited colours. The lower left image shows crystalline modules; the right is amorphous.

BIPV applications are typically considered from the start of a new building as the architect is generally the lead to make sure the “look”, style and appropriate design teams are involved – i.e., structural, electrical. If an envelope BIPV system is being considered, the existing wall will be removed and the new BIPV envelope installed. Other examples of BIPV are skylight and window style of BIPV, will require a structural survey as well and best coordinated with a design team to ensure compatibility with the building style and envelope integrity.

An alternate version is the building applied PV or BAPV. In this case the PV array is mounted onto the structure. A fixed or ballasted PV array on a roof is an example of this arrangement and very common. Wall mounted PV can be hung onto the wall using a racking system or used as an awning over windows to provide some shading as well as power.

Figure 23. *Examples for mounting of BIPV & BAPV*

BIPV and BAPV Considerations

BIPV systems are used as cladding or the window units. The design possibilities are in keeping with the envelope designs available. There are curtain wall, skylights, canopy, ventilated facades, and floors. They are usually constructed as sandwiched PV between glass so can be a substitute for conventional architectural glass. They offer energy production, lighting (depending on transparency), infra-red and UV filter, acoustic and thermal characteristics.

The PV module is either amorphous or crystalline cells. Amorphous can be supplied in a variety of shapes, sizes, colours, and transmission from 0% to 30%. These have a consistent colour across the complete face of the glass. The power ranges because of the transparency from ~57 W/m^2 at 0% to about 28 W/m^2 at 30%.

Crystalline silicon PV can also be customized but are usually configured as square to rectangular shapes. These look more like conventional PV modules with cells spread across the face. This also means they always let some light through even at high cell densities. They range from ~15% to 38% transparency. The power is dependant on the cell density.

Production Potential

The graphs below illustrates a sample output for an amorphous array, 100 m^2 5.7 kW, 0% transmission, 4,000 kWh/yr. and a crystalline array, 100 m^2, 3.5 kW, 15% transmission, 2,756 kWh/yr., both mounted on a vertical wall, facing due south.

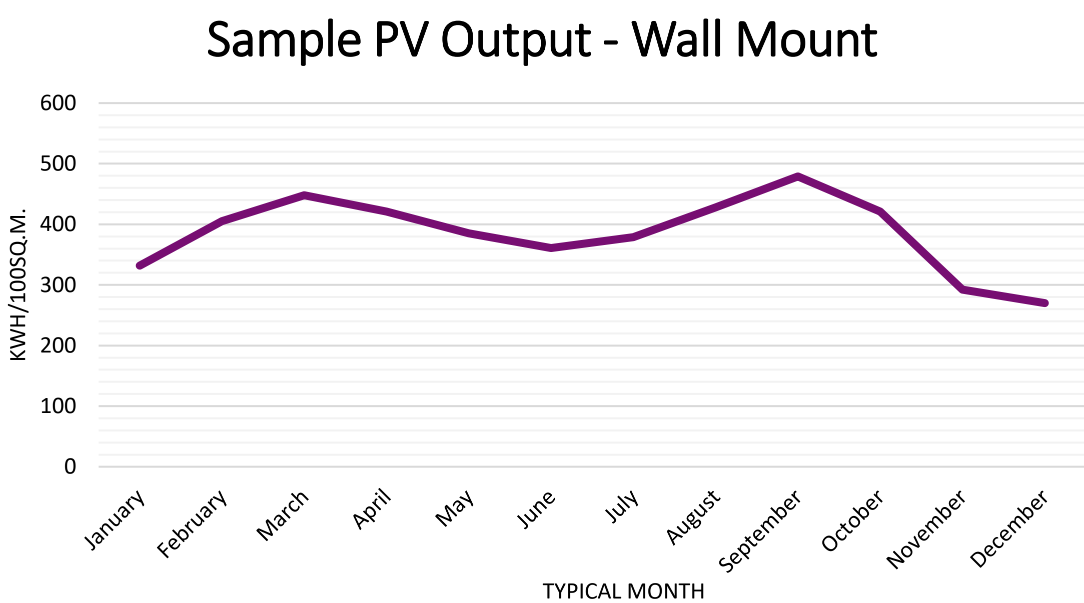


Figure 24. *Sample amorphous wall 100m2 BIPV at 0% transmission, 5.7 kW, 4,000 kWh/yr.*

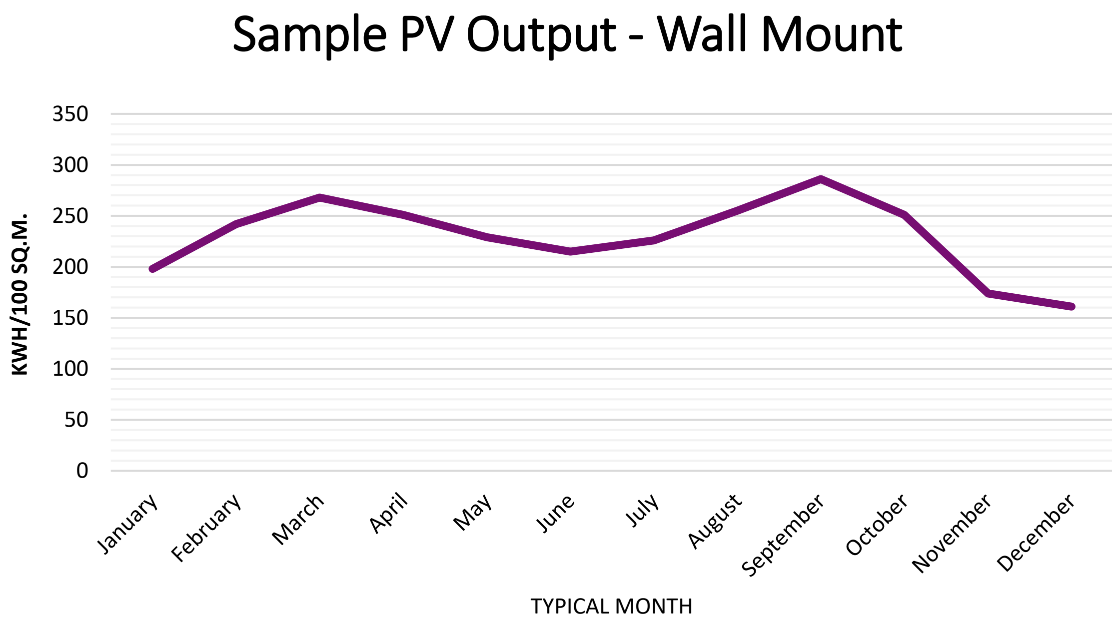


Figure 25. *Sample crystalline wall 100m2 BIPV at 15% transmission, 3.5 kW, 2,756 kWh/yr.*

Cost Considerations

Of the BIPV applications, a fully integrated PV envelope will be more expensive due to the structural elements required to complete the wall. Though a sample has been shown above for 100 m^2, most BIPV systems are at or above 1,000m^2 before the benefits of scale are available. An estimated cost for a full BIPV wall can be expected to be between $1 million and $1.5 million depending on the fastening system.

A wall mounted BAPV can be expected to cost about half of a BIPV but is more dependent on the structural integrity of the existing wall.

As for any PV system, the connection must be evaluated before making the decision to go forward with an installation. This is done early in the design process in coordination with the local distribution company.

4.5. General Sustainability Initiatives

The four pillars will reduce Scope 1 and 2 emissions that result from the energy used by campus facilities and fleets. To reduce Scope 3 emissions from air travel, mileage reimbursements, waste and purchased paper, SLC will need to support general sustainability initiatives.

SLC should ensure that all institutional policies are aligned with the GRRAP. For example, SLC should ban single use plastics and continue initiatives to limit food waste generation. SLC has a well-developed waste management program that has contributed to a reduction in their GHG emission footprint. SLC should also expand sustainable transportation options for the school's community to ensure that low carbon modes of transportation are a part of its carbon neutral future.

4.6 Sustainability Indicators

Climate change is recognized as a risk for financial and sustainability modelling. Markets and society are increasingly aware of the costs and risks of climate change and the results of inaction to mitigate the effects. Establishing a strategy will help to manage the risks associated with environmental, societal and governance dimensions for SLC. This GRRAP is a part of the strategy planning and combines with SLC's sustainability plans and efforts to align with current programs that are being used as benchmarks for acknowledging the efforts. The UN Sustainable Development Goals (SDG) are another recognized platform for this. Elements of this GRRAP support the UN SDG categories that relate to clean energy, resiliency, and action.

Figure 26. UN Sustainable Development Goals

5. GHG Emissions Reduction Scenarios

For SLC to meet its emission reduction targets, it must implement programs to support the four GRRAP pillars. Based on the combinations in which the GRRAP pillars are implemented, four scenarios for SLC to advance towards net-zero are presented.

5.1. Scenario 1: Energy Conservation and Renewbles Only

Under this scenario SLC implements Pillars 1 and 4 – Energy Conservation and Demand Management, and Renewable Energy Generation. SLC's efforts under this scenario are minimal and do not deviate from BAU operations considerably. Therefore, it provides the least GHG reduction. The assumptions made under this scenario apply to three different time periods that are outlined below.

Between 2022 and 2025, SLC will:

- Implement all electricity and natural gas conservation measures.
- Conduct space utilization audits to ensure a 90% space utilization rate.
- Invest in Rooftop and Carport Solar and Geo-exchange heat pumps.

Between 2026 and 2035, SLC will:

- Implement all electricity and natural gas conservation measures.
- Invest in Rooftop and Carport Solar and heat pumps.

Between 2036 and 2050, SLC will:

- Update the ECDM Plan.
- Investigate improvements in RE technology.

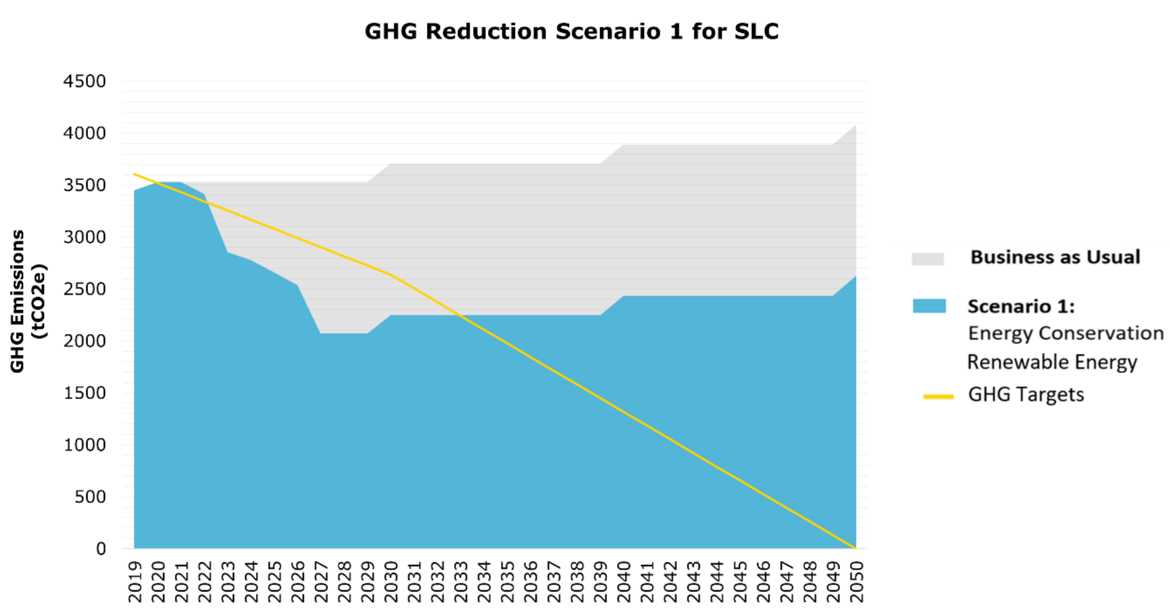


Figure 27. GHG Reduction Scenario 1 for SLC

5.2. Scenario 2: Energy Conservation, Renewbles and Zero Carbon Buildings

Under this scenario SLC implements Pillars 1, 2 and 4 – Energy Conservation and Demand Management, Space Use Optimization & Zero Carbon Buildings, and Renewable Energy Generation. SLC undertakes all efforts from Scenario 1 and additional efforts to manage its space use and built environment. This scenario eliminates the rise in future GHG emissions resulting from campus expansion. Thus, amplifies the efforts from Scenario 2 and avoids GHG emissions in the future. The assumptions made under this scenario apply to three different time periods that are outlined below.

Between 2022 and 2025, SLC will:

- Implement all electricity and natural gas conservation measures.
- Conduct space utilization audits to ensure a 90% space utilization rate.
- Construct Zero Carbon Buildings for planned campus expansion.
- Invest in Rooftop and Carport Solar and Geo-exchange heat pumps.

Between 2026 and 2035, SLC will:

- Implement all electricity and natural gas conservation measures.
- Invest in Rooftop and Carport Solar and heat pumps.
- Construct Zero Carbon Buildings for planned campus expansion.

Between 2036 and 2050, SLC will:

- Update the ECDM Plan.
- Investigate improvements in RE technology.
- Construct Zero Carbon Buildings for planned campus expansion.

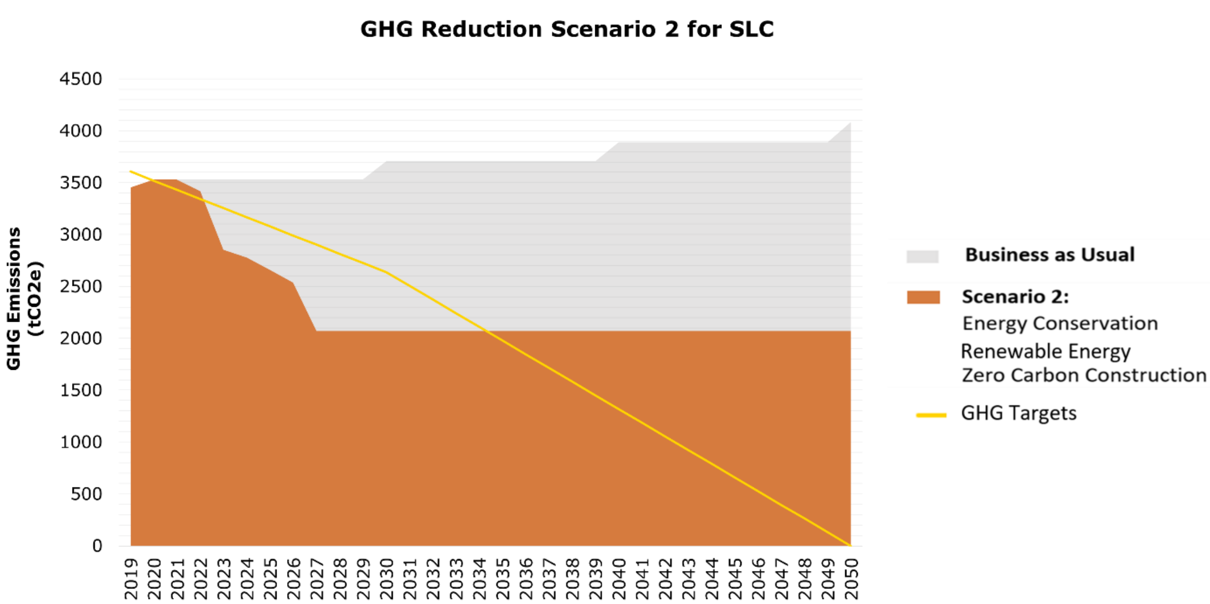


Figure 28. *GHG Reduction Scenario 2 for SLC*

5.3. Scenario 3: Energy Conservation, Renewbles, Zero Carbon Buildings and Delayed Electrification

Under this scenario SLC implements Pillars 1, 2, 3 and 4 – Energy Conservation and Demand Management, Space Use Optimization & Zero Carbon Buildings, Electrification, and Renewable Energy Generation. SLC undertakes all efforts from Scenario 2 and the delayed action for electrifying its natural gas-based equipment. This scenario effectively reduces Scope 1 GHG emissions resulting from natural-gas use and accelerate the college towards its net-zero target. The assumptions made under this scenario apply to three different time periods that are outlined below.

Between 2022 and 2025, SLC will:

- Implement all electricity and natural gas conservation measures.
- Conduct space utilization audits to ensure a 90% space utilization rate.
- Invest in Rooftop and Carport Solar and heat pumps.
- Defer electrification of equipment until 2037.

Between 2026 and 2035, SLC will:

- Implement all electricity and natural gas conservation measures.
- Invest in Rooftop and Carport Solar and heat pumps.
- Construct Zero Carbon Buildings for planned campus expansion.
- Defer electrification of equipment until 2037.

Between 2036 and 2050, SLC will:

- Update the ECDM Plan.
- Investigate improvements in RE technology.
- Construct Zero Carbon Buildings for planned campus expansion.
- Electrify 100% of remaining natural gas-based equipment.

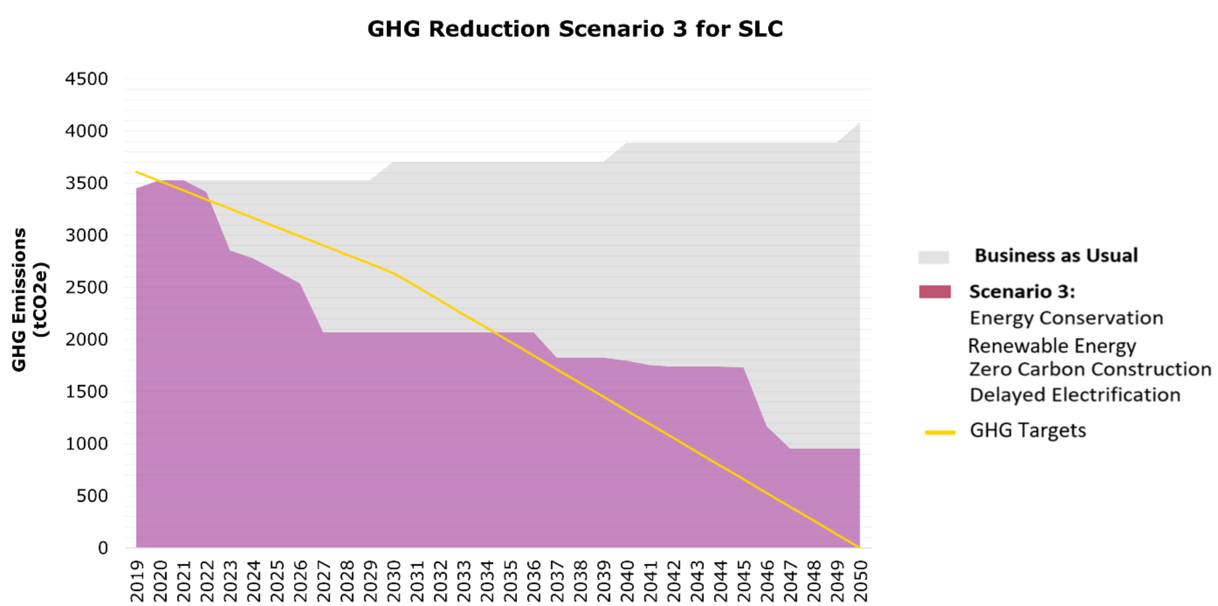


Figure 29. *GHG Reduction Scenario 3 for SLC*

5.4. Scenario 4: Energy Conservation, Renewbles, Zero Carbon Buildings and Aggressive Electrification

Under this scenario SLC implements Pillars 1, 2, 3 and 4 – Energy Conservation and Demand Management, Space Use Optimization & Zero Carbon Buildings, Electrification, and Renewable Energy Generation. SLC undertakes all efforts from Scenario 2 and the aggressive action for electrifying its natural gas-based equipment. This scenario drastically reduces Scope 1 GHG emissions resulting from natural-gas use and provides the maximum GHG reduction for the college. The assumptions made under this scenario apply to three different time periods that are outlined below.

Between 2022 and 2025, SLC will:

- Implement all electricity and natural gas conservation measures.
- Conduct space utilization audits to ensure a 90% space utilization rate.
- Invest in Rooftop and Carport Solar and heat pumps.
- Electrify 31% of natural gas-based equipment.

Between 2026 and 2035, SLC will:

- Implement all electricity and natural gas conservation measures.
- Invest in Rooftop and Carport Solar and heat pumps.
- Construct Zero Carbon Buildings for planned campus expansion.
- Electrify 69% of remaining natural gas-based equipment.

Between 2036 and 2050, SLC will:

- Update the ECDM Plan.
- Investigate improvements in RE technology.
- Construct Zero Carbon Buildings for planned campus expansion.

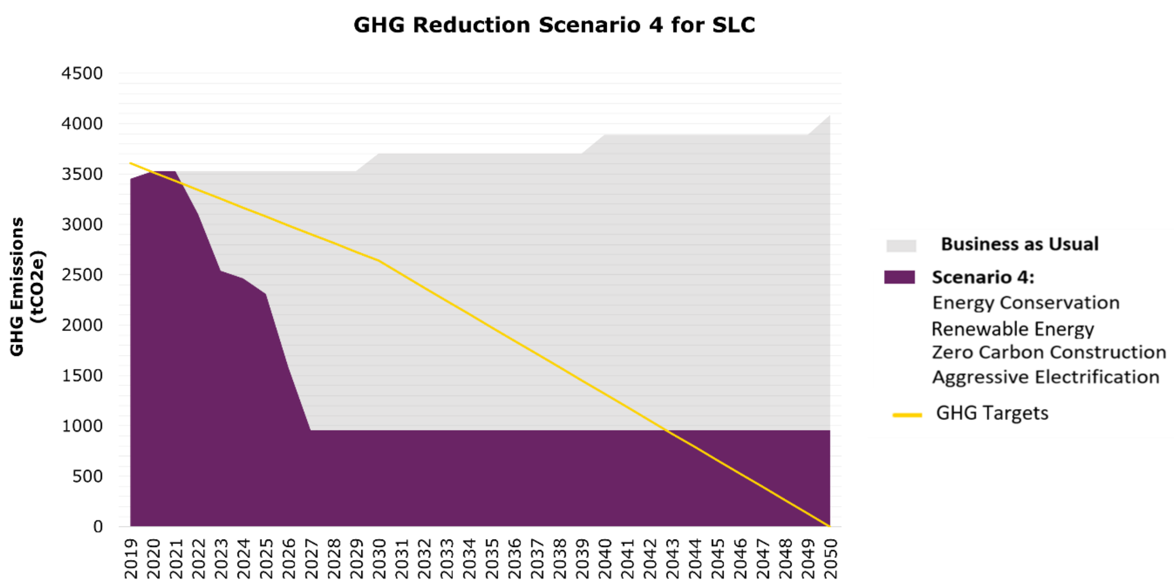


Figure 30. *GHG Reduction Scenario 4 for SLC*

The four pillars will reduce the Scope 1 and 2 emissions that result from energy used by campus facilities and fleets. Each pillar contributes to GHG emission reduction. The graph below depicts four scenarios for advancing towards net-zero, by depicting the GHG emissions under each scenario and the business as usual (BAU) scenario.

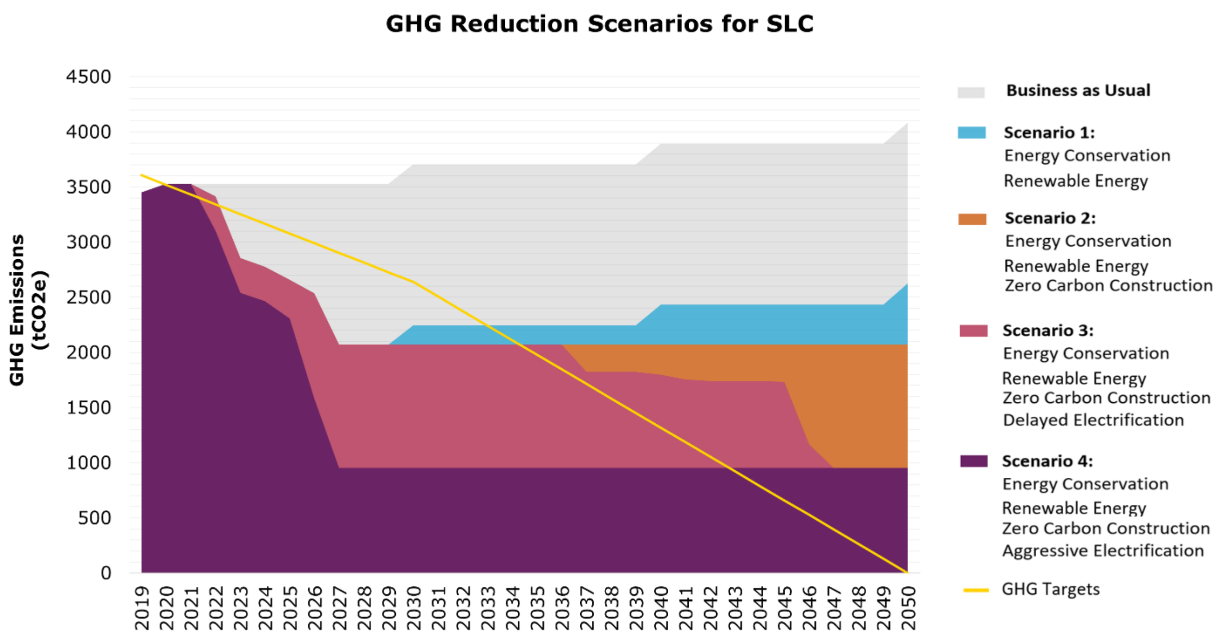


Figure 31. *GHG Reductions Scenarios for SLC*

Natural gas consumption accounts for the largest share of SLC's Scope 1 and 2 GHG emissions. However, after electrification, the share of emissions would get redistributed. This is demonstrated in Figure 32.

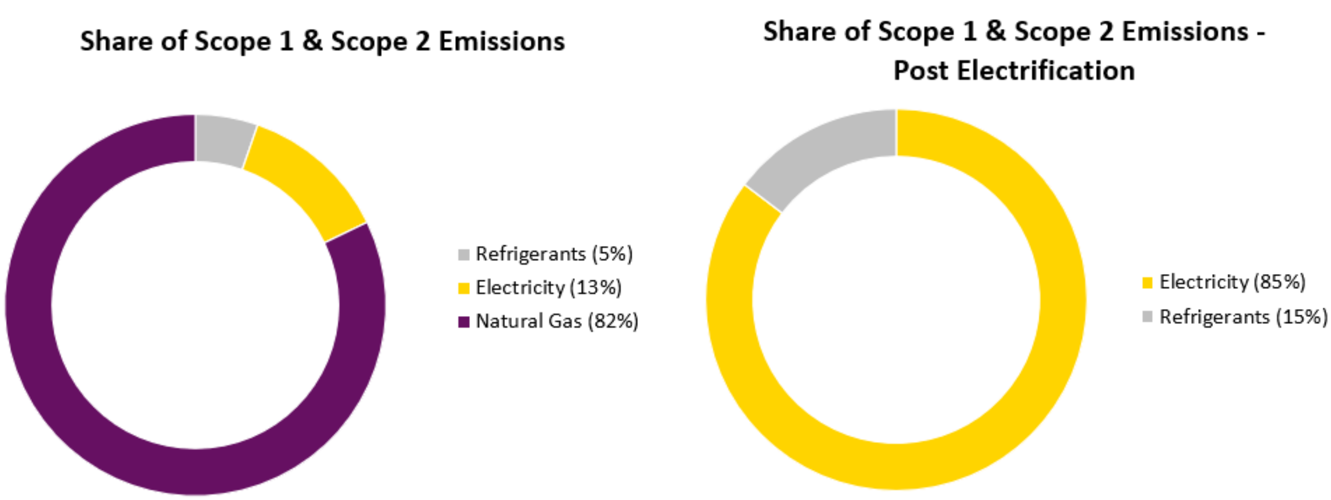


Figure 32. *Effect of Electrification on Scope 1 & 2 Emissions*

6. Net-Zero Gap

Analysis of SLC's future GHG emissions through the years 2043 to 2050 shows that complete facility and fleet electrification would still not be enough for SLC to become carbon neutral. In both Scenario 3 and 4, with current technology and based on the provincially projected electricity mix, SLC will be able to reduce emissions to less than 4,000 tCO_2e. The "gap" between SLC's GHG emissions and its 2050 target is defined as the "Net-Zero Gap".

To reduce emissions, it is recommended that SLC converts fossil fuel burning equipment and vehicles to electric alternatives. This means the conversion of natural gas burning equipment, including heating and hot water boilers, natural gas fired HVAC units and all campus fleet vehicles that use diesel or gasoline over to grid-provided and onsite renewable electricity. It is expected that the annual electricity requirements for SLC will be approximately 52 million kWh in 2050. Installing renewable power generation, with current technology, will provide approximately 3 million kWh of electricity to SLC. The remaining 49 million kWh of electricity will be provided through the Ontario electrical grid. Based on the forecast discussed in Section 6.2 below, the electricity grid is expected to have a carbon intensity of 40g/kWh of power consumed. This will result in carbon emissions from SLC's operations, and this is the Net-Zero Gap.

The Net-Zero Gap also refers to the amount of energy SLC would have to produce using renewable energy, and/or the degree of decarbonization that Ontario's electrical grid would have to undergo, for SLC to become carbon neutral.

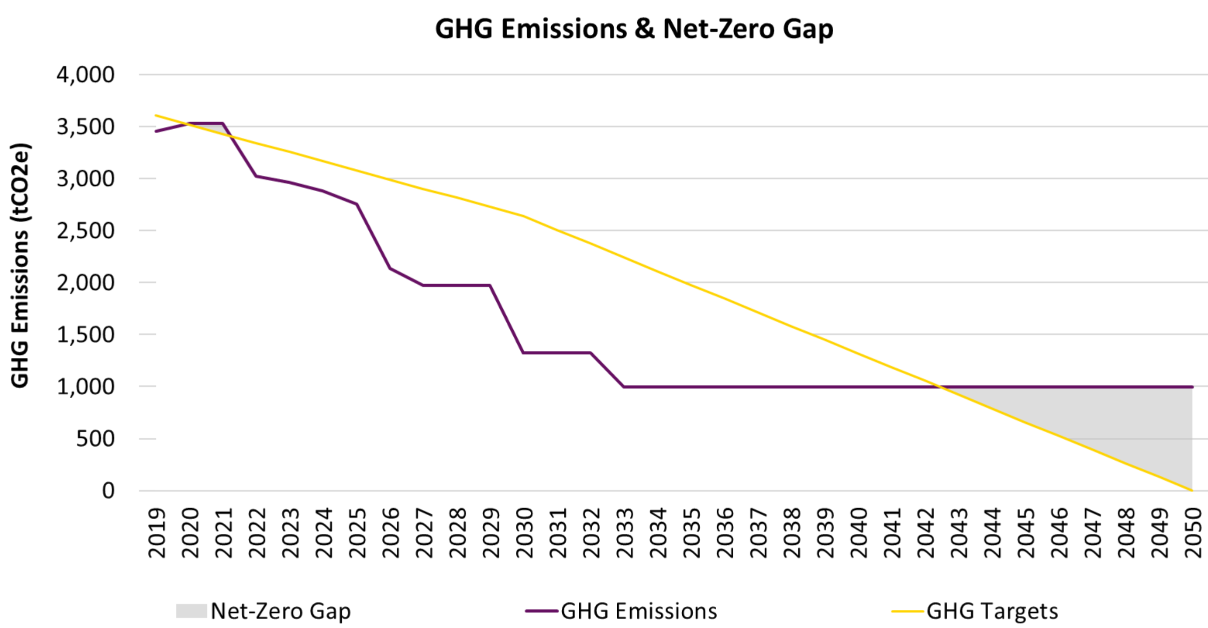


Figure 33. *The Net-Zero Gap*

The Net-Zero Gap will either increase or decrease depending on factors including campus expansion, if ZCB are not constructed and future conservation efforts that would use new technologies beyond what are currently being explored.

SLC's Net-Zero Gap could be addressed by emerging technologies or changes to the Ontario electrical grid. To address the Net-Zero Gap, SLC can consider the following options, which will each be explored in more detail below:

- Renewable Generation
- Grid Carbon Intensity
- Renewable Natural Gas
- Carbon Offsets
- New Technologies

6.1. Renewable Generation

In addition to renewable generation becoming more affordable, the energy density of renewable generation systems is increasing. Significant advancements are being made in the amount of electricity that is produced per square foot of renewable PV panel, which would increase the amount of electricity SLC can produce on its sites.

SLC may have the opportunity to produce renewable energy at an offsite location if the regulatory barriers to Virtual Net Metering are removed. SLC could then install renewable generation capacity offsite. The renewable electricity produced would be fed into the grid and the renewable generation would be credited to SLC as an offset to balance the electricity it consumed.

6.2. Grid Carbon Intensity

The existing carbon grid intensity determines the amount of carbon produced per electricity unit consumed. Since 2008, there have been significant reductions in carbon grid intensity because of the closing of coal plants. If carbon grid intensity is lowered, this would assist SLC in reaching its net-zero target. Grid carbon intensity is discussed further in Section 8.4.

6.3. Renewable Natural Gas

Renewable natural gas (RNG) is a low carbon alternative to traditional natural gas (TNG). It is produced from bio sources such as food waste, sewage, or other organic materials. It is a low carbon alternative to traditional natural gas. RNG is currently expensive, about 10X more than traditional natural gas, and is difficult to source in large quantities. However, in the future RNG will be more readily available. Several Ontario municipalities and major gas distribution companies are investing in RNG facilities. There is potential for the market to supply renewable natural gas through the existing distribution system, which would greatly impact the need for and cost of conversion to electrification. Lastly, as carbon taxes are increased, the price gap between RNG and TNG will be reduced.

6.4. Carbon Offsets

To address the Net-Zero Gap, SLC could buy carbon offsets. A carbon offset is a credit for GHG reduction that has been achieved by one party that can be purchased and used to offset the emissions of another party. Carbon offsets can range from $10 to $20 per tonne, depending on the location and type of offset. It is recommended that SLC consider offsets registered under The Gold Standard – the highest global standard for carbon offsets.

6.5. New Technologies

There is of course an “unknown” factor when it comes to the availability and viability of future clean technologies. Energy technology trends suggest that the alternatives to create low-carbon electricity are improving, becoming more efficient and less expensive. However, is it difficult to predict the rate at which new technologies will make their way onto the market and which will be technically suitable to reduce the Net-Zero Gap. Some examples of emerging technologies are discussed in Case Study 4, in the following page.

Case Study 4: Emerging Technologies - Algae Cultivation

Photobioreactors

When it comes to organic processes that can be leveraged to tackle the problem of climate change, the carbon-sequestering capabilities of algae may be some of the most effective means that can be deployed. The U.S. based company Hypergiant Industries uses a box-shaped machine for algae cultivation. This machine can soak up as much carbon from the atmosphere as an acre of trees[7].

Figure 34. *Bioreactor Concept by Hypergiant Industries*

Through the process of photosynthesis, the aquatic plant algae soak up carbon dioxide, water, and sunlight to produce energy. Hypergiant's Eos Bioreactor measures 3x3x7ft and is designed to be installed in urban environments, where it captures and sequesters carbon from the atmosphere and produces clean biofuels and other products like fertilizers, soaps, cosmetics, and even food. Artificial intelligence (AI) systems are used to monitor and manage air flow, amount of light, available CO_2, temperature, pH, and bio-density to ensure optimum conditions for maximum carbon sequestration.

The company is in the final stages of production of a commercial device. Hypergiant says it aims to make the bioreactor designs available publicly in hopes that this will inspire others to come up with similar solutions. Hypergiant plans to share details about bringing the reactor to market sometime in 2020.

[7] Hypergiant Industries Green R&D
https://www.hypergiant.com/green/
https://www.hypergiant.com/wp-content/uploads/2019/09/algae_is_the_new_green.pdf

Bio Façades

Bio façades are reactive structures that use algae cultivation within glass-paneled facades to generate energy and provide shade to a working building. Unveiled in a pilot project at the International Building Exhibition (IBA) in Hamburg in 2013, the BIQ House uses about 100 bioreactors to cultivate algae[8]. The façade houses a unique architectural ecosystem where living organisms play a crucial role. The design was developed collaboratively by Strategic Science Consult of Germany (SSC), Colt International and ARUP.

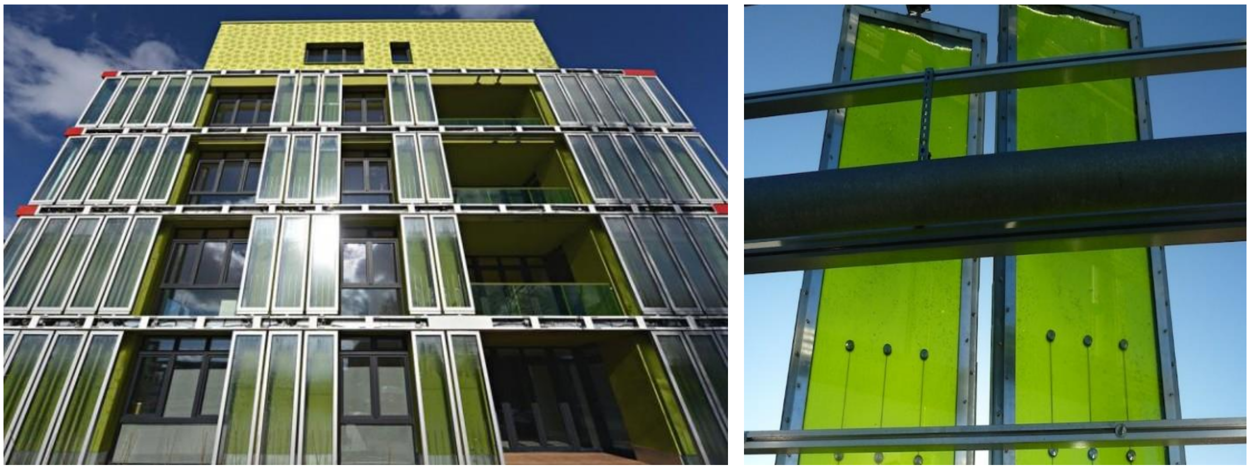


Figure 35. *Bio Facade at the BIQ House*

The biomass and heat generated by the façade are transported by a closed loop system to the building's energy management centre, where the biomass is harvested through floatation and the heat is utilized by a heat exchanger. As the system is fully integrated with the building services, the excess heat from the photobioreactors (PBR) can be used to help supply hot water or heat the building or can be stored for later use.

The algae also work as dynamic shading and acoustic buffering systems that respond naturally to external changes. The more sunlight the system gets, the more the biomass grows and blocks off excess natural light. During peak daylight hours, this provides an organic and automatic shade, plus a noise reduction layer to protect interior spaces.

The notion of bio-architecture – or "growing structures" – has always been a green building ideal. The use of such technologies and building design concepts is growing and will likely continue to do so in commercial scale in the years to come. As such, it is recommended that SLC stays vigilant in monitoring future developments in integrated biotechnology.

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[8] Solar Leaf Concept by ARUP
http://www.morethangreen.es/en/solarleaf-solar-leaf-algae-bio-reactive-facade/
https://99percentinvisible.org/article/architectural-ecosystems-bioreactors-generate-green-energy-shade-oxygen/

7. Financing Net-Zero

This section of the GRRAP outlines the required steps and financial implications of SLC meeting its 2030 and 2050 GHG targets under Scenarios 3 and 4. As part of each scenario, the idea of replacing fossil fuel equipment with electricity equipment is explored. The proposed measures require capital investment and may have utility cost implications or savings. It should be noted that converting from natural gas to electricity will increase operational costs.

7.1. Scenario Cost

7.1.1. Scenario 4: Energy Conservation, Renewables, Zero Carbon Buildings and Aggressive Electrification

Under the Scenario 4, the investment and associated costs include the following:

- Total investment cost for energy conservation and renewable energy projects.
- Incremental investment cost for the construction of ZCB.
- Incremental investment cost for replacing traditional equipment with electric equivalents at the **first end of life replacement.**
- The increase in electricity cost due to equipment electrification.

The cost estimates listed above also include utility cost escalation. This is illustrated in Figure 36.

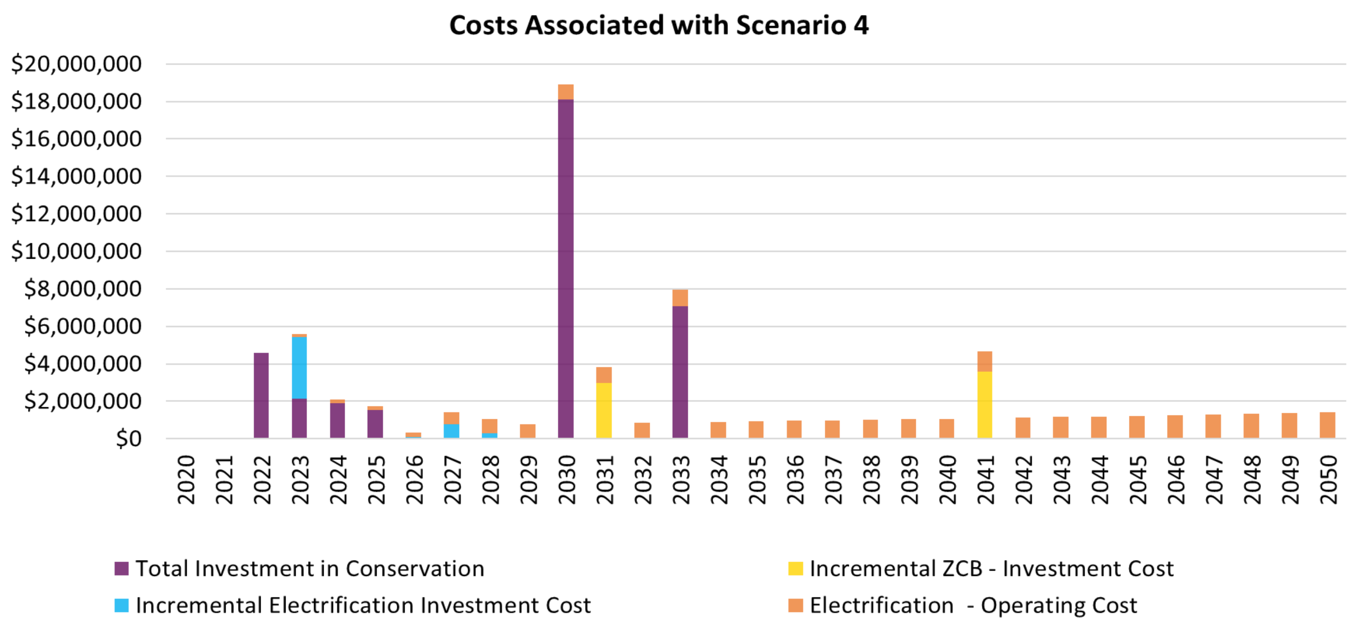


Figure 36. *Annual Costs Associated with Aggressive Electrification Scenario*

Table 9 below summarizes the cumulative total ECDM cost and other incremental costs under the Aggressive scenario at the target milestone years of 2030 and 2050.

Table 9. Cumulative Costs Associated with Aggressive Electrification Scenario

Scenario 4 - Cumulative Costs	GHG Target Milestone Years		
	2022 - 2025	2026 - 2035	2036 - 2050
Total Investment in ECDM & Renewable Energy	$9,587,286	$21,355,760	$0
Incremental ZCB - Investment Cost	$0	$2,969,781	$3,583,383
Incremental Electrification Investment Cost	$3,255,447	$1,166,975	$0
Electrification - Operating Cost	$576,432	$7,631,598	$17,490,554
Total Cost	$13,419,166	$33,124,115	$21,073,938

7.1.1. Scenario 3: Energy Conservation, Renewables, Zero Carbon Buildings and Delayed Electrification

Under the Moderate scenario, SLC would invest in high efficiency natural gas systems. Fossil fuel burning equipment would be replaced at the last date of potential replacement and onsite conservation activities would continue. The annual investment and associated costs include the following:

- Total investment costs for energy conservation projects, renewable energy projects and building envelope upgrades.
- Incremental investment cost for the construction of ZCB.
- The incremental investment cost for replacing traditional equipment with electric equivalents at the **final end of life replacement**.
- The increase in electricity cost due to equipment electrification.

The cost estimates listed above also include utility cost escalation. This is illustrated in Figure 37.

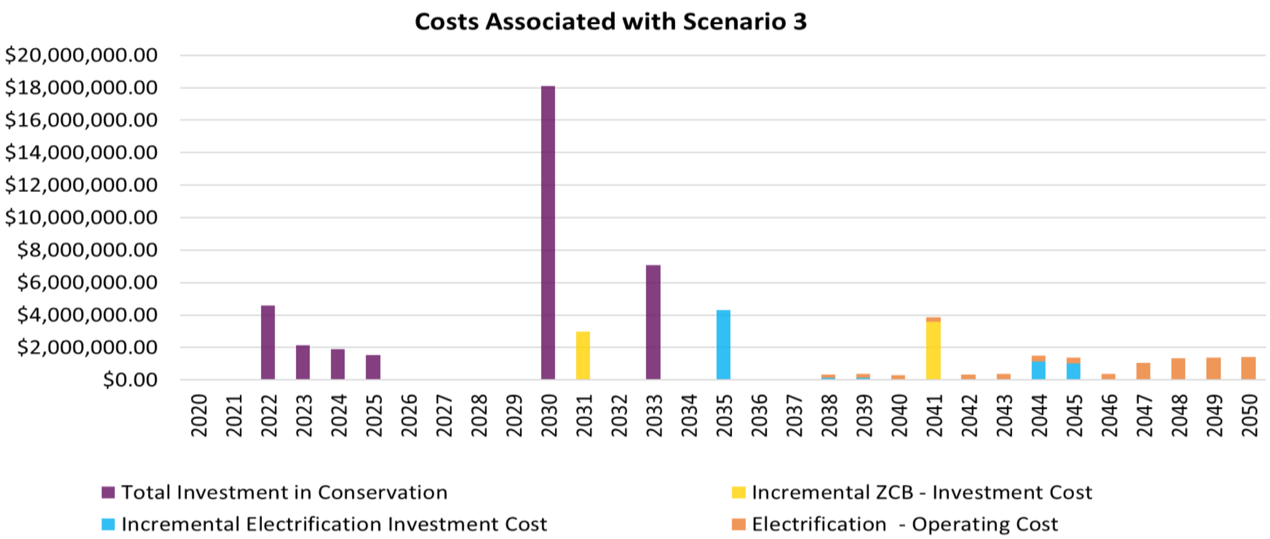


Figure 37. Annual Costs Associated with Moderate Electrification Scenario

The following table summarizes the cumulative total ECDM cost and other incremental costs under the Moderate scenario at the target milestone years of 2022, 2030 and 2050.

Table 10. *Cumulative Costs Associated with Moderate Electrification Scenario*

Scenario 3 - Cumulative Costs	GHG Target Milestone Years		
	2022 - 2025	2026 - 2035	2036 - 2050
Total Investment in ECDM & Renewable Energy	$9,587,286	$21,355,760	$0
Incremental ZCB - Investment Cost	$0	$2,969,781	$3,583,383
Incremental Electrification Investment Cost	$0	$4,302,746	$2,481,258
Electrification - Operating Cost	$0	$0	$7,844,035
Total Cost	$9,587,286	$28,628,287	$13,908,676

The decision of which of the four scenarios to choose for reaching net-zero carbon is dependent upon when SLC decides to replace fossil fuel-based technologies with low carbon alternatives. The sooner SLC switches, the faster emissions will be reduced. However, switching to electricity from natural gas, or from internal combustion vehicles to electric vehicles, requires a significant investment of capital and operational costs (except for electric vehicles which tend to have lower operating and maintenance costs). This will likely influence which scenario SLC chooses. The path to net-zero can be financed through multiple approaches which are discussed in Section 7.2 below.

7.2. Investment Scenarios

7.2.1. Capital Investment

For SLC to meet its 2050 GHG target, it is vital to reduce and where possible, eliminate the consumption of natural gas on-site. Hence, all GHG reduction scenarios prioritize the implementation of renewable energy systems and ECDM measures. To develop plausible investment strategies for the implementation of these projects several factors must be considered. These include current cost of technology, utility prices and incentives or funding avenues, which in some cases do not immediately provide a sound business case for facility electrification and ultimately carbon reduction.

Through strategic planning and grouping ECDM measures with shorter paybacks with longer payback projects like carport solar and geothermal, plans can be structured to create financially feasible decarbonization strategies. By grouping projects, considering timing, and implementing projects in a phased approach and the deferred maintenance capital budgets, the business case for the total investment can be enhanced. Phasing projects to ensure maximum grant funding, economies of scale, optimized technology price points and bundling of measures along with structured financing make a compelling strategy for investing in decarbonization across SLC's campuses.

The various ECDM measures and renewable energy projects identified in the GRRAP grouped according to two implementation timeframes: 2022 to 2025 (Consolidated Program 1) and 2030 to 2035 (Consolidated Program 2).

The following tables provide the project details for the 2022 to 2025 implementation timeframe.

Table 11. *Phase 1 of Capital Investment for ECDM Projects: 2022-2025*

Consolidated Program 1: Phase 1					
Campus	Measure	Estimated Annual Savings ($)	Estimated Annual GHG Savings (tCO2e)	Total Cost ($)	Simple Payback
All	Monitor main Utility Meters (BlackPAC)	$-	-	$45,705	0
Brockville	Replace RTUs by air-to-air HP w/electric booster	-$1,884	20	$521,182	-276.7
Brockville	Install a Solar Thermal system to preheat DHW in Residence	$374	6	$161,353	430.9
Cornwall	Occupancy Sensors in Classrooms to control Light & FCUs (28 Classrooms)	$9,766	19	$108,179	11.1
Cornwall	Install DHW Condensing Boiler	$923	6	$70,102	76.0
Cornwall	Install a 180ton water-to-water GSHP at Moulinette	-$26,907	103	$2,004,123	-74.5
	Total	$ -17,727	154	$ 2,910,643	-164.2

Table 12. *Phase 2 of Capital Investment for ECDM Projects: 2022-2025*

Consolidated Program 1: Phase 2					
Campus	Measure	Estimated Annual Savings ($)	Estimated Annual GHG Savings (tCO2e)	Total Cost ($)	Simple Payback
Kingston	LED Lighting Upgrade	$80,366	9	$948,199	11.8
Kingston	Replace RTUs by air-to-air HP w/electric booster	$430	7	$593,126	1,379.0
Brockville	LED Lighting Upgrade	$15,004	2	$160,355	10.7
Cornwall	LED Lighting Upgrade	$28,506	-1	$313,827	11.0
	Total	$ 121,510	18	$ 2,015,507	16.6

Table 13. *Phase 3 of Capital Investment for ECDM Projects: 2022-2025*

Consolidated Program 1: Phase 3					
Campus	Measure	Estimated Annual Savings ($)	Estimated Annual GHG Savings (tCO2e)	Total Cost ($)	Simple Payback
Kingston	Kitchen Demand Ventilation	$12,162	35	$139,627	11.5
Brockville	Install a water-to-water GSHP at Yellow Wing (120ton)	-$15,892	78	$2,127,448	-133.9
Cornwall	Recommissioning BAS	$10,048	18	$87,701	8.7
	Total	$ 6,318	132	$2,354,776	372.7

Table 14. *Phase 1 of Capital Investment for Renewable Energy Projects: 2022-2025*

2022 -2025: Phase 1 Solar					
Campus	Measure	Estimated Annual Savings ($)	Estimated Annual GHG Savings (tCO2e)	Total Cost ($)	Simple Payback
Brockville	Solar PV Roof 220kW	$41,822	11	$330,000	7.9
Brockville	Solar PV Car Port 575kW	$103,656	26	$1,147,000	11.1
	Total	$ 145,477	37	$ 1,477,000	10.2

Table 15. *Phase 2 of Capital Investment for Renewable Energy Projects: 2022-2025*

Consolidated Program 1: Phase 3 Solar					
Campus	Measure	Estimated Annual Savings ($)	Estimated Annual GHG Savings (tCO2e)	Total Cost ($)	Simple Payback
Kingston	Solar PV Roof 420kW (Kingston)	$75,038	18	$808,320	10.8
Cornwall	Solar PV Roof 400kW	$77,508	10	$768,000	9.9
	Total	$ 145,477	28	$ 1,477,000	10.2

The payback of the individual projects is effectively lower when compared to the payback of an entire phase. By the same principle, the effective payback of the entire program (Phases 1, 2 and 3) is financially improved when compared with individual phases. The concept of bundling the projects improves cash flow and when combined creates investments that how lower impact on operating and capital budgets. This is tabulated below.

Table 16. *Consolidated ECDM & RE Program: 2022-2025*

Consolidated Program 1						
Measure	Estimated Annual GHG Savings (tCO2e)	Annual Savings ($)	Total Cost ($)	Simple Payback	NPV	IRR
Phase 1	154	-$17,727	$2,910,643	-164.2	$572,645	7.68%
Phase 2	18	$121,510	$2,015,507	16.6	-$271,286	4.75%
Phase 3	132	6,318	2,354,776	372.7	-$591,350	3.54%
Phase 1 Solar	37	145,477	1,477,000	10.2	$2,165,133	16.79%
Phase 3 Solar	28	152,546	1,576,320	10.3	$143,042	6.78%
Total	369	$408,125	$10,334,246	25.3	-$4,491,404	1.03%

The cumulative net cashflow for the consolidated program is illustrated in Figure 38. This model assumes that Phase 1 projects including Phase 1 Solar is implemented in 2022, Phase 2 in 2023 and Phase 3 projects including Phase 3 Solar in 2025.

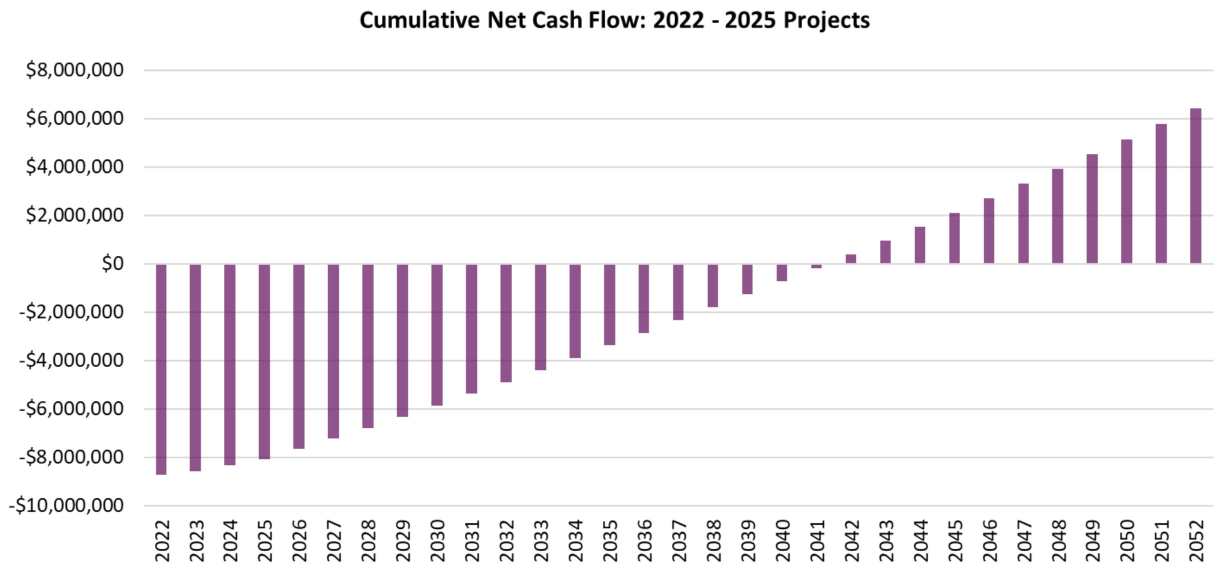


Figure 38. *Cumulative Net Cash Flow for the Consolidated Program 2022 - 2025*

The following tables provide the project details for the 2030 to 2035 implementation timeframe.

Table 17. *Phase 1 of Capital Investment for ECDM Projects: 2030-2035*

Consolidated Program 2: Phase 1					
Campus	Measure	Estimated Annual Savings ($)	Estimated Annual GHG Savings (tCO2e)	Total Cost ($)	Simple Payback
Kingston	Recommissioning BAS	$20,147	41	$129,814	6.4
Kingston	Install DHW Condensing Boiler Residence Phase 3	$1,226	8	$70,102	57.2
Kingston	Install a 420ton water-to-water GSHP at Green, Tan & Orange Wings	-$17,521	367	$4,852,971	-277.0
Kingston	Install a 180ton water-to-water GSHP and replace AHUs roof Green, Tan & Orange	-$58,136	66	$3,408,817	-58.6
Kingston	Install a 200ton water-to-water GSHP at Gray and replace WL_AH2	-$42,431	68	$2,842,352	-67.0
	Total	$ -96,715	550	$ 11,304,056	-116.9

Table 18. Phase 2 of Capital Investment for ECDM Projects: 2030-2035

Consolidated Program 2: Phase 2					
Campus	Measure	Estimated Annual Savings ($)	Estimated Annual GHG Savings (tCO2e)	Total Cost ($)	Simple Payback
Cornwall	Install a 240ton water-to-water GSHP at Aultsville	-$41,425	111	$2,790,152	-67.4
Cornwall	Replace RTUs and expand GSHP at Moulinette	-$30,450	219	$3,023,552	-99.3
Kingston	Install a Solar Thermal system to preheat DHW in Residence	$4,084	37	$182,128	44.6
	Total	$ -67,790	367	$5,995,831	-88.4

Table 19. Phase 1 of Capital Investment for Renewable Energy Projects: 2030-2035

Consolidated Program 2: Phase 1 Solar					
Campus	Measure	Estimated Annual Savings ($)	Estimated Annual GHG Savings (tCO2e)	Total Cost ($)	Simple Payback
Kingston	Solar PV Car Port 940kW	$167,486	41	$1,878,000	11.2
Cornwall	Solar PV Car Port 1180kW	$215,698	55	$2,360,000	10.9
	Total	$ 383,184	96	$ 4,238,000	11.1

The payback of the individual projects is effectively lower when compared to the payback of an entire phase. By the same principle, the effective payback of the entire program (Phases 1, 2 and 3) is financially improved when compared with individual phases. This is tabulated on the following page.

Table 20. Consolidated ECDM & RE Program: 2030-2035

Consolidated Program 2						
Measure	Estimated Annual GHG Savings (tCO2e)	Annual Savings ($)	Total Cost ($)	Simple Payback	NPV	IRR
Phase 1	550	-$96,715	$11,304,056	-116.9	-$11,914,058	-
Phase 2	367	-$67,790	$5,995,831	-88.4	-$5,710,834	-
Phase 1 Solar	96	383,184	4,238,000	11.1	$1,636,994	8.49%
Total		$218,679	$21,537,887	98.5	-$15,455,302	-3.58%

The cumulative net cashflow for the consolidated program is illustrated in Figure 39. This model assumes that Phase 1 projects including Phase 1 Solar is implemented in 2030 and Phase 2 in 2033.

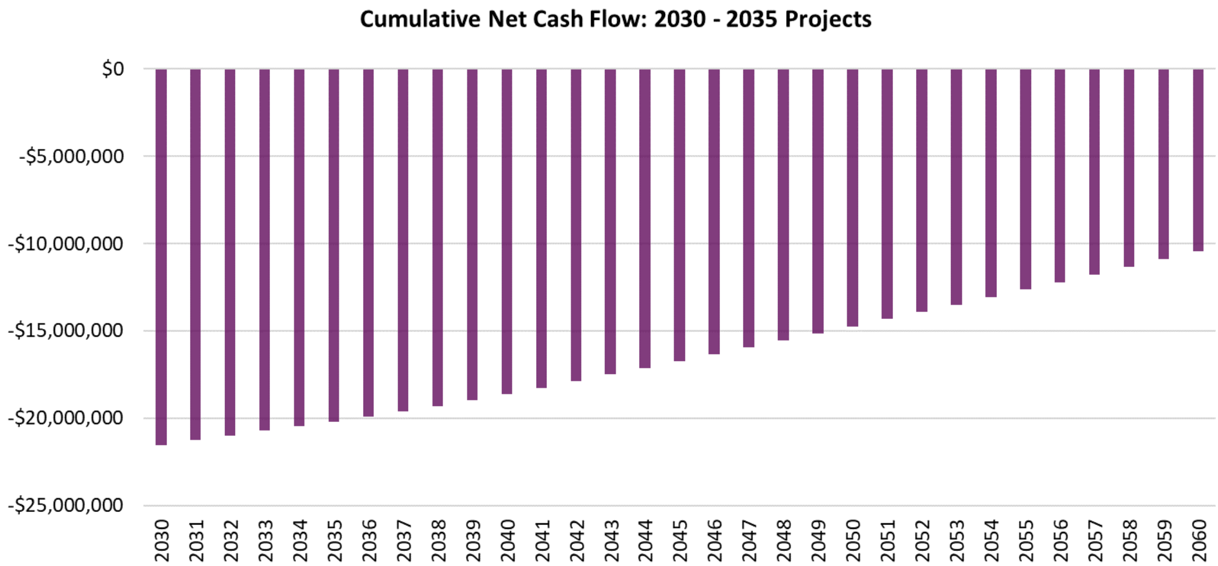


Figure 39. Cumulative Net Cash Flow for the Consolidated Program 2026-2035

7.2.2. Role of Deferred Maintenance

The above capital investment models shown in the previous section depict cashflows based on total project costs and do not account for cash injection like incentives from provincial and federal programs and SLC's capital budgets for deferred maintenance. The capital budget allocated for asset renewal for equipment directly targeted in the ECDM measures is about $5,898,477. Hence, it is vital to include deferred maintenance cost in the investment models. This effectively reduces the capital cost of projects from $31.8 million to $25.9 million. The investment models on the incremental costs are shown below.

Table 21. *Deferred Maintenance & Consolidated Program 2022-2025*

Consolidated Program 1					
Deferred Maintenance Budget Included - $2,949,239					
Measure	Annual Savings ($)	Total Cost ($)	Simple Payback	NPV	IRR
Initial Investment Model	$408,125	$10,334,246	25.3	-$4,491,404	1.03%
Revised Model with Deferred Maintenance Included	$408,125	$7,385,008	18.1	-$1,866,592	3.49%

Table 22. *Deferred Maintenance & Consolidated Program 2030-2035*

Consolidated Program 2					
Deferred Maintenance Budget Included - $2,949,239					
Measure	Annual Savings ($)	Total Cost ($)	Simple Payback	NPV	IRR
Initial Investment Model	$218,679	$21,537,887	98.5	-$15,991,613	-5.55%
Revised Model with Deferred Maintenance Included	$218,679	$18,588,649	85.0	-$13,316,566	-4.66%

7.2.3. Canada Infrastructure Bank (CIB) Public Retrofit Initiative

The CIB Public Retrofits Initiative provides financing for decarbonization retrofits in privately-owned commercial buildings in Canada through an investment of up to $2 billion. The Initiative is part of the Canada Infrastructure Bank's (CIB's) $10 billion Growth Plan that aims to stimulate jobs for Canadians and strengthen Canada's economy through new infrastructure investments. By increasing levels of public and private investment in infrastructure, the CIB's Growth Plan will contribute to Canada's competitive, connected, and resilient economy. The program overview is shown below.

Public Building Retrofits Overview

Target Sponsors
- Provinces
- Municipalities
- Territories & Indigenous
- Universities, Schools and Hospitals (USH)

Target Assets
- **All public sector assets**
- *Real Estate Portfolios, Commercial / Office Real Estate Portfolio, Jails, Courthouses*
- *Hospitals, Schools, Universities, Student Residents*
- *Long Term Care and Social / Affordable housing* ***under investigation***

Definition of Energy Retrofits
- **Deep Retrofits – minimum GHG targets, enhanced energy and near zero carbon projects.**
- **Examples include:**
- Upgrading energy-consuming systems in an existing building, which could include improving or replacing lighting fixtures, windows and doors, HVAC systems, air ventilation, air handling systems etc.
- Fuel switches and replacements of boilers and chillers, replacement of central utility plants etc.
- Associated infrastructure (frames of windows) to enable deep retrofits

Key Features for Public Sector
- **No upfront capital contribution** from the Public Sponsor
- **No minimum payment guarantees** from the Public Sponsor
- Returns on Capital is repaid through **realized energy savings**
- Full energy savings risk is transferred to the CIB and the private sector partner
- Long-term monitoring and verification is the responsibility of the private sector partner

Benefits to the Public Sector
- **Achieve GHG Targets**
- **Address deferred maintenance** while meeting emission targets and achieving indirect O&M savings
- Assistance with building **business case, including energy audits**, to develop marketable bundles
- **Standardized measurement & verification**
- Streamline project development, standardize contractual frameworks and maximize market acceptance

Contractual structures & repayment
- For pure energy retrofit projects we would use Energy Performance Contracts where all energy performance and technical performance risk is passed on and repayment is entirely dependent on **materialized energy savings**
- For projects that include energy retrofits as a part of a large buildings retrofit (example – MacBlock) we can use the DBFM / DBFOM contracts with **partial availability and partial energy** payments associated with energy performance risk

Figure 40. *Public Buildings Retrofits Overview*

The Initiative offers long-term, high leverage, below market interest rate investments for public sector building retrofits that substantially reduce GHG emissions. Financing can apply to investments in large individual projects, or to a pool of investments originated by a retrofit aggregator. To encourage the market to pursue deep retrofits that go beyond the industry norm, the Initiative requires that all projects achieve a minimum level of GHG savings, while offering more favourable financing terms (more affordable capital and longer payback periods) for projects that target deeper savings.

CIB's standardized core Initiative offering is a $40M or greater debt product that requires a minimum 30% equity investment. CIB debt is extended based on the forecasted savings derived from improvements to buildings as the primary source of repayment, with one source of recourse being energy performance guarantee contracts applied to the savings forecasts. The CIB offering is depicted in the following page.

CIB offering – large public sector projects

Large BUNDLED Projects (>$40m capex)

Financing Approach	CIB Advisory Services
▪ Work with all levels of government + USH to aggregate portfolios and develop project bundles that are $50M or higher ▪ Some exceptions may exist where bundled or one-off projects less than $40m may also be included in this bucket **Bespoke Project Finance SPV Structures** ▪ CIB's financing is between 40 and 60%; financing may increase (up to 70%) to enable deeper retrofits and fuel switching projects ▪ At this time, the CIB is expected to be sub debt to protect senior lenders from requiring guarantees; Private Financing is raised at Financial Close ▪ Repayment source is based on energy savings materialized as a result of retrofits.	▪ Standardized measurements and verification standards as well as methods developed by WSP ▪ WPS to manage energy savings to avoid disputes/claims ▪ Energy audits financed and conducted by CIB's advisors or through a technical Vendor of Record (VOR). These reports and audits are required for CIB's commitments, as they form the base to build our business case. ▪ Portfolio and aggregation analysis developed by the CIB and its advisors, with Sponsors, to bundle projects ensuring target rate of returns ▪ Business case and financial modelling development by the CIB ▪ Standardized processes, procurement documents and energy performance contracts, where possible

Figure 41. *CIB Offering*

All proposals and retrofit projects are required to meet eligibility requirements and undergo a technical and financial due diligence process. Interest rates of CIB funding can range from 0.05% - 3% for terms of up to 25 years dependant upon the level of GHG savings that can be achieved by the project. Example scenarios of the CIB program is illustrated below.

Illustrative example and scenarios

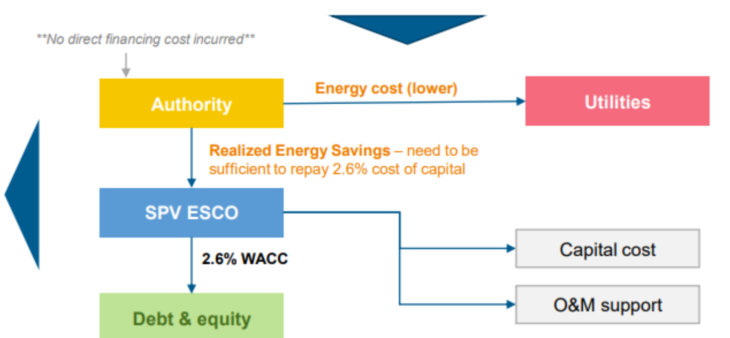
Capital Cost for Retrofit = $100M
(*Replacement of HVAC, windows, air distribution, roof, lightning, heating & cooling etc*)

Annual Buildings Base Energy Cost in 2020 = $12M
Inflation = 2%

Equipment Maintenance = Negligible

ESCO Management Fee = Negligible

ESCO Capital Structure	Rate	Rationale - to be confirmed	Gearing
CIB	**1.0%**	*Sub debt facility assumed*	*60%*
Third-Party Debt	**3.5%**	*GOC + 180-220 bps*	*30%*
Equity	**9.0%**	*Equity IRR close to utility rate (between 8.5 – 10%)*	*10%*
ESCO Cost of Capital		**2.6%**	



Scenarios	Option 1	Option 2	Option 3
Term (*payback period*)	**20**	**25**	**30**
WACC (weighted average cost of capital)	2.6%	2.6%	2.6%
Debt service + distributions	$6.5M	$5.5M	$4.9M
Minimum required % energy savings for business case	**45%**	**37%**	**31%**
Sponsor net savings (*energy*)	$ 0	$ 0	$ 0
Sponsor savings (indirect O&M)	Retained by sponsors		

Note: CIB gearing could vary between 40% to 70% of total project costs, depending on GHG reductions targets
Additional sources of repayment might be required in case cost savings cannot cover full debt service and distributions

Figure 42. *CIB Examples and Scenarios*

The following table summarizes the project details and general assumptions for both consolidated programs under the CIB finance model.

Table 23. *Assumptions for CIB Financing the Consolidated Program: 2022-2025*

Project Details & Assumptions			
Period of Time, Yrs.	30	Estimated Net Annual Savings, $	$8,425,487
Term of Financing Period, Yrs.	30	Inflation, %	1.40%
Interest Rate, %	0.5%	Tax Included in Model	No
Total Project Cost (including interest payments), $	$28,704,640	Tax Rate	13%

The assumptions specific to this model are listed below:

- Consolidated Program 1 commences in 2022.
- Consolidated Program 2 commences in 2023.
- Incentives are introduced to fund 50% of the heat pump and solar projects.
- Deferred maintenance costs are accounted, and cash flow is derived on the incremental costs.

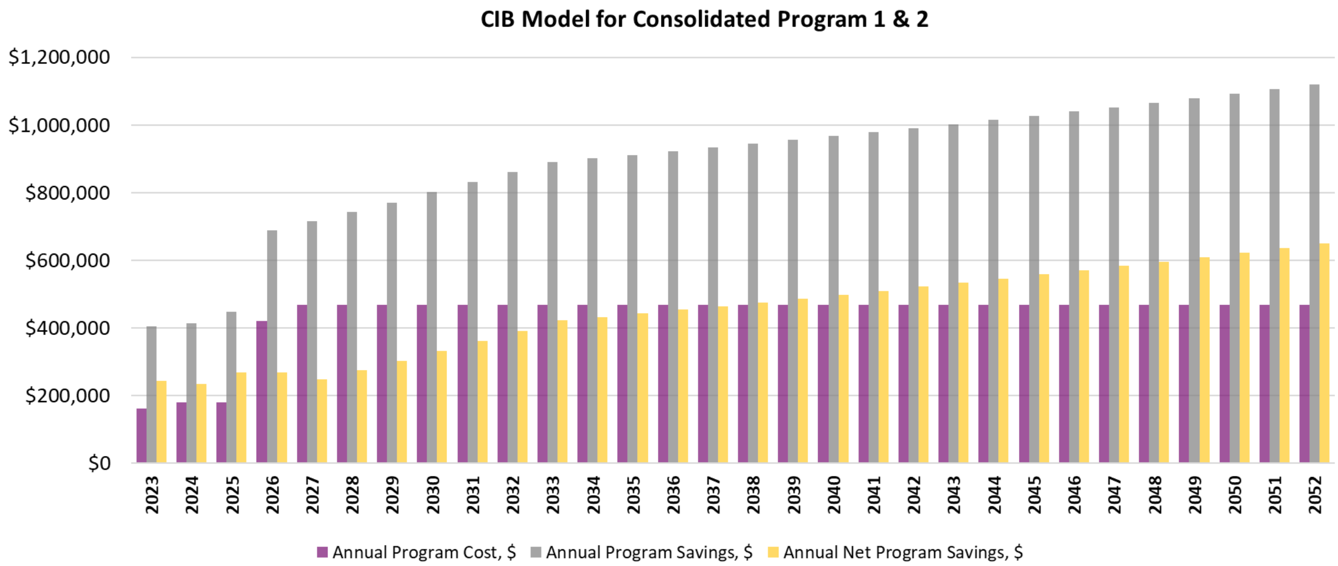


Figure 43. *CIB Model Performance*

Table 24. *Project Investment Metrics for CIB Model*

Project Metrics			
NPV	$958,808	IRR	6.67%

7.2.4. Public Private Partnership and Energy-as-a-Service (EaaS)

To reduce their energy and carbon footprint, public and private sector facility operators and owners are increasingly exploring and leveraging innovative business models that create new opportunities for their organization to finance energy-efficient building technologies, renew infrastructure, and renew or construct net-zero ready buildings. Traditional models previously used to address these opportunities include pay-for-performance contracts, energy savings performance contracts, power purchase agreements, and on-bill financing.

One innovative business model gaining interest offers energy-as-a-service (EaaS). This represents a shift from client-owned equipment toward a model where the service provider maintains ownership and the customer pays for the services provided by the project or program. The maintenance of the equipment is also the responsibility of the service provider. Blackstone anticipates that the integrated nature with much of the EaaS infrastructure and assets, that a hybrid model of collaborative maintenance will emerge to share resources and expertise producing better outcomes for all stakeholders in this critical area of operations.

This financial solution helps organizations implement complex carbon, energy, and water efficiency projects with no upfront capital expenditure. The provider designs the project scope, finances the material and construction costs, maintains (in partnership with the client) project equipment/systems & buildings (if applicable), and monitors the performance to validate energy and operational savings as shown in the figure below.

Develop project scope with client	**Finance** project costs	**Develop** engineer, install, operate, maintain project equipment	**Measure/Verify** carbon, energy and financial savings	**Sustain/Identify** savings and grant opportunities
Identify efficiency Investments	Fund project costs	Own project equipment	Measure/verify performance	Continuous improvement
Identify carbon reductions	Include available incentives	Cover ongoing maintenance	Achieve established KPI	Additional savings pursuit
Structure financing solution	Facilitate future incentives	Collaborate on operations	Share savings with customer	Technology advancement

Figure 44. *Roles Overview of Energy-as-a Service Provider*

The client pays back the project/program costs through a monthly, a quarterly, or an annual fee for the services received. The payment is generally based, directly or indirectly, on the energy, maintenance and other quantifiable operational savings realized on the client's fiscal operating plans. Experience in Europe and the US to date with this service-based model suggests energy related and operational savings potential up to 20–25% can be achieved to create the value for the service provider and clients to develop a mutually beneficial EaaS agreement.

Traditional energy efficiency solution models focus on lighting, HVAC equipment, software, and general energy conservation measures. EaaS solutions are more comprehensive and include green infrastructure renewal initiatives such as district heating systems, geothermal, heat-pumps, solar PV, lighting retrofits, upgrades to HVAC and other equipment, building automation and controls, energy storage, Electric Vehicle charging systems, building envelope upgrades and water efficiency measures.

The EaaS Model

The figure below shows the structure of a typical EaaS relationship.

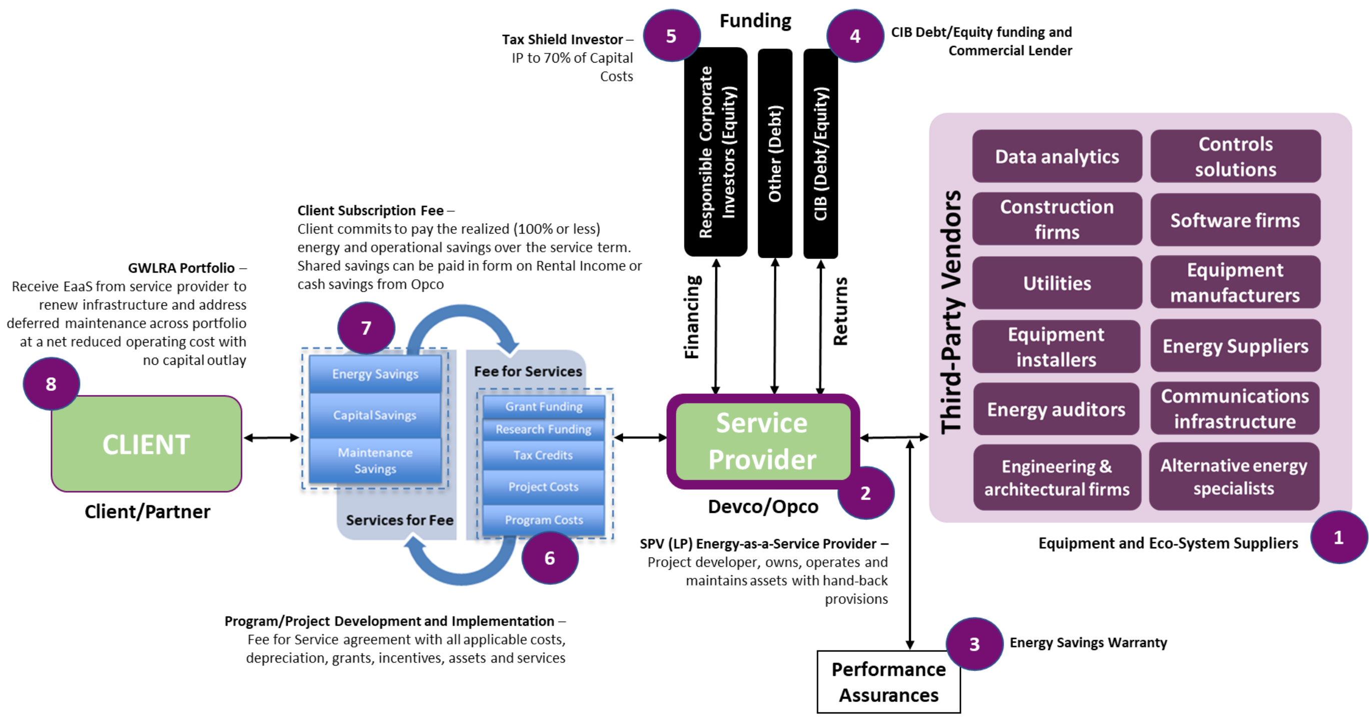


Figure 45. *EaaS Relationship Structure*

The EaaS model usually shifts the burden of financing, owning, installing, and managing the performance of an energy asset from the client to the service provider. Before any energy related or operational saving measure(s) or services are implemented, the service provider conducts or arranges for detailed investment grade feasibility assessments to establish the business case for the client and provider. Once the project or service scope is finalized and construction completed, a measurement and verification (M&V) analysis determines the actual savings. The client is responsible for a service fee, typically based on the units of energy or operational savings associated with the project or program of works. The payment can be structured either as a percentage of the customer's utility budget or as a fixed amount that may include deemed operational savings. In any case the client's payments are below its current utility and operating budget and the provider promises a certain level of savings and adjusts payments if it is not realized. At the end of the contract period (generally 10 to 30 years), the client can purchase the equipment at fair market value, have the provider remove it, or extend the EaaS contract.

Large buildings, or a portfolio of smaller buildings that add up to a bigger footprint, provide an opportunity for greater energy savings and represent an ideal situation of the EaaS contracting process.

The EaaS model may seem similar to Energy Services Company (ESCO) financing, but they differ significantly. While the ESCO industry has delivered savings in the public building sectors in the past, the EaaS model is designed to help public sector building owners now facing limited capital and constrained technical resource or expertise to implement these complex green infrastructure projects/programs.

Using an Energy Savings Performance Contract (ESPC) agreement, an ESCO guarantees energy savings to a client over a set period by installing and maintaining equipment. Depending on the ESCO, it may provide financing or require outside funding through loans, capital lease, or bond issuance, which are on-balance-sheet financing mechanisms. Under this structure, the client owns more-efficient equipment but may be vulnerable to the fluctuations in energy prices and cash savings short-fall due to contractual base-line changes and other risk management instruments leveraged by the ESCO. By contrast, the third-party EaaS providers are responsible for meeting the reliability and energy goals of the client. The provider takes on financial and performance risk by guaranteeing lower energy costs from implementing the selected project measures. The table below summarizes these differences.

Table 25. *ESCO financing versus EaaS Model*

Item	ESCO	EaaS
Capital Investment by Customer	Sometimes	No
Off-balance-sheet Financing	No	Yes
Ownership of Equipment by Customer	Often Yes	Often No
Performance Risk Borne by the Customer	Sometimes	No
Flexibility to add Retrofit During Contract Period	Difficult	Yes
Term of Contract	10-20 Years	10-30 Years

The Benefits

The EaaS model can provide valuable services to commercial, hospital, and higher education clients. This section offers a preliminary list of benefits.

First-Cost Savings

Many higher education organizations hesitate to divert capital from essential business objectives to invest in building retrofits. The EaaS model can be a good fit for organizations that want to pursue deep energy and carbon infrastructure renewal without using their own finances. Under an EaaS agreement, the service provider provides equity funding and secures third-party funding to pay for all project costs, so the client has no upfront expenses or internal capital outlay and can use their own funds for other projects.

Off-Balance-Sheet Financing

EaaS offerings are typically designed as an off-balance-sheet financing solution. The use of service payments allows businesses to shift energy and carbon infrastructure renewal projects from an expense asset that they must buy, own, maintain, and depreciate to an operating expense similar to a standard utility bill or power purchase agreement.

Since the provider owns the energy equipment, clients have no debt on their balance sheet and their bottom line is improved. Thus, they are able to secure the energy and services they need with fewer uncertainties because the provider has assumed the risk for achieving energy and operational savings.

Deeper Operational and Maintenance Savings

The cost savings from the projects are calculated and guaranteed using agreed upon M&V protocols. Because the EaaS paradigm generally relies on the pay-for-performance model, it offers potential operational efficiencies and positive cash flow from energy, water, and maintenance cost savings. The pay-for-performance nature, along with maintenance and verification of project savings, reduces the performance risk for clients and may encourage more-persistent savings and implementation of newer green infrastructure and clean technologies.

Clients have the additional benefit of being able to finance multi-measure deep green infrastructure retrofits with long simple payback periods. EaaS projects may include capital-intensive investments in HVAC upgrades with motor, pump, and boiler replacements, energy management systems, and distributed renewable energy resources. These measures offer greater energy savings, can optimize comfort and tackle carbon reduction targets. However, they are difficult to fund under traditional financing sources due to their lower return on investment.

As the EaaS providers are responsible for the energy equipment, they pay for periodic maintenance services to encourage long-term reliability and performance. The level and structure of such service varies by project type and client needs. By rewarding a third-party provider for successfully managing operations, clients reduce the risks and challenges associated with implementing, managing, and monitoring new technology. Installing more-efficient equipment with continuous maintenance may also mitigate the risk of unplanned events.

Lower Operational Risks

For many organizations, energy management is not a core competency. Staff frequently struggle with selecting technology options, sifting through incentives, and retrofitting the infrastructure. EaaS vendors provide access to experts who can design the project scope and install, maintain, and verify the performance of the efficiency measure. Clients have a lower risk of paying for underperforming equipment because vendors guarantee energy savings at a known cost and can attract large grants and incentives which can be used to lower capitals costs and ultimately service payments.

Long-term agreements allow clients to secure a fixed lower price for energy over the course of the contract if the service provider can achieve the promised savings.

Ways forward

With rapid paybacks, upgrades to the latest technology, and no upfront capital investment, the EaaS model could provide solutions for higher education institutions to achieve net-zero targets and undertake strategic and comprehensive deferred maintenance and capital infrastructure renewal.

Some of the challenges to consider would be that the development and award process for an EaaS solution is long and complicated because it requires pitching the service to multiple organizational players.

Undertaking education and socializing EaaS contracts within an organization can help overcome inertia and simplify communications among the different divisions that are involved in the decision process (e.g., finance, procurement, facilities, and operations departments).

(ACEEE- Energy as a Service)

The following table summarizes the project details and for both consolidated programs under the EaaS model.

Table 26. *Project Details – EaaS Model*

Project Details & Assumptions			
Upfront Project Cost	$0	Estimated Net Annual Savings ($)	$679,592

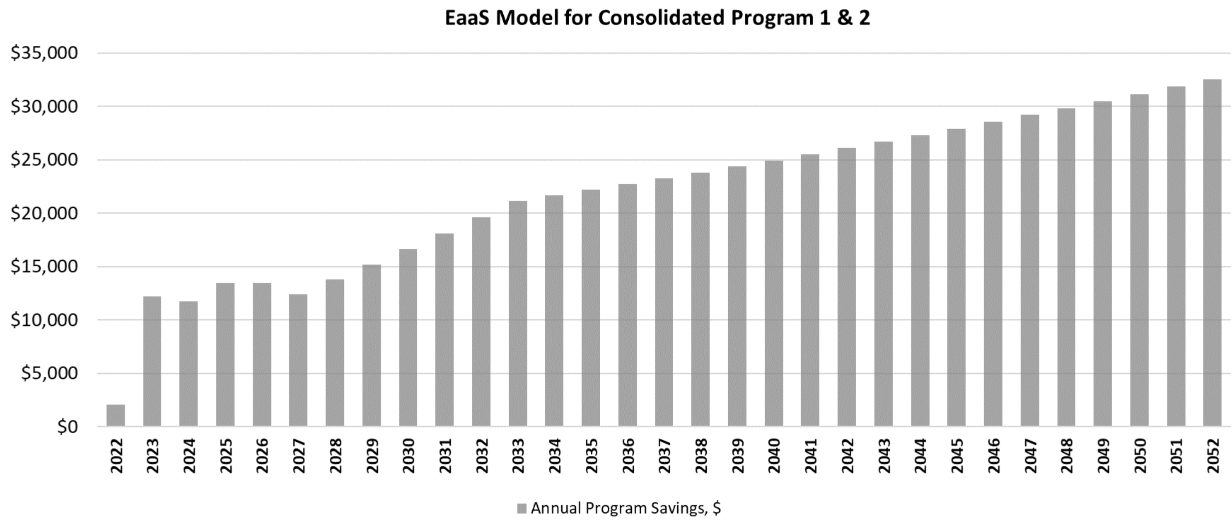


Figure 46. *EaaS Model for Consolidated Program 1&2*

7.3. Factors that Influence Cost

In choosing its path to net-zero emissions, SLC will need to consider several factors that influence project costs, including:

- Replacement Cost
- Operational Cost
- Forecasted Utility Cost
- Cost of Solar
- Carbon Tax
- Funding Opportunities
- Utility Rate Structure
- Supporting Infrastructure Costs
- Emerging Technology Costs

7.3.1. Replacement Cost

The Aggressive and Moderate scenarios mentioned previously were based on the timing of when SLC's assets will reach end of life. Each asset was evaluated to determine how expensive high efficiency natural gas options would be when contrasted with comparable low-carbon, electric options. The investment difference was calculated and used to model the required investment needed to reach SLC's emission reduction goals.

As the tax on carbon-based fuels increases, the cost difference between natural gas equipment and non-fossil fuel-based equipment and other fuel sources will decrease. An example of this is presented in Case Study 5.

Case Study 5: Cost of Heating – Natural Gas vs. Electric Boilers

Table 27 lists the specifications of an industry standard natural gas boiler and the specifications of the electric equivalent.

Table 27. *Comparing Electric & Natural Gas Boilers*

2 Million BTU Natural Gas Boiler (Space Heating Application)		
Specifications	Natural Gas Boiler	Electric Boiler
System Size	2 Million BTU	510 kW
Boiler Efficiency	87%	100%
Estimated Installed Cost	$60,000	$95,000
Estimated Equipment Life (Years)	20	25
Annual Maintenance Cost	$500	$125
Annual Utility Consumption	59,883 m^3 of gas	515,680 kWh
Current Utility Cost (2018 $ without Carbon Price)	$0.22/$m^3$	$0.12/kWh
Estimated Annual Operating Cost	$13,174.26	$61,881.60

The table above shows the equivalent electric boiler capacity required to produce the same energy (BTU) output as a natural gas boiler (510 kW electric boiler to a 2 MBTU natural gas boiler). The higher installation cost of the electric boiler ($95,000 for the electric boiler compared to $60,000 for the gas boiler) is balanced by its life cycle (25 years for electric to 20 years for gas), and operational efficiency (100% for electric and 87% for gas). However, the annual operational costs (based on current utility prices) render the electric boiler impractical from a financial perspective.

The significant difference lies in the utility consumption and costs. An electric boiler requires 515,680 kWh to produce the same heat output as a natural gas boiler, which requires only 59,883 m^3 of gas to produce the same output. Grid electricity is approximately 35% more expensive than natural gas per BTU of energy, so it would make financial sense to defer the electrification of boilers to a later time.

However, considering the 20-year lifetime of a gas boiler, the latest SLC could defer its electrification would be 2030, after which it would have no option but to electrify in order to meet 2050 targets. In other words, no new gas boilers should be installed after 2030.

7.3.2. Operational Cost

The cost to operate traditional equipment using fossil fuels is significantly less than using electricity. Converting all fossil fuel burning equipment onsite (including the campus fleet) would result in an increase in operational cost, or total annual utility expenditure, at SLC. An estimated average 24% additional utility cost would be incurred by SLC from the process of total facility and fleet electrification with conservation and ZCB in place. The same increase in average utility costs rises to approximately 32% when conservation and ZCB are not in place. This is detailed in Figure 47.

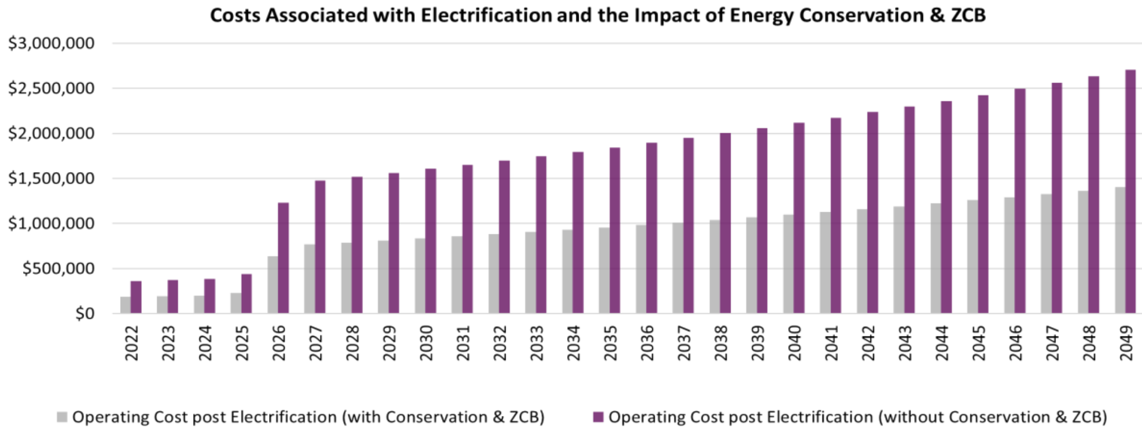


Figure 47. *Costs Associated with Electrification and the Impact of ECDM & ZCB*

Figure 48 compares the current price for several fossil fuels and their respective GHG emissions factors. Natural gas is inexpensive compared to other fuel sources. To date, this has made the business case ineffective for converting from natural gas to electricity. On an equivalent cost per unit of energy ($/ekWh), the prices for electricity and natural gas do not intersect under current market rate forecasts. As a result, there is no financial incentive for SLC to convert from natural gas to electricity in the short-term.

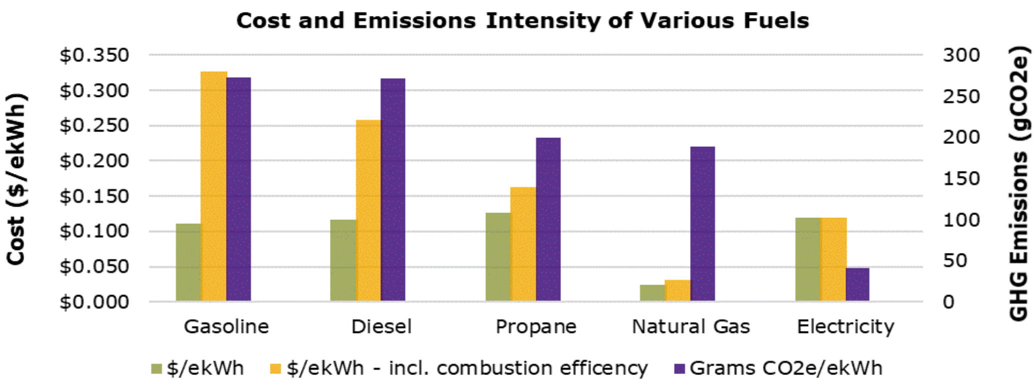


Figure 48. *Cost & Emission Intensities of Various Fuels*

Electric vehicles reduce fuel costs and carbon emissions. The business case for the replacement of existing fleet vehicles with comparable electric vehicles must be considered on a case-by-case basis. Due to carbon taxes, the cost to operate non-electric vehicles will increase due to the increase in fuel cost. Other technologies like heat pumps provide an example of how existing technology is becoming more cost-effective. This is illustrated in Case Study 6 on the following page.

Case Study 6: The Case for Heat Pump Technology

Heat pumps exchange energy by extracting heat from an outside source (geothermal, solar thermal etc.) and pumping it into a space. Heat pumps can also be scaled to service smaller-size buildings in residential applications and can be scaled to service entire campuses. Heat pumps are more energy efficient than natural gas burners and electric resistance heating coils. SLC is scheduled to install a ground source heat pump at the Alumni Field during its upcoming renovation.

Heat pumps with Variable Refrigerant Flow (VRF) systems can provide simultaneous heating and cooling and multiple zone control. Outdoor units are connected to indoor fan coil units via refrigerant pipes and can be integrated with smart building technology and BAS. A typical VRF system is demonstrated in the figure below:

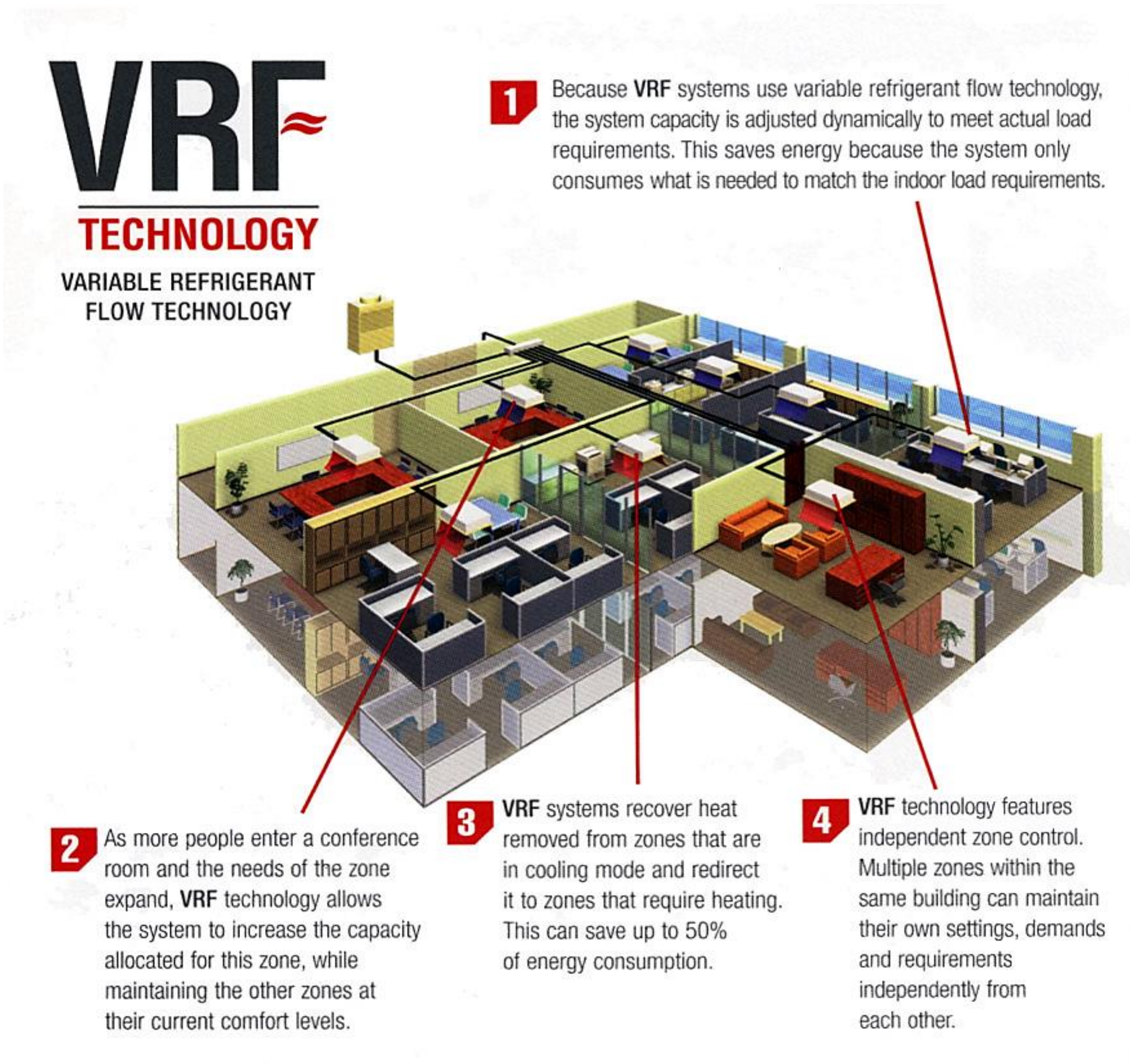


Figure 49. *Variable Refrigerant Flow Technology*

Price

Today, using a heat pump can cost twice as much as traditional packaged rooftop units that consist of direct expansion (DX) cooling and natural gas burners. However, heat pump technology is becoming increasingly cost-effective and, according to the National Energy Board, costs could drop 10% to 20% by 2025 to 2030, and 20% to 30% by 2040. These numbers line up with the forecasted replacement HVAC replacement schedule listed throughout this GRRAP.

Heating

Depending on outdoor air temperature, a heat pump can achieve COP as high as 3.4 in heating mode, meaning the heat pump can produce 3.4 kW of heating energy for every kW of electricity consumed.

As outdoor air temperature drops below 0°C, the efficiency of heat pumps drops significantly and requires additional support from either an electric heating coil, a natural gas burner or a larger heat pump capacity. For example, at sub-zero temperatures, a 20-ton heat pump may only produce the heating equivalent of a 15-ton heat pump.

Cooling

High efficiency heat pumps or DX units provide substantial energy and utility cost savings compared to traditional standard efficiency DX cooling applications, as demonstrated in the example below. Depending on outdoor air temperature, a heat pump can achieve IEER as high as 18.6 (COP of approximately 5.4), meaning the heat pump can produce 5.4 kW of cooling for every kW of energy consumed.

Example: 20-Tonne Heat pump RTU Annual Operating Costs

The following table shows the difference in annual operating costs associated with using a 20-ton heat pump instead of an RTU that has 15-ton DX cooling and a natural gas burner, based on current electricity and natural gas utility rates. The case is based on a theoretical 5,000 sq. ft. space with one exterior wall in the Greater Toronto Area. The assumed operating schedule is Monday to Friday from 7AM to 5PM.

Table 28. *Comparing Heat Pumps with Natural Gas Burning Equipment*

Technology	Cooling Energy ($)	Heating Energy ($)	Fan Energy ($)	Total Annual Energy Cost ($)
Rooftop Unit + Gas Boiler	$1,014	$1,026	$1,688	$3,728
20-ton heat pump	$460	$4,377	$434	$5,271
Heat pump savings	$554	-$3,351	$1,254	-$1,543

Relatively low prices of natural gas compared to electricity prevents electric heat pumps from yielding cost savings compared to high efficiency natural gas furnaces. A 20-tonne electric heat pump is more expensive to operate annually than a rooftop natural gas unit based on current electricity and natural gas utility rates. However, improvements to heat pump technology and an increased cost of carbon will make heat pumps a cost-competitive alternative to natural gas equipment[9]. The technology cost curve mapped against technology efficiency is illustrated in Figure 50.

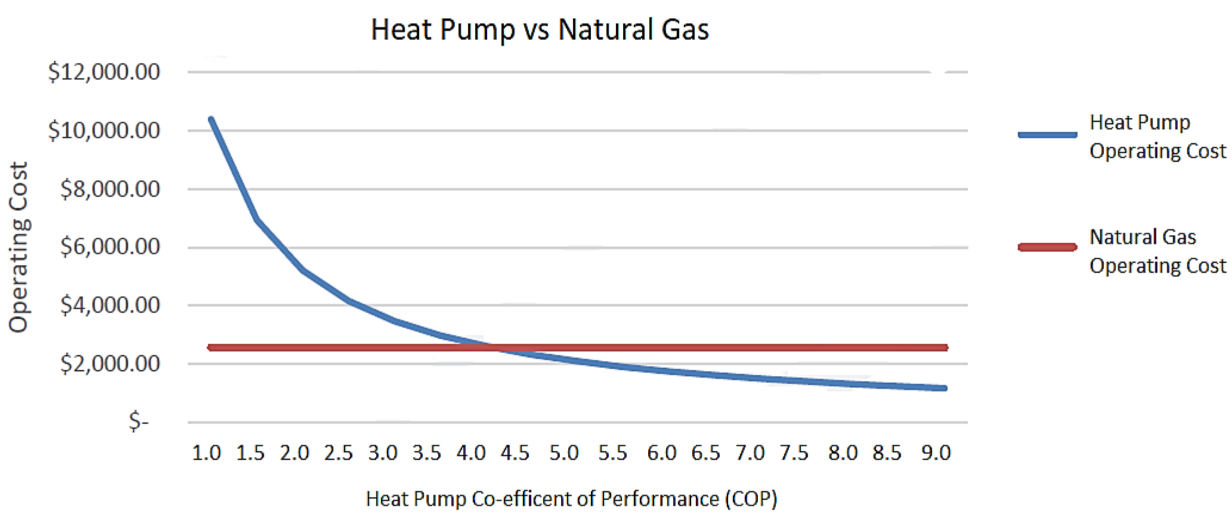


Figure 50. *Technology Cost Curve for Heat Pumps*

[9] Graham Cootes (P.Eng.), HTS Toronto. Email: graham.coote@hts.com

7.3.3. Forecasted Utility Cost

Ontario's 2017 Long Term Energy Plan (LTEP) created by the Independent Electricity System Operators (IESO), states that electricity prices will continue to rise in Ontario between 2019 and 2050. The federal carbon tax will increase the price of electricity and natural gas. The price escalation rate for electricity was derived from Ontario's LTEP[10], and escalation forecasts for natural gas were derived from the current commodity and distribution costs.

Table 29. *Forecasted Utility Prices*

Forecasted Utility Prices	2019	2030	2050
Electricity ($/kWh)	$0.1377	$0.2113	$0.2768
Natural Gas ($/m3)	$0.26	$0.35	$0.46
Natural Gas ($/ekWh)	$0.025	$0.034	$0.047
Nat Gas with Eff Losses ($/ekWh)	$0.032	$0.044	$0.059

The future forecasted rates for both grid electricity ($/kWh) and natural gas ($/ekWh) would not intersect, i.e. the forecasted price for grid electricity was not found to be equal to or less than the price for the equivalent of amount of energy from natural gas.

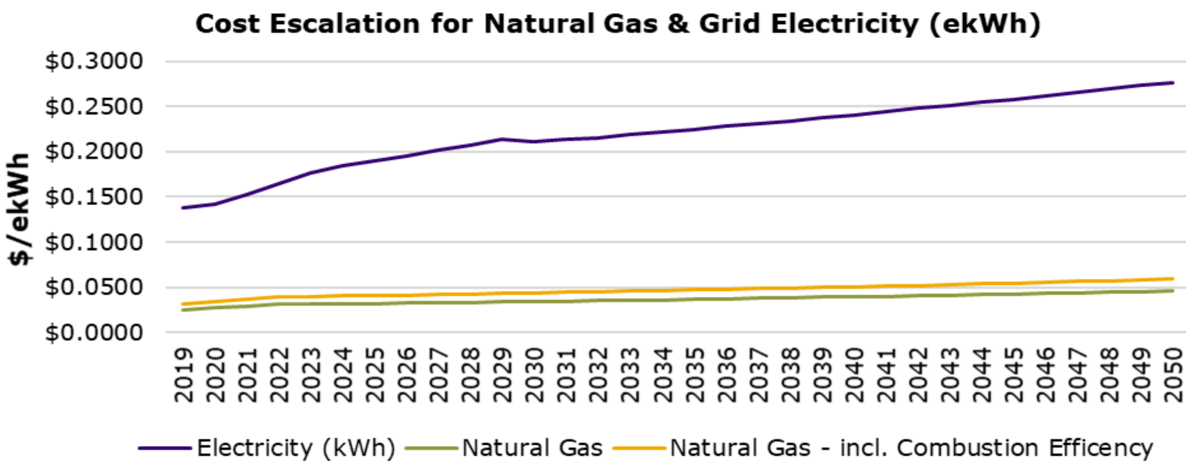


Figure 51. *Forecasted Utility Cost Escalation*

[10] Ontario's Long-Term Energy Plan - Delivering Fairness and Choice, 2017; https://files.ontario.ca/books/ltep2017_0.pdf

7.3.4. Cost of Solar Power

Pillar 4 of SLC's GRRAP, renewable energy, plays a significant role in supporting SLC in meeting its 2050 targets. Under each scenario, SLC will need to acquire electricity from clean or renewable sources. Solar panel prices, for example, have been declining steadily since 2010. The following chart shows the estimated price for solar panel installations in Ontario.

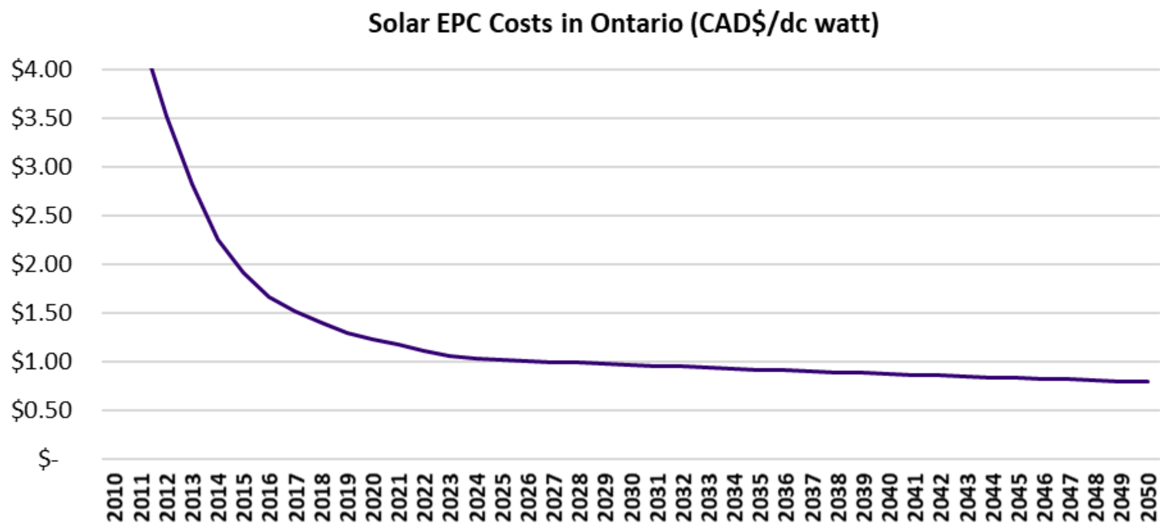


Figure 52. *Forecasted Solar PV Costs*

The following analysis was conducted based on price curve in the chart above, Solar EPC Costs in Ontario, forecasted grid electricity rates ($/kWh) in Ontario, and the price for electricity generation ($/kWh) for onsite solar generation (including annual maintenance costs) assuming a 25-year life on solar panels.

Figure 53 shows that the price to produce electricity from either roof-mount or carport solar onsite would be less expensive than the cost to purchase electricity from the grid from 2019 through 2050. The chart also shows the cost of solar electricity if SLC was to finance the roof-mount or car park solar. The model assumes an interest rate of 6.5% over a 25-year term. The price for electricity generation ($/kWh) was determined under the assumption that an average solar panel at 1 kW would produce 1,200 kWh/year.

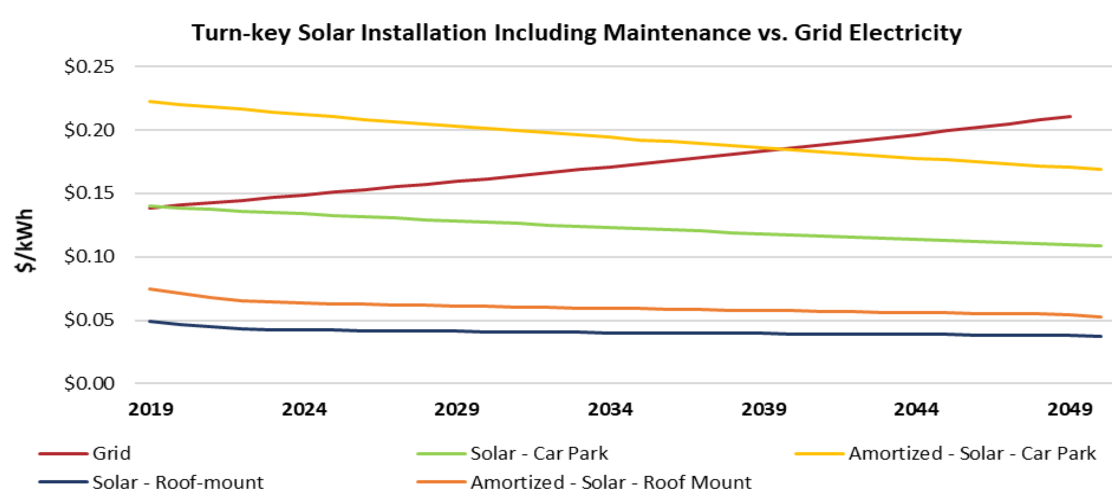


Figure 53. *Solar PV Costs vs Utility Cost for Grid Electricity*

7.3.5. Carbon Tax

A carbon tax increases the price of natural gas, gasoline, diesel, and propane. It will have minimal impact on the price of Ontario's grid-produced electricity, as it is relatively low carbon. The federal government of Canada committed to a carbon tax of $20/tCO$_2$e in 2019, which will escalate annually by $10 until 2022, when it would reach $50/tCO$_2$e. this was further revised to escalate annually by $15 until 2030, when it would reach $170/tCO$_2$e.

Table 30. *Effect of Carbon Price on Natural Gas Costs*

Effect of the Federal Carbon Backstop	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Federal Price on Carbon ($/tCO$_2$e)	$20	$30	$40	$50	$65	$80	$95	$110	$125	$140	$155	$170
Federal Price on Carbon ($/m^3)	$0.039	$0.059	$0.078	$0.098	$0.127	$0.157	$0.186	$0.215	$0.245	$0.274	$0.303	$0.333
Actual Price of Natural Gas ($/ekWh)	$0.025	$0.027	$0.029	$0.031	$0.057	$0.070	$0.083	$0.096	$0.109	$0.122	$0.135	$0.149

The implementation of a carbon tax creates financial incentives to move to low carbon fuel sources. Currently, the prices of gasoline, diesel and propane are like the price of electricity for the equivalent energy output with a cost of between 0.111 $/ekWh and 0.127 $/ekWh. Natural gas, at 0.027 $/ekWh, is currently about a fifth of the cost of grid electricity for the equivalent energy output.

The Canadian federal government has established a 2030 price for carbon at $170/tCO$_2$e. To truly discourage burning natural gas would require a price of ~$372 - ~$600/tCO$_2$e. Carbon pricing schemes in Canada are inconsistent and can vary year to year by jurisdiction.

7.3.6. Funding Opportunities

Identifying funding opportunities to support electrification may be required to support SLC in achieving net-zero targets. Renewable energy, ECDMs and green buildings all have proven, fiscally responsible business cases. However, given the low cost of fossil fuel-based technologies, electrification currently does not have a sound business case.

Since 2009, the federal and provincial governments have provided financial grants to universities to support GHG emissions reductions programs. In 2019, the federal government announced multiple initiatives to support Canada's achievement of net-zero emissions by 2050.

However, funding for the post-secondary sector has not been announced. Currently, there is insufficient government funding or incentive support to assist in paying for the additional installation and/or operational cost associated with total facility and fleet electrification. However, the GRRAP provides the roadmap for SLC to be "shovel-ready" for grants and incentives as soon as they become available.

7.3.7. Utility Rate Structure

The utility rate structures differ for natural gas and electricity consumption. For natural gas, rates are based on consumption. For electricity, rates consider how much electricity (demand) is required, for how long (kWh) and when the electricity is consumed (time of use). SLC consumers who have a demand of more than 1 MW (and less than 5 MW) can opt into being "Class A" consumers to reduce their global adjustment (GA) charges. In Ontario, the GA charge is a significant component of electricity bills. It covers the cost of building new electricity infrastructure in the province, maintaining existing resources and providing conservation and demand management programs. GA currently represents approximately 80% of the total price of electricity.

To determine the full cost of an ECDM or renewable energy measure, the potential increase of SLC's total electrical cost should be considered if the Class rating is impacted. It is recommended that SLC evaluates each project on a case-by-case basis to evaluate if projects will impact Class rating. For this document, modelling assumed that the price per kWh was based on a Class B consumer rate.

7.3.8. Supporting Infrastructure Costs

In addition to the cost to upgrade infrastructure, further investments may be required to upgrade supporting electrical systems at SLC. It is likely that, as each piece of HVAC equipment is converted to fully electric, the supporting electrical infrastructure will also need to be upgraded. This will have cost implications.

7.3.9. Emerging Technology Costs

New clean technologies such as EVs, battery storage and renewable energy are currently quite expensive and face roadblocks during scaling and commercialization. It is expected that these technologies will become more cost-effective in the future, either through government incentives or favourable regulatory and financial market conditions in Ontario, Canada and around the world.

8. Barriers and Considerations

The following section outlines the barriers and considerations that will impact SLC's path to net-zero. As SLC moves towards net-zero, each issue should be seriously considered.

8.1. Physical Space Available for Renewal Projects

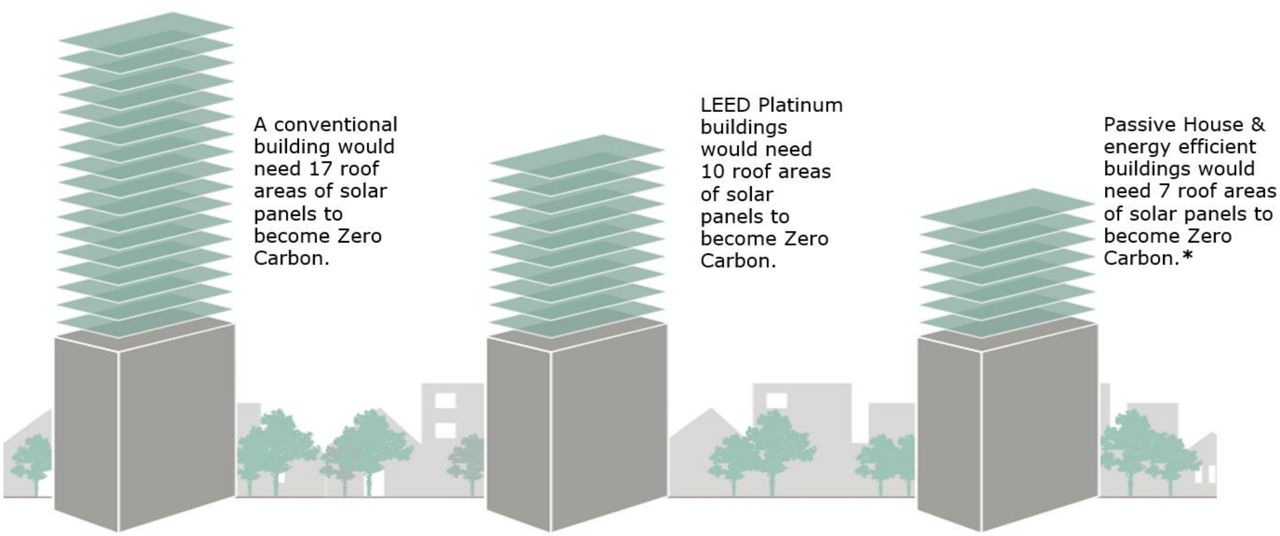
8.1.1. Barrier

Based on the current solar analysis and a review of the potential for onsite geothermal systems, there is currently not enough space available onsite for SLC to generate the amount of renewable energy required to make its buildings net-zero. Solar PV is a proven and cost-effective form of renewable energy. However, its utility can be limited by the amount of physical space it occupies.

8.1.2. Consideration

Based on the solar review for SLC, the three campuses combined have enough rooftop space to accommodate approximately 1.04 MW of rooftop solar and 2.69 MW of car-port solar. This would generate approximately 4.3 million kWh of electricity. Based on current forecasts, SLC's would require about 24 million kWh of solar generation to offset the emissions associated with grid purchased electricity to reach net-zero by 2050.

The more energy efficient the building, the fewer solar panels required to make it zero carbon. Figure 54 shows the correlation between energy efficient building design and future renewable energy requirements in terms of solar panels[11]. The image also references the total amount of roof space that would be required to accommodate the solar panels required for SLC's buildings to reach zero carbon.



* The equivalent of seven roof areas of solar panels can be found in the future advancements in technology and scale jumping.

Figure 54. *High Performance Buildings & Solar Requirement*

[11] New Buildings Institute: Net Zero and Living Building Challenge Financial Study: A cost comparison report for buildings in the District of Columbia

8.2. Virtual Net-Metered Renewable Energy Generation

8.2.1. Barrier

SLC's renewable energy generation potential is currently limited by the insufficient amount of physical space available on campus. As shown in Figure 55, virtual net metering for renewable energy generation would allow SLC to produce renewable energy offsite that could be credited against the energy use in their facilities on campus. However, virtual net metering is currently not permitted by the IESO.

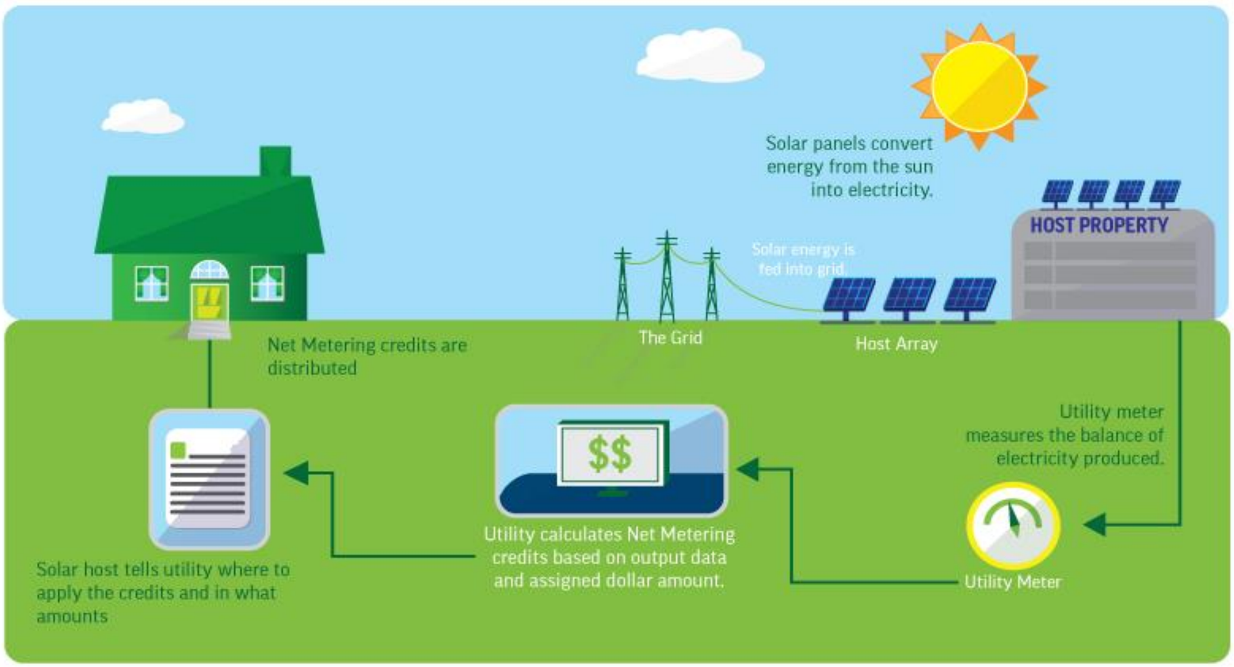


Figure 55. *Virtual Net-Metering Model*

8.2.2. Consideration

Virtual net metering is a bill crediting system administered by the local electricity distribution company that allows the owner of a power-generating asset to be in a different geographic location than that of the actual power-generating asset. With virtual net metering, the owner of the power generating asset might not be the direct consumer of the electricity generated but would still take ownership of the environmental attributes associated with generation with the local distribution company. The local distribution company would credit SLC's monthly utility bills for the electricity generated by the renewable generation system. Virtual net metering would eliminate the need for physical space requirements for onsite generation and help SLC meet its 2050 target of net-zero. However, as mentioned it is not currently permitted by the IESO.

8.3. High GHG Factor for Refrigerants

8.3.1. Barrier

The electrification of cooling systems, specifically installing heat pumps and high efficiency chillers, increases refrigerant use. Refrigerants are prone to leakage and are carbon intensive.

8.3.2. Consideration

It is recommended that SLC replaces fossil fuelled equipment with electrical equipment. When electric equipment is installed – specifically chillers, heat pumps and refrigeration equipment – the updated technology requires refrigerants as part of the cooling process. Refrigerants are fluorinated gases, which create GHG emissions. Refrigerants are used onsite when the technology is installed and are refilled annually as a small portion of the refrigerants can leak out. Leakage is dependent upon the operating efficiencies of the equipment and is included in SLC's annual Scope 1 emissions profile.

The refrigerants have a high global warming potential (GWP) and are expressed relevant to CO_2 emissions. The more electrification, the higher the emissions from refrigerants. However, fossil fuel-based equipment is still significantly more carbon intensive and emits substantially more carbon per GJ produced and consumed.

8.4. Grid Carbon Intensity

8.4.1. Barrier

In every scenario considered, SLC will continue to be reliant on grid-provided electricity for a portion of electrical needs. It is difficult to project the carbon intensity of Ontario's utility-provided electricity.

8.4.2. Consideration

The carbon intensity of the electrical grid, as measured in grams produced per kWh consumed (g/kWh), is determined by the source of electricity production. Compared to other provinces, Ontario's electricity is relatively low carbon. It is predominantly supplied by non-emitting sources of power generation, including hydroelectric and nuclear.

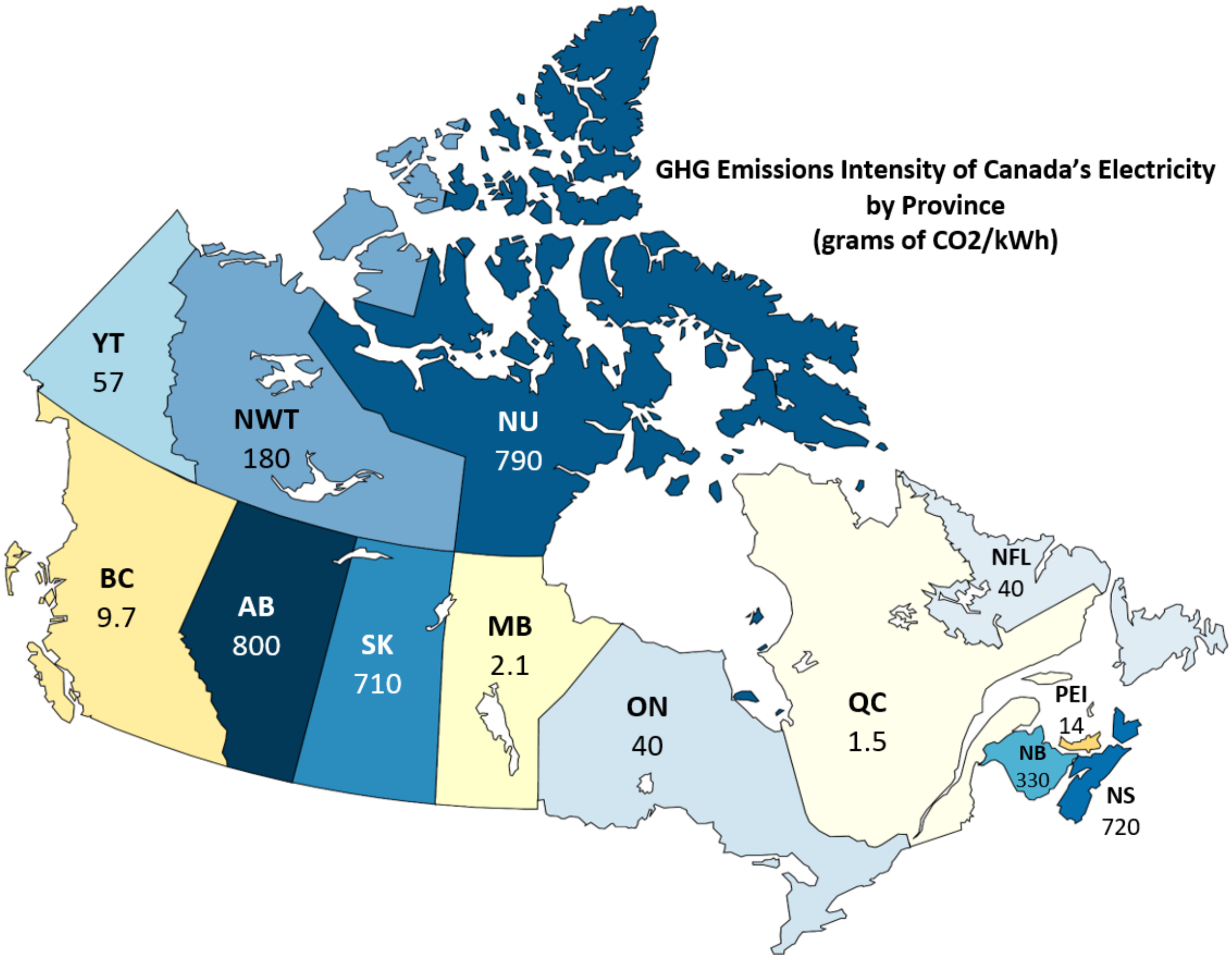


Figure 56. *Emission Intensities of Electrical Grids across Canada*

The electricity generation in Ontario is mostly powered by nuclear and hydroelectric plants. This has rendered the province with a carbon frugal electric grid – 0.000040 tCO_2e/kWh or 40 grams of CO_2e/kWh. This is one of the lowest emissions intensities of electric grids across all Canadian provinces (see Figure 56). The electrical mix of Ontairo's grid is illustrated Figure 57.

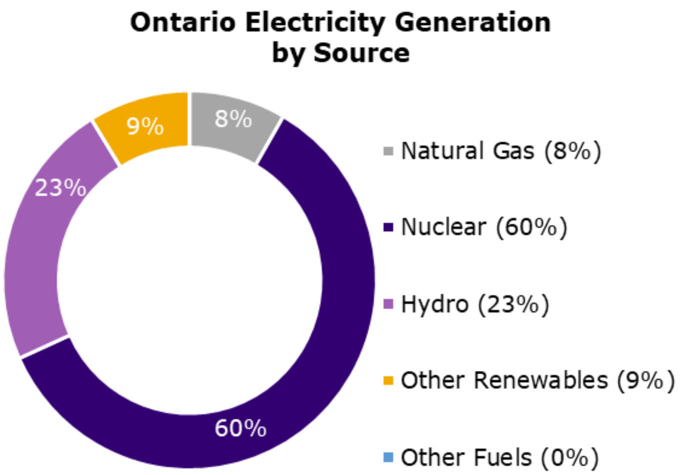


Figure 57. *Electricity Generation Mix in Ontario*

According to Environment and Climate Change Canada (ECCC), natural gas combustion provides approximately 8% of all electricity generation in Ontario. It also accounts for approximately 97% of the total GHG emissions for electricity generation. If Ontario was to replace existing natural gas generators with either nuclear or renewable energy, the GHG emissions intensity of electricity would reduce significantly, thereby reducing SLC's onsite emissions and eliminating the need to invest in its own renewable energy production.

The IESO procures Ontario electricity generation contracts. The 2019 IESO LTEP outlined Ontario's current electricity procurement contracts, including expiration dates. In Ontario, natural gas fired electricity plants currently provide the peak energy requirements in the province and are the main contributor to the GHG emissions of the electrical grid. The last natural gas fired generation is contracted to end between 2038 and 2041. The grid mix – and subsequent grid carbon intensity – is not defined past 2041. However, for the GRRAP is assumed to be consistent to 2050.

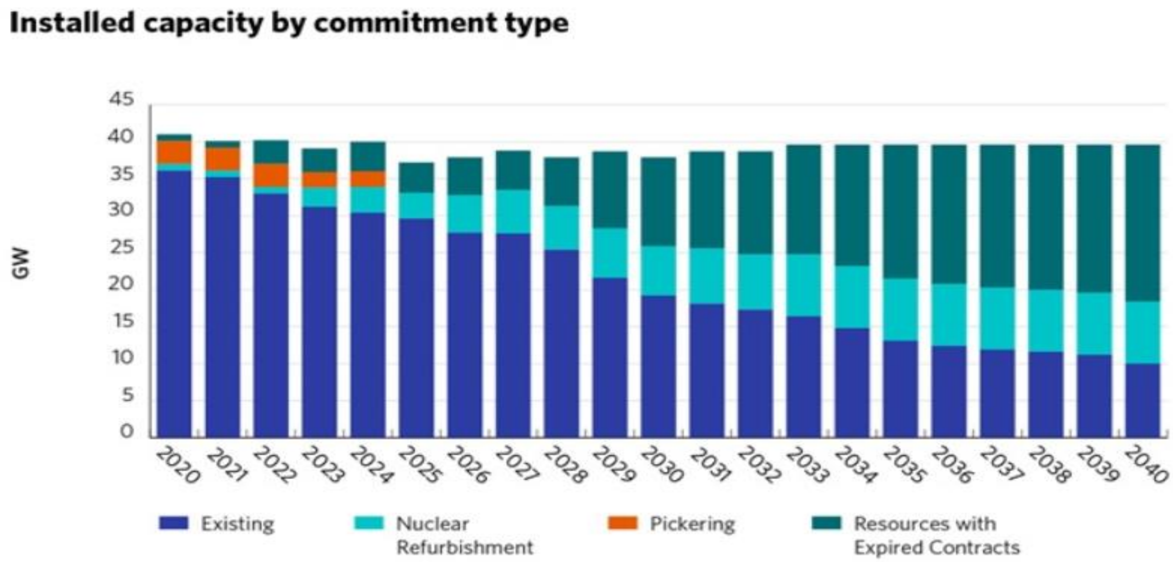


Figure 58. *Ontario's Installed Power Capacity*

Between 2020 and 2050, the grid could potentially decarbonize further if there is political will, which would significantly impact SLC's path to net-zero carbon. Ontario's electricity generation is determined by the IESO as directed by the Ontario Ministry of Energy[12]. Currently, the grid has a low carbon intensity factor as the result of eliminating coal from the generation stack in 2013.

[12] *IESO: http://www.ieso.ca/Powering-Tomorrow/Data/The-IESOs-Annual-Planning-Outlook-in-Six-Graphs*

9. Sustainability Initiatives to Support the GRRAP

Recommendations listed under the General Sustainability Initiatives in Section 3 will reduce Scope 3 emissions and continue to foster sustainable practices on campus. The Sustainability Policy Cycle will help garner support and spread awareness amongst the broader SLC community. Scope 3 GHG emissions account for 5% of SLC's overall emissions. Operational policies established by SLC can influence student and employee behaviour.

Scope 3 GHG emissions are generated by both SLC's operations and as a direct result of those that live, work, and study at SLC. It is vital to have sustainability policies that align with SLC's climate action strategy and its GHG emissions reduction targets. Although not an exhaustive list, the strategies presented in the GRRAP should be considered for all facets of SLC's operations.

The GRRAP has included the following Scope 3 GHG emission sources:

- Mileage reimbursements
- Air travel
- Paper purchases
- Waste

Emissions from purchased goods and services, transportation and distribution, waste generated from construction, commuting and leased assets were not included due to lack of information and as per discussions with the Sustainability Office.

9.1. Waste Management

Waste accounts for the largest share of SLC's Scope 3 emissions. SLC recognizes the importance of waste reduction and waste diversion and has an ongoing culture of recycling and composting.

To achieve its carbon neutral target, SLC should implement programs and strategies to continue to reduce emissions from Scope 3 emissions, including a target to have zero waste campus by 2050.

There are three waste diversion strategies that should be focused on: upstream, onsite, and downstream. Upstream is waste that is produced before a product reaches the campus; onsite is produced on campus; and downstream is the way in a product is disposed.

The following strategies can be implemented on SLC's campuses to help achieve the goal of a zero-waste campus and zero emissions associated with waste:

Upstream

- Upstream waste reduction through sustainable material management.
- A stronger focus on waste reduction as it related to purchasing decisions. Look for products less packaging; bring fewer single use disposable items on to campus and reduce the amount of less non-recyclable and non-compostable materials being purchased.

Onsite

- Eliminate single-use products (i.e. disposable food service ware, disposable cups, straws, etc.).
- Require new buildings, expansions, or renovations to reuse or recycle at least 50% of the construction debris or dispose of no more than 2.5 lbs. per sq.ft.
- Replace plastic bags with reusable, compostable or paper bags labelled with 40% post-consumer recycled content.
- Create programs for students to submit proposals for service enhancements, innovations, or cost-savings on waste.
- Host recycling/reuse events every semester.

Downstream

- Create multiple locations on campus where students can bring their hard-to-recycle materials (i.e. electronics, small appliances, books, textiles, etc.).
- Increase awareness around proper waste sorting to improve student and staff participation in composting and recycling programs (i.e. improved signage, more centralize waste bins, expand composting to all campuses).

The reduction strategies focus on reducing the total amount of disposable products purchased by SLC, while the diversion strategies focus on recycling and composting all waste.

9.2. The Sustainability Policy Cycle

SLC does not have the same degree of control over its Scope 3 GHG emissions as it does over Scope 1 and 2 emissions. The implementation of the Sustainability Policy Cycle shown in Figure 59 can help maximize that control and reduce the overall impact of Scope 3 emissions. This section will provide detailed analysis of each step in the Sustainability Policy Cycle. Each phase of the policy cycle is elaborated below.

Polices that Require a Minimum Level of Sustainability

SLC can develop policies that would foster environmental sustainability and GHG reduction practices on campus. Below is a list of policies that SLC could implement to improve campus sustainability and reduce GHG emissions from its operations.

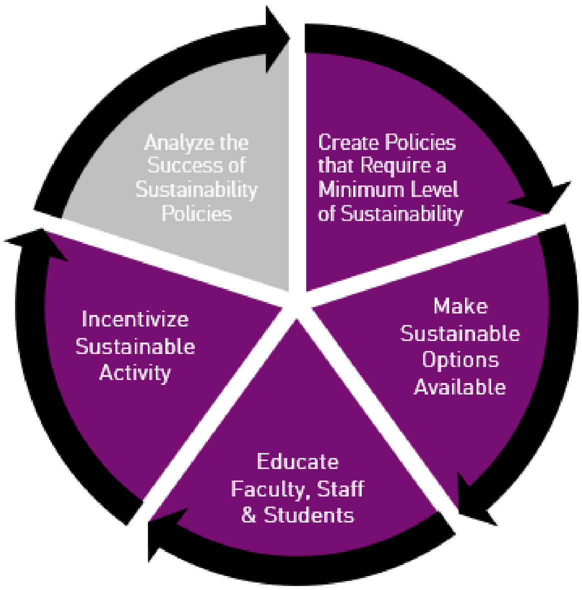


Figure 59. *The Sustainability Policy Cycle*

Table 31. *Operational Sustainability Policies*

Category	Concept	Policy Description Summary
Air & Climate	Outdoor Air Quality	Create policies (e.g. anti-idling) that limit outdoor air pollutants from sources such as idling vehicles and fossil fuel powered lawn care equipment
Buildings	Building Operations and Maintenance	Create a publicly available Indoor Air Quality (IAQ) management policy, green cleaning policy, energy and water management and benchmarking program
	Building Design and Construction	Create a policy that requires all new building construction be either LEED, Net Zero Energy or Net Zero Carbon
Energy	Building Energy Consumption	Make historical energy consumption data publicly available
	Clean and Renewable Energy	Create a policy that requires a minimum amount of total annual energy consumption to come from renewable sources
Food & Dining	Food and Beverage Purchasing	Create a policy that requires a minimum amount of food and beverages purchased to be locally sourced, Certified Organic or Certified Humane
Grounds	Landscape Management	Create a policy that requires a minimum amount of the campus to use organic fertilizers and non-toxic pest control methods

		Biodiversity	Create a policy that requires a minimum amount of vegetation on the campus be a species native to its jurisdiction
	Purchasing	Sustainable Procurement	Eliminate or reduce single use disposable packaging and materials on campus
		Electronics Purchasing	Create a policy that requires all electronics to be registered through the Electronic Product Environmental Assessment Tool (EPEAT) and/or to be Energy Star certified
		Cleaning and Janitorial Purchasing	Create a policy that requires onsite cleaning and janitorial supplies to be Green Seal certified, ECOLOGO certified, US EPA Safer Choice labelled (or a comparable local equivalent)
		Office Paper Purchasing	Create a policy that requires paper be purchased with post-consumer recycled, agricultural residue, and/or Forest Stewardship Council (FSC) certified content
	Transportation	Campus Fleet	Create a policy that requires campus vehicles to be replaced with hybrid or electric vehicles when each vehicle is replaced, or a new lease is entered
	Rainwater	Rainwater Management	Create a comprehensive rainwater management policy and plan that incorporates green infrastructure and rainwater management, including using rainwater for irrigation purposes

Make Sustainable Options Available

Below is a list of policies that SLC could implement to encourage sustainable practices among its larger community of students and employees. This would improve campus sustainability, reducing Scope 3 GHG emissions from dining, transportation, and planning. As per SLC's Sustainability Plan many of these initiatives are underway or planned as part of their goal to be STARS Gold.

Table 32. *Sustainable Lifestyle Policies*

Category	Description Summary
Sustainable Dining	• Create a campus garden or farm • Host regular farmers' markets • Host low-impact or sustainably themed dining events • Provide locally sourced, Certified Organic and/or Certified Humane dining options • Encourage onsite food outlets to donate food that would otherwise go to waste
Support for Sustainable Transportation	• Provide electric vehicle charging stations • Provide dedicated places for faculty, staff, and students to securely lock their bicycles • Increase the number of online classes/programs to reduce travel • Create a car-sharing program
Coordination & Planning	• Create a sustainability committee made up of faculty, staff, and students

Educate Faculty, Staff and Students

Awareness around the environmental impacts associated with individuals' daily actions would help motivate more members of the SLC community to by into the idea of creating a culture of sustainability on SLC's campuses.

Table 33 on the following page outlines various educational, awareness and engagement programs that SLC can implement. This will help its faculty, staff and students support efforts to reduce Scope 3 GHG emissions on an individual level. It is recommended that these programs be tailored to include (at a minimum): 1) transportation, 2) waste and 3) purchasing of goods/procurement, as these are the main contributors to SLC's Scope 3 GHG emissions.

Table 33. *Academic Sustainability Policies*

Category		Concept	Description Summary
Academics	Curriculum	Academic Courses	Institution conducts an inventory to identify its sustainability course offerings
		Learning Outcomes	Institution's students graduate from degree programs that include sustainability as a learning outcome or include multiple sustainability learning outcomes
		Undergraduate Program	Institution offers at least one sustainability-focused, undergraduate-level major, degree program, minor or concentration
		Graduate Program	Institution offers at least one sustainability-focused, graduate-level major, degree program, minor, concentration or certificate
		Immersive Experience	Institution offers at least one immersive, sustainability-focused educational study program
		Sustainability Literacy Assessment	Institution assesses the sustainability literacy of its students
		Incentives for Developing Courses	Institution has an ongoing program that offers incentives for faculty in multiple disciplines or departments to develop new sustainability courses and/or incorporate sustainability into existing courses or departments
		Campus as a Living Laboratory	Institution is utilizing its infrastructure and operations for multidisciplinary student learning and applied research that contributes to understanding campus sustainability challenges or advancing sustainability on campus
	Research	Research and Scholarship	Institution conducts an inventory to identify its sustainability research activities and initiatives
		Support for Research	Institution has programs to encourage and/or support sustainability research
		Open Access to Research	Institution has a formally adopted open access policy that ensures that versions of future scholarly articles by faculty and staff are deposited in a designated open access repository

Category		Concept	Description Summary
Engagement	Campus Engagement	Student Educators Program	Institution coordinates an ongoing peer-to-peer sustainability outreach and education program for students (sometimes known as an "Eco-Reps" program).
		Student Orientation	Institution includes sustainability prominently in its student orientation activities and programming
		Student Life	Institution has co-curricular sustainability programs and initiatives
		Outreach Materials and Publications	Institution produces outreach materials and/or publications that foster sustainability learning and knowledge
		Outreach Campaign	Institution holds at least one sustainability-related outreach campaign directed at students and/or employees that yields measurable, positive results in advancing sustainability
		Assessing Sustainability Culture	Institution assesses campus sustainability culture that focuses on sustainability values, behaviors, and beliefs
		Employee Educators Program	Institution administers or oversees an ongoing faculty/staff peer-to-peer sustainability outreach and education program
		Employee Orientation	Institution covers sustainability topics in new employee orientation and/or in outreach and guidance materials distributed to new employees
		Staff Professional Development	Institution's staff participate in sustainability training or professional development opportunities that are provided or supported by the institution

The following is a list of program examples designed to reduce faculty, staff, and student transportation: Experiment with virtual platforms

- Organize regional hub conferences
- Hold fewer conferences
- Limit overseas conferences
- Experiment with coordinating conference timing
- Invite speakers to give talks remotely
- Invite fewer distant speakers and ask for more work from each one
- Focus on making a single flight serve more purposes
- Envision new ways to build a community online
- Convene online reading or discussion groups
- Make best use of the setting
- Plan longer or smarter meetings that occur less frequently

Incentivize Sustainable Activity

Sustainable activity can be incentivized in the ways summarized in the table below.

Table 34. *Sustainability Incentives*

Incentive Target	Description Summary
Faculty, Staff & Students	Programs to encourage more sustainable, low, or no-GHG emission practices like interdepartmental energy challenges, zero-waste challenge etc.
Product & Service Vendors	Procurement policies that reward vendors for their sustainable and GHG reducing products and services

Combined with education, awareness and engagement programs, the items featured in the following table provide potential incentives to promote sustainable and GHG emission reduction practices.

Table 35. *Operational Sustainability Incentives*

Category	Incentive
Sustainable Dining	Provide incentives or discounts for faculty, staff, and students to purchase locally sourced, Certified Fair Trade, Certified Organic or Certified Humane. Offer discounts or incentives to those who utilize reusable containers
Support for Sustainable Transportation	Provide an increased transit pass discount for faculty and staff. Create preferred parking for fuel-efficient and electric vehicles
Sustainable Investment	Create an internal carbon pricing mechanism whereby collected funds are invested in projects on campus that reduce campus wide GHG emissions and support innovation

Analyze the Success of Sustainability Policies

It is recommended that SLC analyzes the success of each sustainability and GHG emission reduction policy annually. Success can be evaluated by looking at the uptake of each program and the reduction in each relevant Scope 3 category. Policies and programs can be revised over time to encourage more participation and improved uptake.