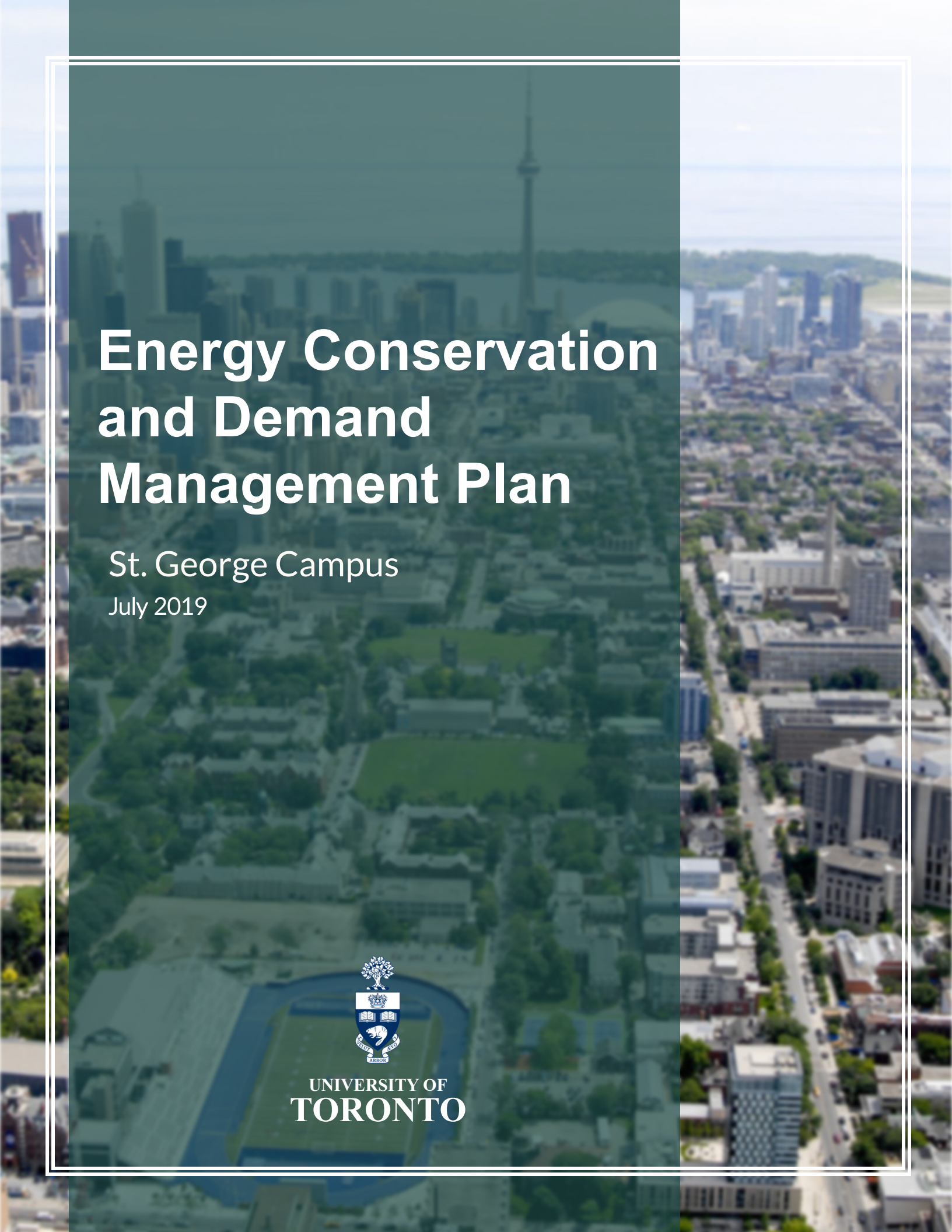


Energy Conservation and Demand Management Plan

St. George Campus

July 2019

UNIVERSITY OF TORONTO

Table of Contents

A Letter from Chief Operating Officer, Property Services & Sustainability

The University of Toronto has a long-standing commitment to operational sustainability and environmental stewardship that continues to grow in momentum. We are committed to sustainability and recognize our role in helping to meet the challenge of climate change.

In 2018, the University of Toronto joined the University Climate Change Coalition (UC3); a group of leading research universities in North America committed to reducing greenhouse gas (GHG) emissions on their own campuses and in their communities. In line with this commitment, the University of Toronto set a goal to reduce GHG emissions 37 per cent by 2030, below a 1990 baseline level.

Our operations team strives to deliver the very best to our outstanding students, faculty, and staff that we serve. With an increase in student population and building area, the University has lowered carbon and energy intensity over the last two decades. We will need to further reduce energy and carbon intensity in our existing and new buildings on our St. George campus to meet our 2030 GHG reduction goal.

Achieving our 2030 goal requires a diverse mix of strategies and solutions that we will implement across our campuses over the next five years and beyond. We will improve power and thermal production, distribute energy more efficiently, and reduce energy consumption. This Energy Conservation and Demand Management Plan for St. George campus serves to complement our tri-campus Low-Carbon Action Plan (2019-2024) to help drive energy and carbon reduction efforts.

Ron Saporta

Chief Operating Officer, Property Services & Sustainability

We wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Executive Summary

The University of Toronto, in particular the St. George Campus, is a research-intensive collection of facilities, staff and students. It consists of over 120 buildings ranging in age from brand new to almost 200 years old on 72 hectares of urban land. The campus is growing in floor area, staff and students every year and will continue to grow over the next ten years and beyond. As a result of the size, population, diverse operations and utility needs, a lot of energy is used to keep the community that uses the campus comfortable throughout the year.

Responsibly managing growth and operations is vital to sustainability at the St. George campus. Focused energy reductions efforts that were rooted in the 2014 CDM (2013-14 to 2018-19) surpassed projections through efficient design, optimization and, on-going performance validation. Over the last 5 years, electrical use has been reduced by approximately 179 GWh and thermal energy by approximately 214,000 mmBTU (about 6 million m^3 of natural gas) for a total of 242 eGWh. This has avoided over 18,400 tonnes eCO_2 emissions.

In 2018, the University of Toronto committed to reducing greenhouse gases (GHGs) 37% by 2030 across its three campuses, below a 1990 level baseline. The downtown Toronto St. George campus currently represents over 80% of U of T's total emissions. To meet tri-campus commitments, St. George campus will need to achieve significant GHG and energy reductions over the next ten years and beyond.

This Energy and Conservation Demand Management Plan for the St. George campus supports our energy production, distribution, and conservation goals as outlined in the University of Toronto's tri-campus Low-Carbon Action Plan (2019-2024), to be released summer 2019. As such, the CDM plan for 2019-2014 is GHG reduction focused with energy savings resulting when GHGs are targeted in both scope 1 and scope 2 emissions.

The period between 2018/19 to 2023/24—this 2019 CDM—provides an overview of the type of strategies and projects planned for the next 5 years, given information currently available. To advance reductions on campus, St. George will need to improve the

performance of its existing building stock, and mange growth by designing any new buildings or major renovations to high performing standards with respect to carbon and energy intensity. Thermal energy savings, which yield higher GHG savings compared to electricity, are expected to increase compared to the previous CDM due to emphasis on greenhouse gas reduction goals that are driving planned reductions for the 2019-2014 period.

Developing teams with internal building science expertise, leveraging our Utilities Revolving Reduction Fund, designing to high performance standards, support from partners, engaging building occupants, and continuous monitoring and analysis will advance operations and position U of T on a path towards achieving its GHG reduction target

Time Period	Status	Total energy saved, ekWh	GHG saved, tonnes eCO2/yr
2013/14 - 2018/19	SUM over 5 years	242,277,143	18,461

Table 1 Summary of total energy and GHG reductions from 2013/14 until 2018/19 at St. George Campus. GHG savings include those due to reduced thermal energy.

Time Period	Status	Total energy saved, ekWh/yr	GHG saved, tonnes eCO2/yr
2019/20 - 2023/24	By 2024	150,831,735	38,092

Table 2 Estimated ekWh and GHG annual savings by 2024 going forward, in addition to the values in Table 1.

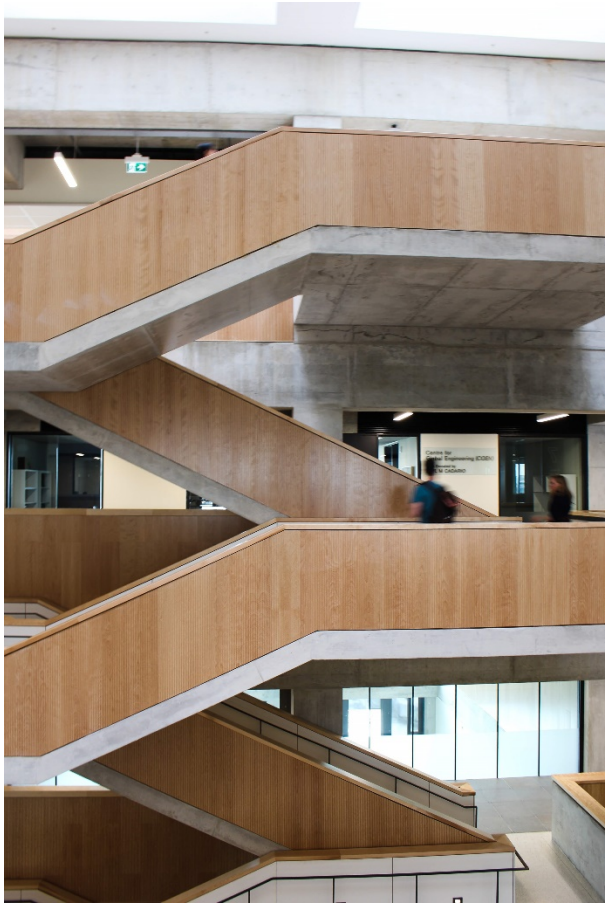
Introduction & Background

The University of Toronto is committed to providing a world-renowned campus where students, faculty, and staff thrive in vibrant, safe and sustainable environments. The Facilities & Services team that operates the St. George campus aims to create spaces that foster learning and discovery by harnessing the power of partnerships, people, technology, innovation and passion. Our history of efficient operations through a culture of optimized energy management combined with our commitment to significantly reduce our greenhouse gas (GHG) emissions by 2030 supports the plan presented in this Energy Conservation and Demand Management (CDM) document.

The results of our efforts over the last five years and opportunities for future initiatives during the next five years are described. Given our targets for 2030 and beyond are GHG based we will focus on projects that maximize GHG reductions in a mix of thermal (high GHG content) and electricity (low GHG content) projects in an integrated and responsible way. Similar to the situation for the 2014 CDM, projects are planned and then must go through rigorous business case development and evaluation before final pricing and scheduling can be confirmed. A key criteria as we develop these business cases is that we strive to improve the comfort, sustainability and well-being of our students, staff and faculty for the long term.

Conservation & Demand Management Regulation - O. Reg. 507/18

The original legislation for CDM reporting, O. Reg. 397/11, was repealed in late 2018 and replaced with the O. Reg. 507/18 "Broader Public Sector: Energy Reporting and Conservation and Demand Management Plans", made under the Electricity Act, effective January 1, 2019. As a post-secondary



educational institution, the University of Toronto "*shall prepare, publish, make available to the public and implement energy conservation and demand management plans or joint plans in accordance with section 25.35.2 of the Act and with this Regulation.*" The requirements of the Act and Regulations include a summary of our annual energy consumption and GHG emissions along with a description of "previous, current and proposed measures that" reduce the demand for energy and GHG emissions. This document presents the information required and will be made available on the University of Toronto website on July 1, 2019. A printed version will be made available to the public at the Facilities & Services head office, 255 McCaul St, 4th floor, Toronto, Ontario.

Note that throughout this report University of Toronto fiscal years are used. Our year starts May 1st and finishes April 30th each year, unless otherwise stated.

Profile: University of Toronto, St. George campus

College and university campuses are unique in terms of the variety and complexity of their facilities operations. Perhaps no other type of organization under one management has a more diverse facility infrastructure. Here at the St. George campus, in the heart of downtown Toronto, we serve a student population of over 61,000 – the largest single campus student population in North America. Daily occupancy can exceed 100,000 people, placing St. George in line with the 50th largest municipality in Canada by population.

Due to the sheer geographical size (St. George sits on ~72 hectares), urban location, extensive district energy system, diversity and complexity of the built environment, the St. George Campus is often described as a "city within a city". We manage and provide utilities to over 120 buildings that are widely diverse in age, size, design and function. Beyond the significant diversity of the portfolio, the St. George campus has an extensive distributed energy system (DES) and network which supplies heat, electricity, and chilled water to most of the campus buildings through kilometers of underground tunnels. This happens to be a very efficient way to provide energy to such a wide variety of buildings on a large campus such as St. George. It also presents many opportunities to optimize energy generation, distribution and consumption that benefit the performance across a large range of buildings.

Existing Building Stock

The St. George Campus is comprised of more than 120 buildings ranging in size from 165 m^2 to 80,000 m^2, with an average building age of 70 years. A large majority of the buildings that will be here in 2030 are already built — and as we prefer to keep our properties and systems, we want to make sure they are efficiently designed for the long lives we expect. Many of our buildings are designated as heritage or represent important architectural designs which poses challenges when attempting to implement conventional energy conservation measures. The wide variety of facilities in an urban setting requires that we prioritize the buildings to tackle first, develop solid business cases, consider solutions that achieve the best return on investment, and ultimately improve the educational experience at this world recognized university.

Goals & Objectives

In 2018, the University of Toronto joined the University Climate Change Coalition (UC3), a group of leading research universities in North America committed to reducing GHG emissions in their campuses and communities. In line with this commitment, the University of Toronto set a goal to reduce absolute GHG emissions 37 per cent by the year 2030, below 1990 baseline levels. Our plan described in this CDM indicates we are on track to meet this target.

2030 GOAL 37% Reduction below 1990 GHG baseline

1.

PRODUCE

Clean Energy and Carbon Capture

Increase the use of low-carbon energy sources for heating and cooling. Investigate carbon capture solutions.

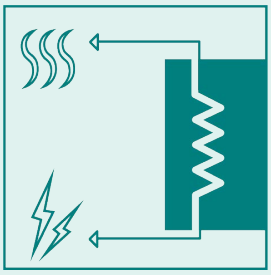
2.

DISTRIBUTE

Efficient Distribution

Improve the efficiency of energy distribution systems, reduce losses, maximize heat recovery, and distribute more low-carbon heating and cooling.

3.



CONSUME

Reduce Energy Consumption

Reduce energy consumption in existing and new buildings through retrofits, building systems optimization, and by designing to standards with superior performance in energy and carbon intensity.

Baseline Consumption

St. George campus uses energy in many forms - electricity, natural gas, steam, high temperature water, low temperature water and chilled water to provide comfort to a wide range of building types, ages and uses. The St. George Campus generates and supplies these utilities across the campus, the majority from a centralized plant. About 25% of the campus electricity is supplied by a 6 MW natural gas fired cogeneration unit that also makes steam from the waste flue energy. The balance is supplied from our local distribution company Toronto Hydro.

Fiscal Year	Total UofT GSM	Total Student	Total Hydro kWh	Hydro GHG eCO2 Tonnes	Total mmBTU	Thermal GHG eCO2 Tonnes	Total GHG eCO2 Tonnes	eCO2 kg/GSM	kWh/GSM	mmBTU/GSM
2014/15	1,365,881	58,286	230,040,499	16,103	1,039,646	88,182	104,285	76.4	168.4	0.76
2015/16	1,365,881	59,434	223,874,210	13,432	848,737	79,885	93,318	68.3	163.9	0.62
2016/17	1,419,589	61,339	223,711,210	8,948	860,265	80,501	89,450	63.0	157.6	0.61
2017/18	1,438,918	61,690	218,549,993	8,742	916,130	81,990	90,732	63.1	151.9	0.64

Table 3 Summary of energy and GHG indices for St. George Campus

About 230 GWh of electricity and 1 million mmBTU of natural gas was used in 2014/15. The energy required is dependent on a number of variables, such as weather, student/staff/faculty population, behaviour, on-going growth, special events, maintenance, and equipment down-time. We also supply energy to outside facilities like the Royal Ontario Museum, Gardiner Museum and Federated Colleges which we do not directly control but impact our energy and GHG indices.

The University of Toronto is a growing urban campus. From 2014 to 2018 the gross floor area increased by 7% due to new construction with a student population increase of 5% over the same period. The campus may grow 30 per cent in GSM by 2030, based on current projections.

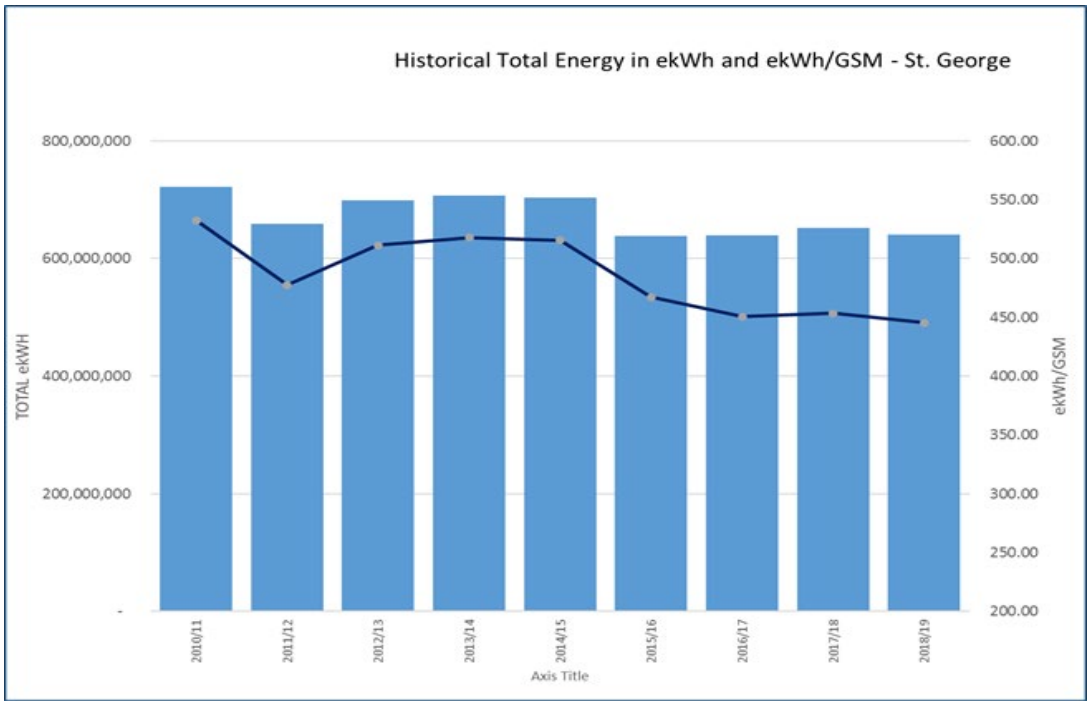


Chart 1 History of total energy use in ekWh and ekWh/GSM from 2010/11 to 2018/19

This chart illustrates the trend of equivalent energy use from 2010/11 until 2018/19 (sum of electricity and thermal energy as ekWh and ekWh/GSM).

The electrical and thermal energy conservation projects have resulted in cumulative savings about 117 GWh of electrical energy and about 213,623 mmBTU over 5 years.

With the utility savings comes reductions in GHGs as well - both scope 1 and scope 2. Thermal energy represents about 90% of the GHG loads (scope 1) with electricity at about 10% (scope 2). Thermal energy, predominantly supplied by burning natural gas creates the most GHG emissions and is relatively inexpensive compared to electricity which on the other hand is low carbon but much more expensive. Electricity however is about 8 times more expensive and 4 times cleaner than natural gas. Striking a balance of energy mix is important as we plan forward, increasing electricity use where possible and targeting conservation of natural gas for maximum GHG reductions.

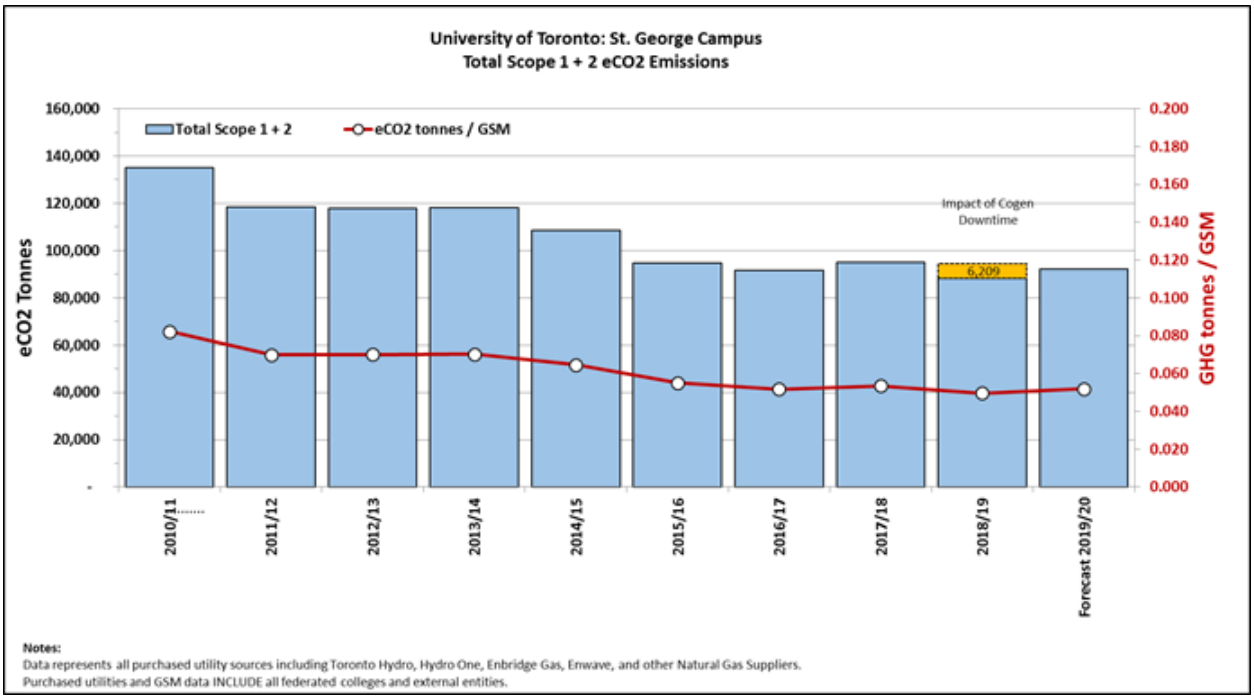


Chart 2 Summary of Scope 1 and Scope 2 GHG emissions at St. George for facilities under direct control

Exceeding the 2014 CDM Plan

The above information provides a backdrop for the results of energy and demand savings we have carried out since 2014. Our 2014 CDM estimated approximately 51.52 GWh of electrical savings due to energy conservation projects and high performance design measures.

The CDM presented in 2014 predicted energy savings on the order of 51,515,000 kWh/yr in 9 project categories. These were new buildings and large renovations with actual savings starting between 2014 and 2018. The following discussion illustrates that we in fact surpassed the reduction estimates described in the 2014 CDM Report.

Building/Project	Description	Project Cost	Completion Date	Reductions/yr			Saved to Date		
				Electricity, kWh/yr	Natural Gas, mmBTU/yr	GHG, tonnes eCO2/yr	Electricity, kWh	Natural Gas, mmBTU	GHG, tonnes eCO2
Robarts Library	VSD of fans and HVAC controls	$ 2,168,729	2015	4,704,951	26,500	202	20,147,160	51,930	2,305
OISE	New BAS	$ 1,198,923	2015	2,300,000	16,430	991	14,244,009	42,131	1,505
MSB	BAS upgrade	$ 1,500,000	2014	5,277,000	18,900	1,253	32,848,298	131,099	2,439
Various	LED retrofits	$ 4,974,013	2018	5,084,683	-	219	17,562,602	0	755
Earth Sciences	Occ based	$ 378,118	2018	380,000	1,344	89	380,000	4,500	89
Bissell	BAS	$ 943,678	2019	550,000	1,200	89	154000	350	72
BCIT	BAS	$ 1,076,072	2018	577,250	4,165	251	288,625	1,388	239
TOTAL		$ 12,239,533		18,873,884	68,539	3,094	85,624,694	231,398	7,404

Table 4 Summary of conservation projects completed from 2014 to (early) 2019.

The Table 4 above summarizes conservation projects completed between 2014 and 2018 and the resulting energy and GHG reductions per year. These projects total over 85 GWh/yr of electrical savings, 231,400 mmBTU/yr of thermal savings and a reduction of 7,400 tonnes eCO_2.

Active conservation measures reduce energy for the long term - they are removed and stay off our grid. Passive measures due to behavioural changes are not easily quantified but are a part of our conservation initiatives and strategy. Other savings can be attributed to non-measured reductions due to, weather, scheduling, events, and on-going system upgrades, small projects and deferred maintenance which are not recorded.

During this period we received assistance, both financially and technically, from the saveONEnergy program. Incentives were delivered through our local distribution companies (Toronto Hydro and Enbridge Gas) that were included in our business case models. The support, credibility, and technical resources provided by our LDCs were a valuable component in our developments.

Comparing 2014 Reported with Actual Results	
2014 - 2019	kWh
Reported	51,515,000
Actual	85,624,694
Exceeded	**34,109,694**

Table 5 Comparison of predicted savings in CDM 2014 with actual performance

On-Going and Proposed Measures: 5 Year Plan

Technical Measures

The University embarked on a plan to meet our 2030 goal of reducing the GHG levels to 37% below the levels in 1990 in absolute terms. The Low Carbon Action Plan (2019 - 2024) proposes a collection of conservation and efficiency programs to put us on the path to achieving this target. Table 6 below summarizes the activities being developed and pursued between 2019 and 2024.

Low-Carbon Action Plan : Future Planned Projects for St. George Campus (2019-2024)

Project	Description	Targeted GHG Reductions (Tonnes eCO2 /year)	Targeted ekWh / year
Greenhouse Gas Campus Retrofit Program (GGRP)	In 2018-19, leveraged provincial funds to implement and complete projects ranging from rooftop solar, building controls, and increased heat recovery capacity.	5,592	2,981,410
Geoexchange Systems	Using the heating/cooling properties of the earth via boreholes to heat buildings during the winter and cool them during the summer.	15,000	80,939,227
Renewable (Solar Electric and Hot Water)	New solar panels will be installed reducing the use of electricity from the grid and will also be used to heat water for pools and showers.	175	4,070,000
Distribution (Heat Recovery)	Capture of waste heat normally exhausted from the Central Plant's stack to heat various buildings.	2,000	10,791,897
Building Optimization	Improved building control systems, replacement of old equipment with high efficiency HVAC equipment, low temperature hot water heating, capturing and reusing heat within buildings.	6,000	27,049,202
High Performance Building Design Standards - new and retrofits	All new buildings and construction will be designed to be 40% better than ASHRAE standard 90.1.	8,325	*Potential Savings
Lighting	Replacement of interior and exterior lights with more efficent LEDs.	1,000	25,000,000
Trees - All U of T Canopy capture	Implementing an active forest management strategy ensuring the long term growth, maintenance and health of the university's canopy.	Tri-Campus	Tri-Campus
	Total Targeted Annual Savings for 2024	38,092	150,831,735

Table 6 Low Carbon Action Plan Summary of GHG and ekWh targets for St. George campus only.

Greenhouse Gas Campus Retrofits Program (GGRP):

The University of Toronto accomplished the first phase of major projects aimed at reducing current and future greenhouse gas emissions across all three campuses. Support was leveraged from the Provincial government and combined with U of T's investments, to complete projects ranging from rooftop solar systems to ground source heat pumps. Started in 2018, these 15 projects represent the foundation of the multi-year, low-carbon action plan. They are worth more than $34 million in investment with ~$2 million in annual energy cost savings and 5,592 tonnes/year in GHG emission reductions that began accumulating March 31, 2019. Meeting the tight deadline confirms U of T's capacity and ability to develop and implement high performing energy and carbon reduction projects with timely efficiency.

The Table 7 below lists the projects submitted and completed under the GGRP program. Performance is being evaluated internally and with a third party verifier. Note that some of these projects were combined into a single project costing package and therefore not broken out.

Building	Description	Electricity, kWh/yr	Thermal, mmBTU/yr	GHG, tonnes/yr	Project Costs, $	Savings, $/yr
MSB	High performance steam chiller & optimization	(54,263)	50,900	2,761	$ 11,241,000	$ 1,059,491
Central Steam Plant	Sofame Optimization & HX upgrade & cogen VSD compressors	653,496	30,200	1,870	$ 12,100,000	$ 433,804
Central Steam Plant	PRV Back pressure turbines	1,032,643		41	$ 2,458,000	$ 138,271
Warren Stevens	BAS upgrade	365,476	2,740	165	$ 4,145,000	$ 246,473
Clara Benson	BAS upgrade	380,200	2,903	172		
Sig Sam Library	BAS upgrade	363,200	2,588	155		
Warren Stevens	Solar PV & T	35,000	540	35	$ 1,109,000	$ 40,996
Clara Benson	Solar PV & T	35,000	540	35		
Varsity Arena	Solar PV & T	30,000	650	36		
Physical Geography	Envelope & HVAC upgrades	-	400	25	$ 300,000	$ 5,847
80 buildings	Metering & targeting program	140,658	4,300	296	$ 2,940,340	$ 111,844
TOTAL		2,981,410	95,761	5,591	$ 34,293,340	$ 2,036,726

Table 7 Summary of GGRP projects completed in March 2019, with projected energy and GHG reductions per year. Note that GHG emission factors are based on 2019 values. Note: MSB and the Central Steam Plant include multiple projects.

An on-site electricity generation project listed in Table 7 above, "PRV Back Pressure Turbines" is a novel way to convert pressure drops required in the central steam plant to electricity. Normally,

steam is delivered at high pressures then reduced before being utilized at the loads. These pressure reduction valves (PRV) present an opportunity to capture energy that is normally lost and turn it into electricity for use inside the building. Two such turbines were installed in the Central Steam Plant and predicted to generate approximately 900,000 kWh/year each. On-site generation benefits the building with a reduction in purchased electricity thereby reducing scope 2 GHGs. Opportunities for such on-site generation will be further investigated during the next 5 years.

Renewable Energy - Solar and On-Site Generation

U of T has renewable energy systems in operation for over a decade now with the Warren Stevens flat panel solar hot water system contributing to the domestic hot water loads since 2008. Existing renewable energy systems include photovoltaics and solar hot water. Table 8 below lists the systems in place now (~394 kWdc of photovoltaics plus ~552 ekW thermal)). The energy collected is used to offset electricity in the buildings (net metered or displacement electricity) in the case of photovoltaics and displace natural gas hot water in the case of solar hot water systems. The challenges for installing more solar systems is the state of the roofs. We may have a large roof area to seemingly select from but many are not structurally sufficient for the added weight of the arrays. Other normal design considerations like access to the loads, available area, and shading prevent the use of solar energy on many buildings.

Doubling Our Renewable Solar Energy

Plans are to more than double solar electricity capacity on campus, adding about 600 kW

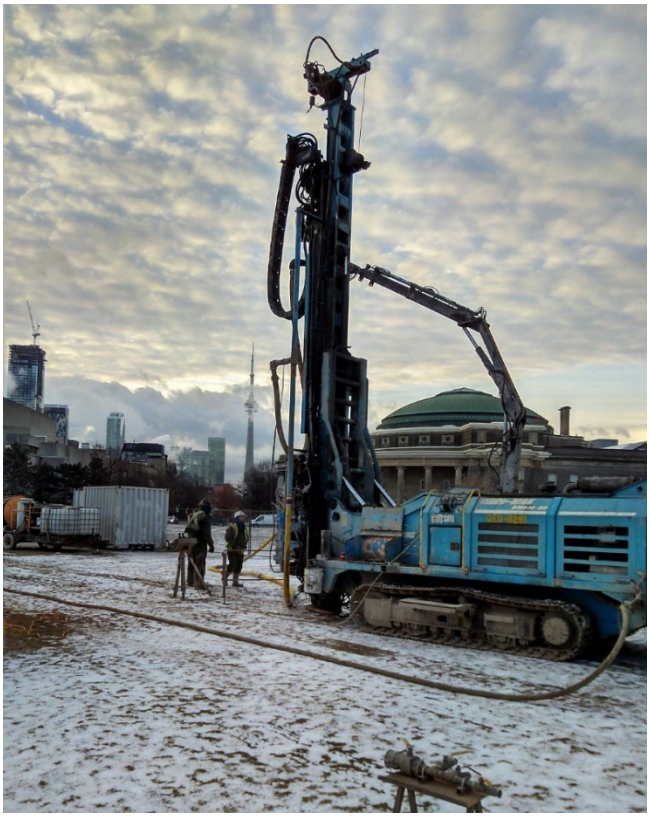
electric and 700 ekW thermal over the next 5 years. The necessary connection, structural, and performance assessments have begun.

- To maximize GHG savings, solar hot water opportunities will be evaluated to reduce natural gas used to make hot water. The best potential is typically found in residences and athletic facilities on campus
- We plan to double the use of solar hot water generation to reduce the use of natural gas heated water.

Target GHG Reductions: 175 tonnes eCO_2/year

Location	Generation Capacity, ekW	Annual ekWh	Utility Offset	Tonnes/ yr
Trinity College	57	68,291	Electricity	3
GRIT Lab	12	14,377	Electricity	1
255 McCaul	67	80,272	Electricity	3
Galbraith	2	2,396	Electricity	0.1
Lassonde Mining	24	27,600	Electricity	1
LED Lab	29.1	34,864	Electricity	1
Myhal Engineering	64	76,678	Electricity	3
Warren Stevens	60.1	72,005	Electricity	3
Warren Stevens	210	200,000	Natural gas	47
Warren Stevens	144	140,765	Natural gas	33
Clara Benson	60.1	72,005	Electricity	3
Clara Benson	144	140,765	Natural gas	33
Varsity Arena	19.1	22,883	Electricity	1
Varsity Arena	54	46,308	Natural gas	11
TOTAL @ 2019 ekW &ekWh	**946.4**	**999,210**		**144**
New photvoltaics @2024	605	695,750	Electricity	30
New hot water @ 2024	764	654,000	Natural gas	121
TOTAL @ 2024 ekW &ekWh	**2,315**	**2,348,960**		**295**

Table 8 Existing and proposed solar energy systems and annual performance at St. George Campus.



Geoexchange

For the St. George geoexchange project, over 500 boreholes at 600-feet deep will be drilled under Front Campus, creating the largest known Canadian ground source heat pump system in an urban setting. The low-carbon, electric powered heat pumps will be used to produce low temperature hot water heating for buildings around King's College Circle. These buildings are currently heated by high GHG content steam and will be upgraded to be able to use and fully realize the benefits of the geoexchange energy.
Target GHG Reductions: 15,000 tonnes eCO_2/year

District Energy System Efficiencies

The Central Plant on the St. George campus generates and distributes electricity and steam to many of the buildings on campus and off-campus including the Royal Ontario Museum and Gardiner Museum. The Central Plant uses natural gas to make steam and electricity (with a cogeneration turbine) which is a more efficient way to generate and distribute energy than placing boilers in every building or connecting all electrical loads directly to the grid. Plans are underway to reduce the use of natural gas through conservation, improved operations, and switching from steam to low-temperature water through geoexchange and increased capture of waste heat energy.
Target GHG Reductions: 2,000 tonnes eCO_2/year

Featured Project: Waste Heat Recovery

The exhaust heat recovery system at the Central Plant collects heat in the stack—what would be waste heat— and converts it to hot water for use in building heating. This captured waste heat is considered zero incremental carbon, as additional natural gas is not used to heat the water. Plans are to increase waste heat recovery by expanding the system to capture even more heat. Heating systems in currently steam-heated buildings will be retrofitted in order to make use of the captured heat.

Building Optimization

The St. George campus comprises 83% of U of T's carbon footprint and the existing building stock accounts for the bulk of current GHG levels. There is currently a large range in building GHG intensity, with a current average of about 69 kg eCO_2 /m^2. This average needs to be reduced to an intensity below 32 kg eCO_2/m^2/year to meet U of T's 2030 GHG reduction goal. The combination of increased building energy efficiency and renovations will enable the use of waste heat recovery and geoexchange energy, thereby reducing the use of higher GHG content steam energy.
Target GHG Reductions: 7,000 tonnes eCO_2/year.

Featured Project: Energy Recovery in Existing Buildings

Capturing and reusing exhaust air with the help of heat pumps is one way to optimize energy use in buildings. For example, a large data centre on campus generates thermal waste. We can capture the wasted heat and use heat pumps to create low-carbon hot water to heat and cool the building year round. We consider these systems "computational boilers". This renovation will offset about 1,000 tonnes of GHGs at one server centre and reduce the need for conventional heating supplies by 73%. We plan to look at other buildings where capturing otherwise wasted energy can help us lower energy use and GHG emissions.

Lighting

Quality lighting is an important influence on high performance work and learning and crucial for security on campus grounds. A significant number of interior and exterior lights will be replaced with far more efficient LEDs. These new lights, combined with state of the art controls, will save about 40% of the lighting electricity costs and last longer than traditional bulbs. Savings will be used to invest in projects with higher GHG reductions. Replacement of over 3,000 lights has been planned over the next 5 years.
Target GHG Reductions: 875 tonnes eCO_2/year

A New Approach to Driving Energy and GHG Reductions

The University is focused on reducing the energy and GHG levels, sustainably and for the long term. We have established a funding and project development model that uses in-house funds and expertise to bring about our goals. The Utilities Reduction Revolving Fund (URRF) and University Energy Services Company (U-ESCo) are programs based on successful models in the private sector tailored to our unique needs and available skills. The URRF is similar to a revolving fund in that we finance a project and "repay" the fund with agreed upon annual payments from the project brought about from the energy conservation measure(s). The U-ESCo is based on the ESCO model except that we use in-house engineers and energy managers to target, qualify and quantify deep energy savings opportunities then going out to consultants with projects already developed to a high level of understanding. The following sections describe these programs in more detail.

URRF

Then Utilities Reduction Revolving Fund (URRF) is a fund set up by the University to facilitate energy and GHG reduction projects through (effectively) a zero interest loan. The value of the fund is

currently at ~$8.5 million. The buildings on Campus are assessed for energy conservation potential using internal energy manager staff. When a site is considered a good candidate for savings, a project is further defined and evaluated. Once this is complete a formal project introduction is arranged with the building owner (typically the faculty chief financial officer) who is informed of the opportunity and the URRF financing model. The model provides the financing and technical expertise to implement the savings project with the funds paid back to the URRF through the agreed upon annual savings. The URRF requires that the project be paid back within 10 years. The following Table 9 shows the projects being assessed to be installed in 2019/20. As with previous projects, each one is subject to business case approvals and are now in the process of being costed.

URRF project development is an on-going process and we expect to have a list of projects to follow these in Table 9 by the Fall, 2019. The following U-ESCo section describes a means to take advantage of the URRF model and drive deep energy savings that will focus more on scope 1 reduction opportunities to help us reach our 2030 targets.

Building	Technology	kW saved	kWh/yr saved	Est $ saved/yr	*Est Costs $	GHG tonnes/yr	Payback, yrs
McLennan	LED	152	616,000	$ 88,000	$ 500,000	26	5.8
Sandford Fleming	LED	82	280,000	$ 39,200	$ 250,000	12	6.4
Sidney Smith	LED	167	692,000	$ 98,857	$ 240,000	30	2.5
CCBR	LED	87	600,000	$ 85,714	$ 220,000	26	2.6
MSB	LED	154	690,840	$ 93,623	$ 382,200	30	4.1
Ramsay Wright	LED	96	420,000	$ 60,000	$ 450,000	18	7.5
Galbraith	LED	84	367,920	$ 52,560	$ 340,000	16	6.5
Grad House	LED	62	276,000	$ 41,350	$ 171,217	12	4.1
30 Charles St	DCW Booster	15	137,234	$ 19,605	$ 67,424	6	3.4
35 Charles St	DCW Booster	11	93,467	$ 14,020	$ 59,076	4	4.2
89 Chestnut St	DCW Booster	11	202,199	$ 30,330	$ 92,360	9	3.0
McLennan Physics	Heat Pump	0	(164,757)	$167,154	$1,200,000	730	7.2
Total		**0**	**4,210,904**	**$ 790,413**	**$ 3,972,277**	**919**	**5.0**

Table 9 Summary of proposed URRF energy conservation projects for installation in 2019. *Note: These are high level cost estimates as the business cases including total project costing are being prepared. For “ball park” payback evaluation and prioritization only.

U-ESCo

Under the direction of the Chief Operating Officer, Facilities & Services, St. George campus, is assembling an internal U of T Energy Services Company (U-ESCo) team to develop deep-dive energy conservation projects. Team members will consist of energy managers, utility staff, building operators and building engineers to collaboratively define and assess significant energy and GHG reduction programs for existing buildings which account for the bulk of our current GHG emissions. The projects will be financed from our utility reduction revolving fund (URRF)—now worth $8.5 million.

The URRF discussed above uses a model based on an energy services company to develop and finance energy savings. Facilities & Services management realized that the expertise to develop energy conservation measures is resident with the staff. With this understanding, a team made up of

energy managers, utility managers, operations managers, and directors was assembled to pursue deep energy conservation project development internally versus going to outside consultants. The team has reviewed a collection of top energy users on campus and will select projects based on the best impact on energy and GHG levels. The Table 10 below illustrates the list of buildings being reviewed and the current energy indices.

The intention of this program is to develop projects that will reduce the energy performance indices to "at or below" benchmarks for the building archetype. We are planning to develop and implement significant energy and GHG reduction projects in one to two buildings each year for the next 5 years. Preliminary evaluation indicates total energy savings (in terms of ekWh/m_2) on the order of 25 - 35% are realistic (blended electrical and thermal energy). With this level of savings we anticipate approximately 22 GWh of electricity and 18 eGWh of thermal energy saved per year (on completion of all projects shown in Table 10). At 2019 emissions factors this will reduce our GHGs by ~4,300 tonnes/year (3,800 of which are scope 1 GHGs). These sites are being evaluated and developed by our internal U-ESCo team to develop business cases for approval and implementation. These projects and the estimated savings at ~66%, put us on track to achieve our 2024 low carbon plan of 6,000 tonnes/yr heading toward 2030 due to building optimization. Conservation measures being considered include BAS improvements, heat recovery, air sealing, envelope improvements, demand based scheduling, retro commissioning, and improved sequences of operation. This is an example - we are reviewing a number of sites and opportunities in the top energy use indices buildings.

Building	U-ESCo Potential Savings/yr			
	Electricity, kWh/yr	Thermal, mmBTU/yr	Total, tonnes/yr	Total ekWh/yr
Robarts Library	3,108,896	7,361	524	5,266,184
Medical Sciences	5,457,840	15,991	1,087	10,144,322
Bahen C.I.T.	311,851	5,650	431	1,967,697
O I S E	1,397,738	4,192	284	2,626,287
Earth Sciences	2,902,750	4,588	365	4,247,355
Lash Miller Labs.	2,825,000	7,790	536	5,108,015
Fac Mgmnt Studies	1,228,412	3,370	232	2,216,058
Wallberg	2,025,000	4,678	334	3,395,981
CCBR	2,650,000	7,772	528	4,927,740
	21,907,487	61,392	4,321	39,899,640

Table 10 Initial list of potential deep dive energy conservation U-ESCo project sites.

These, and other high energy use index projects are being assessed for development. Once the business cases have been made they will be prioritized and turned into projects. The sites in Table 10 above constitute about 30% of the GSM and over 40% of the total ekWh on the Campus.

Organizational Measures: Policy, Procurement, & Design Standards

U of T is large and growing. St. George campus has a large portfolio of existing buildings, many of which are heritage, that require significant retrofits to reduce energy use and GHG footprints. We

also have many new buildings and major renovations planned over the next ten years. We will need to reduce our energy consumption in existing buildings and enforce our high-performance design standards in all buildings to ensure we meet our low-carbon goal. Through engagement programs, we will continue to interact with occupants to monitor and analyze operations and to safeguard conduct is in alignment with U of T's carbon reduction goals.

Design Standards for new buildings and major renovations

All new buildings and major renovations will be designed to high standards that define superior performance for energy intensity, sustainability, resilience and comfort. In Spring 2019, new design standards were established that architects and builders must follow to ensure low energy and GHG metrics. All new buildings and large renovations will have energy indices +40 per cent higher than the industry-respected American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard 90.1. Our standards will incrementally increase in performance over the next five years and beyond, targeting very low GHG and energy indices, skills, technologies, designs and construction capabilities improve. We expect these advanced energy and GHG performance standards to account for close to 9,000 tonnes of avoided eCO_2/year by 2025 through significant building energy use reductions compared to industry standards. .

Environmental Standards and Procurement

The Sustainability Office is in the process of revising environmental standards and developing a Sustainable Procurement guideline policy with staff, vendors and faculty in order to ensure energy efficiency in new equipment (e.g., appliances, generators etc.) which, where possible, are furnished with smart features that will display, track and measure use and performance.

Living Labs & Experiential Learning Programs

Students and faculty apply skills in teaching and research to real-world operational settings, through coursework, collaborations with research teams, programs like the Campus as a Living Lab and Work Study. These opportunities facilitate the development of hands-on-skills, crucial for the creation of the next generation of leaders and problem solvers tackling climate change. The Operations team has the privilege of leveraging U of T's talent to adopt innovative, carbon capture and reduction technologies as well as to collect, measure and analyze results. We will encourage and facilitate the integration of students and faculty within Operations in developing tomorrow's solutions.

For example, research-intensive universities have many laboratory fume hoods that exhaust large amounts of energy as conditioned air. With more than 1,200 fume hoods in labs across our campuses, U of T is no exception. We have the opportunity to improve fume hood use to save energy, improve safety and reduce GHGs. In collaboration with the Environmental Health & Safety department, we have developed a unique way to test and certify fume hood operation resulting in energy savings, and therefore GHG reductions, while maintaining a high level of safety. This collaboration will be continued and safe energy savings at fume hoods pursued across campus.

Behavioural Measures

The Sustainability Office will develop and implement a building occupant engagement program aimed at staff, students, and faculty. The program will aim to:

1. Increase awareness about building features, environmental standards and efforts by the university to help build an identity and culture around energy conservation on campus;
2. Educate about conservation actions and habits at the user level, such as turning off the lights, shutting the stash, and avoiding phantom power;
3. Develop occupant guidelines and metrics in consultation with staff, students and faculty;
4. Further identify and empower champions and
5. Solicit energy saving ideas.

The Sustainability Office will work with Residence Life Coordinators and other groups on campus, like the Green Chemistry Initiative to help disseminate information and scale targeted programming. The Energy Conservation and Demand Management plan will be shared with divisional representatives to allow an open and transparent approach and to ensure inclusivity in the planning and application of energy conservation projects.

Measurement & Verification

Measurement and Verification (M&V) teams will be expanded to track costs and energy savings. Teams will include energy managers, utility analysts, and internal finance. Planning, design and construction project managers and architects will also be involved in evaluating building performance against models. M&V procedures follow the recognized International Performance Measurement and Verification Protocols. All energy performance improvement designs include a M&V plan with sub-meters specified where needed to ensure a detailed M&V report can be prepared. The chart below illustrates expected reductions to GHG emissions across all three campuses.

University of Toronto Low-Carbon Action Plan, Tri-Campus

(2019-2024)