1.0 EXECUTIVE SUMMARY

1.1 OVERVIEW

This document has been prepared for Dalhousie University as a Campus Energy Master Plan. This Campus Energy Master Plan document is the culmination of a comprehensive analysis of the current and future use and production of energy and water on campus. The purpose of this document is to guide Dalhousie's future energy development. This will be achieved by examining the costs and strategies required for the university to grow at forecast rates, while simultaneously improving energy security and striving to achieve short-term and long-term reductions to the university's utility costs and carbon footprint.

1.2 PROJECT GOALS

The Campus Energy Mater Plan goals reflect the short and long term opportunities for Dalhousie to improve health, environmental, and economic conditions.

Key goals of the plan include increasing energy efficiency, conservation, and energy security while reducing carbon and air quality emissions and costs. The following areas have been examined in detail:

- Existing and future plans;
- Energy security issues;
- Utility monitoring;
- Central energy distribution systems;
- Renewable energy systems;
- Sustainable facilities planning; and
- Energy efficiency retrofits.

This Energy Master Plan outlines strategies and measures in each of these areas, along with a decision and implementation matrix to assist the university with prioritization and budgeting. It also describes the design and implementation necessary for each strategy to succeed. As part of the Campus Energy Master Plan, the buildings on campus have been audited for energy and water savings opportunities. A series of recommended measures for each building has been developed.

This plan has been developed with the best intentions towards capitalization of available resources. Every effort has been made to minimize costs while striving to achieve the University's ambitious carbon footprint goals and growth plans.

1.3 BUILDING SUMMARY

The scope of this document covers buildings on all three campuses of Dalhousie University: Studley Campus, Carleton Campus, and Sexton Campus. The scope also includes two off-campus buildings. Please refer to **Appendix I** for the complete Building List. Following is a breakdown of the buildings at each campus:

Dalhousie University Campus	No. of Buildings	Area (sq. ft.)	Area (sq. m.)
Studley Campus Buildings	67	3,064,563	284,710
Carleton Campus Buildings	8	902,004	83,799
Sexton Campus Buildings	31	559,270	51,959
Off-Campus Buildings	2	159,457	14,814
Total:	***108***	***4,685,294***	***435,282***

1.4 EXECUTIVE PROGRAM SUMMARY

Program Summary

Opportunities available to the University were reviewed and the expected savings and costs calculated. ***Table 1.2 Program Summary*** summarizes the costs and savings for the Opportunity Program developed for the buildings on campus.

Table 1.2: Program Summary

Program	Utility Cost Savings [$]	Total Measure Cost [1] [$]	GHG Emissions Reductions [tonnes eCO2]	Simple Payback [Yrs]	Net Present Value [2] [$m]	Internal Rate of Return [%]
1. Short-Term Measures [3]	$2,457,000	$14,876,000	16,555	6.0	$35,188,000	17.1%
2. Long-Term Measures [4]	$917,000	$42,176,000	5,909	46.0	-$27,042,000	-0.6%
3. RECAPP Measures – Capital Renewal [5]	$482,000	$38,254,000	3,025	79.4	-$31,844,000	-3.4%
4. Renewable Energy Measures [6]	$158,000	$16,400,000	1,269	104.0	-$14,671,000	-4.7%
5a. Trigeneration Measure [7] *5b. Chiller Addition* [7] ***5. Total Central Plant Systems*** [7]	*$2,623,000* *$ 0* ***$2,623,000***	*$24,303,000* *$ 8,787,000* ***$33,090,000***	*Up to* ***30,576***	*9.3* - ***12.6***	$28,143,000 - **$18,520,000**	*11.5%* - ***1.3%***
6. Total	**$7,397,000**	**$123,769,000**	**60,049**	**16.7**	**$18,870,000**	**6.0%**

Notes: See following page.

Notes to Table 1.2 Program Summary:

1. *Total Costs include soft costs for engineering and project management. Most measures have 20% soft costs. Tri-generation and Chiller Program have 20% soft costs included. RECAPP Program does not include soft costs.*

2. *Net Present Value (NPV) and Internal Rate of Return (IRR) use a 30-year timeframe with a 5% discount rate and 3% annual utility escalation. Inflation is not included.*

3. *Short-Term Measures have a Simple Payback less than or equal to 15 years.*

4. *Long-Term Measures have a Simple Payback greater than 15 years. The category includes Dalplex Renewable Energy / Roof Replacement measures)*

5. *RECAPP Measures are recapitalization measures from Dalhousie University's facility condition assessment reports.*

6. *Renewable Energy Measures are for all reasonable opportunities identified. The category does not include Dalplex Renewable Energy / Roof Replacement measure.*

7. *Tri-generation and Chiller Addition comprise the Central Plant Systems. The GHG emissions reduction range from 6,000 to 31,000, depending on the option selected.*

The amounts in the Program Summary Table 1.2 do not include incentives or other sources of funding grants. These amounts would need to be factored into any more detailed financial analysis of selected programs.

1.5 UTILITIES SUMMARY

Table 1.3 compares the actual energy use and cost of the Dalhousie University buildings included in this this study within the Program portfolio from 2008/2009 (Year 1) to 2010/2011 (Year 3). Please note that the natural gas and oil use serviced to the Central Plant has been dropped to instead account for the steam use at the building level. The central plant was converted to natural gas in 2010.

The actual utility energy use overall has decreased (**4.0%**) while utility costs decreased by only (**0.1%**) over the last three Fiscal Years to March 2011.

At the same time, 263,000 sq.ft. of new facilities has been added to the building portfolio with the Mona Campbell Building and the LSRI facility, representing an increase of **5.6%** in conditioned space.

Table 1.3 Utility Use and Cost Changes FY 08/09 to 10/11 vs. Energy Balance

	Units	Year 1[1]	Year 3[1]	Energy Balance	Change	% Change	EMP Baseline[2]
Electricity Use	kWhs	78,280,238	75,600,226	68,632,945	-2,680,013	-3.4%	78,280,238
Electricity Demand	kWs	148,099	145,940	147,619	-2,159	-1.5%	148,099
Electricity Cost	$	$7,085,293	$7,177,457	$6,307,129	$92,165	1.3%	$7,085,293
Chilled Water Use	Ton hrs			1,864,578			
Chilled Water Cost	$			$339,351			
Gas Use	m^3	7,145	5,006	5,246	-2,139	-29.9%	7,145
Gas Cost	$	$95,461	$67,379	$63,755	($28,082)	-29.4%	$95,461
Fuel Use	L	183,947	202,365	179,811	18,418	10.0%	183,947
Fuel Cost	$	$116,574	$138,698	$135,084	$22,123	19.0%	$116,574
Steam Use	klbs	376,539	360,786	344,722	-15,753	-4.2%	376,539
Steam Cost	$	$4,089,209	$3,918,136	$3,743,683	($171,073)	-4.2%	$4,089,209
Water Use	m^3	978,033	1,002,433	969,665	24,400	2.5%	978,033
Water Cost	$	$1,609,036	$1,672,608	$1,605,380	$63,572	4.0%	$1,609,036
Total Use	ekWh	189,091,312	181,514,940	176,604,354	-7,576,372	**-4.0%**	189,091,312
Total Cost	$	$12,995,574	$12,978,272	$12,194,382	($17,302)	**-0.1%**	$12,995,574

NOTES:

1. Costs presented above are actual costs unadjusted for EMP Savings Rates and include:
   - all applicable taxes, monthly services charges and levies which the Program can't achieve any savings.
2. Costs presented above are adjusted costs calculated based on the EMP Savings Rates and do not include those same charges noted above for which the Program can't achieve any savings from.

1.6 CAMPUS – EXISTING AND FUTURE

Campus Energy Systems

The major buildings at Dalhousie University are generally heated from two 85,000 PPH 1971 central steam boilers with a capacity of 170,000 PPH at the Central Services Building. The current peak load for 2010-2011 heating season was determined to be 162,990 PPH.

The major buildings at the Carleton Campus and the Studley Campus are currently cooled with a combination of a central cooling system, and localized building cooling systems. The central cooling system consists of a 1,000 ton 1988 electric centrifugal chiller and a 1,660 ton 2000 absorption chiller at the Central Services Building. The peak centralized cooling capacity is approaching the limit and is approximately 2,400 tons. The buildings at Sexton Campus are locally cooled.

The primary electrical service to the Carleton Campus and Studley Campus consists of a main incoming 25kV service to the Weldon Law Building with a 25kV to 23kV transformer. There are other building specific electrical services. The distribution is a combination of 23kV and 4160V services. Sexton Campus has a combination of three services at 4160V and other smaller electrical services.

Campus Growth and Load Reductions

The Campus Master Plan indicates there is the potential for the campus building portfolio to grow by 3,100,000 sq.ft. from the current level of 4,600,000 sq.ft. over the long-term future of the study period in the Campus Master Plan. The following is a summary of the peak load reduction potential on the centralized systems for the existing buildings for all measures considered.

Table 1.4 Peak Load Reduction Potential – Existing Buildings

System	Peak Load Reduction Potential
Steam	19,154 PPH
Chilled Water	112 tons
Electric	1499 kW

The following is a summary of the peak loads and timeframe for construction for future new buildings.

Table 1.5 – Projected Peak Loads and Timeframe for Future New Buildings

Timeframe	Total New Area Cumulative [ft2]	Steam Load Cumulative [PPH]	Chilled Water Load Cumulative [tons]	Electric Load Cumulative [kW]
0 to 5 years	613,872	17,300	700	1,100
5 to 10 years	1,373,214	43,900	1,700	2,900
10+ years	3,210,849	99,800	3,900	7,100

Combining the loads for planned new buildings with the possible steam load reduction projects, the projected peak steam loads can be reviewed with the timeframe. The new buildings planned over the next five years would push the steam load to 180,290 PPH which is beyond the current heating capacity. However by implementing the steam peak load reduction projects at the same time identified would reduce the steam peak load to 166,739 PPH, which is lower than the capacity. So, although the current steam capacity situation is critical as there is no redundancy, the steam load can be managed to control the steam peak below the steam capacity for the immediate near-term.

Table 1.6 – Projected Peak Steam Loads and Timeframe

Timeframe	Current Steam Load, 2011 [PPH]	Total New Steam Load for New Buildings Cumulative [PPH]	Total Steam Load with New Buildings [PPH]	Steam Load Reduction Potential Cumulative[1] [PPH]	Total Steam Load [PPH]
0 to 5 years	162,990	17,300	**180,290**	-13,551	**166,739**
5 to 10 years	162,990	43,900	**206,890**	-19,154	**187,736**
10+ years	162,990	99,800	**262,790**	-19,154	**243,636**

The next development period between 5 years and 10 years would push the steam load (187,736 PPH) beyond the current capacity, and steps to address the shortfall are required by this period of time.

1.7 CENTRAL ENERGY DISTRIBUTION SYSTEMS

Objective

An analysis was developed to address the need for the identified utility system upgrades in a manner which provides the most economical and reliable solution incorporating additional infrastructure needs for potential future loads. Specifically the steam, chilled water, and electric utility systems are addressed to ensure adequate and economically optimal generation and distribution capacities.

Analysis

The installed boiler capacity at the Central Services Building is currently 170,000 pph. In general, the firm capacity of a steam system is typically maintained at a level greater than the peak boiler load to ensure reliable steam supply. For heating, the system firm capacity is 85,000 PPH, which represents the output of the system with the loss of the largest single unit, which for Dalhousie University is either one of the boilers (85,000 PPH each). With a current peak boiler load of 162,000 pph, the existing plant does not have adequate firm capacity to support the peak steam demand of the campus. The existing boilers are currently 40 years old (1971), are well-maintained, however have an expected remaining life of less than 10 years. Because of this, there is a need for the replacement of the existing boilers in addition to the need for additional capacity.

The steam distribution has adequate capacity to support the existing peak steam load.

Several alternative options were evaluated based upon developing cogeneration for the site. The cogeneration systems evaluated in this study are considered ‘electrically-rich’ where electric power is generated and the exhaust heat is utilized to supply the campus heating and/or cooling loads. The efficiency of this process is between 70% and 80%.

Two types of electric generation equipment were evaluated which included combustion turbine and engine generators sets. A natural gas-fired combustion turbine utilizes the expansion of heated air to drive a turbine coupled to a generator, thereby producing electric power. The high temperature exhaust gas is circulated through a heat recovery steam generator (HRSG) to produce steam to supplement the boiler system. An additional duct burner can be added to increase the total steam generation capacity of the HRSG. To optimize a combustion turbine system the total waste heat generated by the turbine should be fully utilized.

The larger combustion turbines result in lower life cycle cost than the base option. The preliminary recommendation includes a 7,300 kW combustion turbine with a 70,000 PPH boiler and HRSG, producing a 34,200 PPH unfired and 68,400 PPH fired. The optimal capacity of cogeneration facility also requires a review of utility rates to maintain Dalhousie University at the preferred rates of an industrial user.

The existing steam distribution system was reviewed to determine available capacity to support the future load growth. Based upon the results of the hydraulic model, the velocity within the existing 12-inch piping is above 12,000 fpm from the Central Service Building to the main east-west split near the Arts Centre. This pipe section would need to upgraded in order to accommodate the future planned load, either by replacement or by adding a new twinned pipe.

The projected peak cooling load at the end of the 20-year planning period is estimated to be approximately 5,360 tons. This is based upon the peak load of the existing campus cooling load plus the subsequent increased resulting from the future projects. This load estimate assumes that the future building projects located in the Sexton Campus will not be connected to the Central Services Building chilled water system.

The installed chiller capacity at the Central Services Building is currently 2,660 tons. For cooling, the system firm capacity is approximately 1,000 tons, which represents the output of the system with the loss of the largest single unit, which for Dalhousie University is Chiller No. 1 (1,660 tons). In general, the firm capacity of a chilled water system is typically maintained at a level greater than the peak cooling load to ensure reliable chilled water supply. The peak cooling load for the campus is approximately 2,400 tons. Therefore, the existing plant does not have adequate firm capacity to support the peak cooling load. Chiller Nos. 1 and 2 are currently 11 and 23 years old, respectively. The chilled water distribution piping is sized adequately to support the peak cooling load.

The American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) has identified a typical service life for electric centrifugal and absorption chillers to be approximately 25 years. These standard service lives can be extended with excellent maintenance. Despite this, based upon the age of the existing chillers at the Central Services Building, a major replacement interval of the existing chillers will occur during the planning period. Because of this, there is a need for the replacement of these chillers in addition to the need for additional capacity.

An analysis was performed to determine whether the future building cooling loads should be connected to the existing centralized cooling system versus individual building cooling. Capital costs as well as electric energy and maintenance costs were included in the analysis and the recommended option is to connect the future building cooling loads to the Central Service Building.

Currently, steam is served to the Sexton portion of the Dalhousie Campus via a direct-buried piping system. It is reported by Dalhousie University personnel the Sexton Campus does not return steam condensate back to the boiler plant. Because of this, an analysis was performed to determine the best option to reliably serve the heating load for the Sexton Campus. Based upon the analysis, it is recommended to serve the Sexton heating load via a new hot water plant.

The Studley and Carleton campuses electrical system were in good to excellent condition. The Sexton campus appears to not have received the same level of maintenance that the other two campuses have received.

1.8 PHASING AND IMPLEMENTATION

The following key issues are the priorities addressed as part of the Campus Energy Master Plan.

Immediate and Short-term Requirements

- Reduce building heating peak demand loads
- Upgrade and expand campus central heating systems to support new development

Medium-Term Requirements

- Energy conservation measures
- Capital renewal / deferred maintenance measures
- Energy security measures

Decision-Making Analysis

A Decision Matrix was developed to determine the relative ranking of need, importance, sequence an opportunity. Issues related to life safety and risk to business were determined to be high priority items. The relative importance for measures of net present value, greenhouse gas emissions reduction, impact on central plant capacity, impact on energy security and impact on facility condition through capital renewal were reviewed.

A sample of the results of the Decision-Making Matrix is shown in ***Table 1.71 Decision-Making Matrix Results – Top 50 Ranked Projects.***

The range of projects that have been identified as high-priority based on these criteria include:

- Trigeneration Central Plant – High impact on GHGs, high NPV, risk to business related to capacity
- Enhanced Campus Utilization – Programming changes to make effective use of space, high NPV
- Recommissioning – Investing in operations to have systems at optimal efficiency, high NPV
- Chiller and Chilled Water Systems for Central Plant – Required for capacity of system
- Dalplex Fieldhouse Roof Replacement – Replace roof and add solar heating, impact on energy security, asset renewal, GHG reduction, heating system capacity
- Training and Energy Awareness – High impact programs and high NPV
- Ventilation Fume Hoods and VAV conversions – High NPV projects
- Dentistry Heat Pumps and Lighting – Asset renewal
- Lighting Retrofits – High NPV projects
- Heat Recovery Projects – High impact on heating system capacity
- Solar Air and Solar Water Heating Systems – Impact on energy security, GHGs

Table 1.7 Decision-Making Matrix Results – Top 50 Ranked Projects – Summary

	BUILDING / MEASURE				CRITERIA
Ref.	Building Code	Building Name	Measure Tag	Measure Description	Total Weighting
1	E280	Central Services	B01-1g	Trigeneration - Combustion Turbine - 7330 kW	6,432
2	Z999	General Measures	M07	Enhanced Campus Utilization	847
3	Z999	General Measures	M01	Recommissioning	751
4	E280	Central Services	C02	Chilled Water - Variable Flow Pumping Application	547
5	E280	Central Services	C05	Chiller Replacements or Additions	460
6	B100	Dalplex	K01	Dalplex Fieldhouse Roof Replacement	399
7	Z999	General Measures	M02	Operator Training Allowance	375
8	Z999	General Measures	M03	Energy Awareness Allowance	375
9	C580	Killam Library	E02	Ventilation System - VAV Conversion	290
10	J150	A. Macdonald - D Bldg	E11	Ventilation System - Variable Flow Lab Hood	236
11	F100	Dentistry	E04	Heat Pump Replacement	235
12	J051	B Building	E07	Ventilation Renewal	207
13	C381	Chemistry	E11	Ventilation System - Variable Flow Lab Hood	202
14	F200	Tupper Building	A01	Lighting Retrofit & Redesign	193
15	F200	Tupper Building	E02	Ventilation System - VAV Conversion	184
16	C220	Shirreff Hall	A01	Lighting Retrofit & Redesign	166
17	C381	Chemistry	E05	Heat Recovery Upgrades	163
18	C382	Chemistry Podium	E05	Heat Recovery Upgrades	155
19	D400	Arts Centre	A01	Lighting Retrofit & Redesign	154
20	C220	Shirreff Hall	E05	Heat Recovery Upgrades	154
21	F100	Dentistry	A01	Lighting Retrofit & Redesign	151
22	B100	Dalplex	A01	Lighting Retrofit & Redesign	147
23	D620	Weldon Law	A01	Lighting Retrofit & Redesign	146
24	B100	Dalplex	E05	Heat Recovery Upgrades	144
25	F200	Tupper Building	E05	Heat Recovery Upgrades	143
26	C381	Chemistry	E05	Heat Recovery Upgrades	143
27	F200	Tupper Building	E02	Ventilation System - VAV Conversion	143
28	C520	Howe Hall	E05	Heat Recovery Upgrades	140
29	C381	Chemistry	A01	Lighting Retrofit & Redesign	140
30	F100	Dentistry	E05	Heat Recovery Upgrades	136
31	G200	P. Green Hall	I02	Solar Air Heating	133
32	J910	Gerard Hall	A01	Lighting Retrofit & Redesign	131
33	E280	Central Services	I02	Solar Air Heating	131
34	C280	Chase Building	I02	Solar Air Heating	130
35	B100	Dalplex	I02	Solar Air Heating	128
36	C580	Killam Library	I02	Solar Air Heating	127
37	C260	Dunn Building	A01	Lighting Retrofit & Redesign	127
38	C382	Chemistry Podium	E05	Heat Recovery Upgrades	126
39	F120	Burbidge	I02	Solar Air Heating	126
40	D420	McCain Arts&SS	I01	Solar Domestic Water Heating	126
41	C580	Killam Library	A01	Lighting Retrofit & Redesign	126
42	J011	Ira Macnab - A Building	I01	Solar Domestic Water Heating	126
43	C580	Killam Library	I01	Solar Domestic Water Heating	126
44	C520	Howe Hall	I02	Solar Air Heating	125
45	C540	Studley House	I01	Solar Domestic Water Heating	125
46	E280	Central Services	A01	Lighting Retrofit & Redesign	123
47	C260	Dunn Building	I02	Solar Air Heating	123
48	C300	Henry Hicks Academic	A01	Lighting Retrofit & Redesign	121
49	E100	Student Union Building	A01	Lighting Retrofit & Redesign	121
50	E190	Risley Hall	A01	Lighting Retrofit & Redesign	121

Decision-Making Analysis Discussion

Various factors were involved in the decision-making process. The results of the table above are highly sensitive to the parameters applied, and other considerations may favour one measure or project over another. Some of the high priority projects identified are discussed below.

The firm heating capacity of Dalhousie University's central heating plant, when one steam boiler is not available, is lower than the peak heating load of the connected buildings. Efforts to provide new capacity and reduce existing peak heating loads on the central heating are of primary near-term importance. These efforts include planning and implementation for a new trigeneration plant, and implementation of heat recovery projects in particular. At the time of planning and implementation of the trigeneration system, a new chiller in the central cooling plant would be included to provide firm capacity and potentially take advantage of the steam from the trigeneration system.

Several initiatives have the potential to provide high net present value and returns, including: recommissioning, enhanced campus building utilization, training, and energy awareness. Each of these initiatives has their associated challenges, but also significant financial benefits, and undertaking these initiatives engages a variety of important stakeholders in the energy planning process.

Renewable energy is a hedge against potentially volatile fuel costs. The capital costs can be reduced through incentives, power-purchase agreements, or partnering with organizations that provide lease-back arrangements for example. Other partnering opportunities exist to utilize programs such as the Nova Scotia COMFIT (Community Feed-in Tariff) Program, where the renewable energy system does not necessarily have to be on Dalhousie University property. So while renewable energy measures are a relatively high priority, the additional funding can make these measures financially attractive.

The Dalplex Fieldhouse Roof Replacement is a measure that has opportunity to renew building infrastructure while at the same time greatly reducing central heating plant load, and providing space for a solar heating system. Often there are structural obstacles to installing solar heating on existing buildings, and if a new roof were designed for the existing Dalplex Fieldhouse, the structural requirements for solar heating could be incorporated relatively easily. This measure has impacts on energy security, asset renewal, GHG reduction, and heating system capacity.

Other energy saving and peak-load demand saving measures that are attractive include ventilation system conversions to variable air volume (VAV), conversion of laboratory spaces to VAV, lighting system upgrades and retrofits.

The University also has a need to maintain the facilities and infrastructure in good condition, and many items are identified as recapitalization (RECAPP) measures that have the additional result of reduced energy. An example of this includes replacement of the Dentistry heat pumps and lighting systems, a measure that is identified as a higher priority item.

1.9 ACHIEVING GREENHOUSE GAS EMISSIONS REDUCTION

Greenhouse Gas Emissions Reduction Targets

The greenhouse gas (GHG) emissions for Dalhousie University using a baseline of 2008-2009 are 115,000 tonnes of eCO2. The net heating and electricity account for 95,800 of this amount.

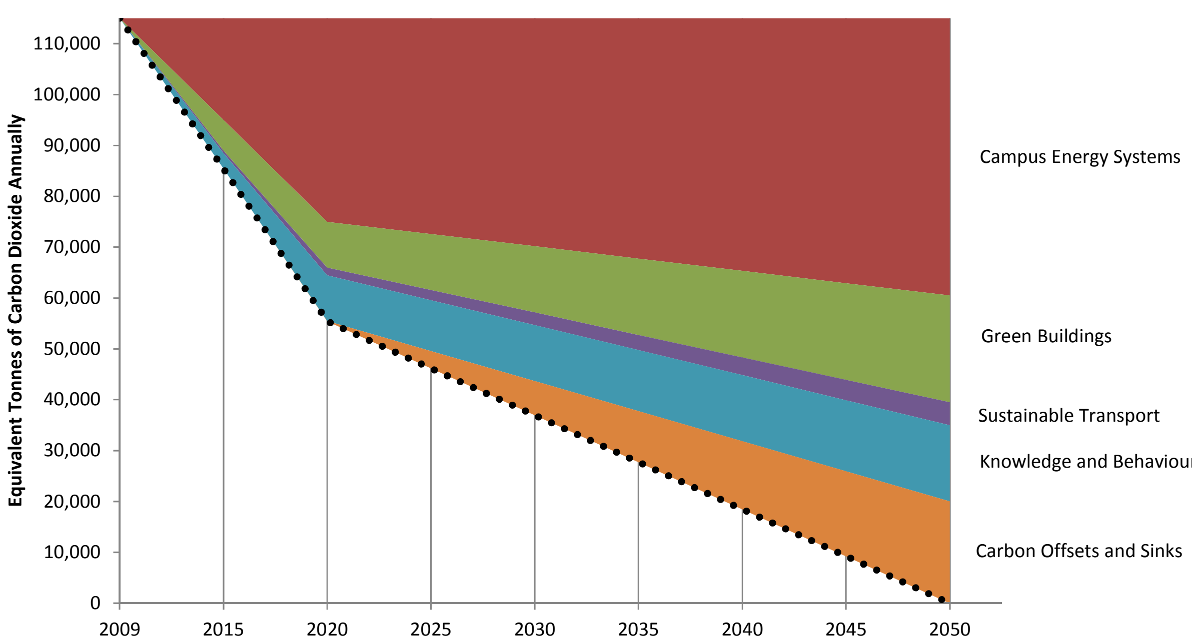
The Dalhousie University Climate Change Action Plan, 2010, has developed a plan to reduce GHG emissions in five key strategic areas with the goal of carbon neutrality in 2050 with key intermediate milestones in 2015 and 2020. The GHG emissions reductions are shown ***in Table 1.8*** and ***Figure 1.1 GHG Emissions Reduction Targets.***

Table 1.8 GHG Emissions Reduction Targets

Climate Change Strategies	2015	2020	2050	Total
Campus Energy Systems	20,000	20,000	14,500	**54,500**
Green Buildings	6,000	3,000	12,000	**21,000**
Sustainable Transport	500	1,000	3,000	**4,500**
Knowledge and Behaviour	3,000	6,000	6,000	**15,000**
Carbon Offsets and Sinks	40	40	19,920	**20,000**
Total	**29,540**	**30,040**	**55,420**	**115,000**
Savings percentage in period	25.7%	26.1%	48.2%	**100%**

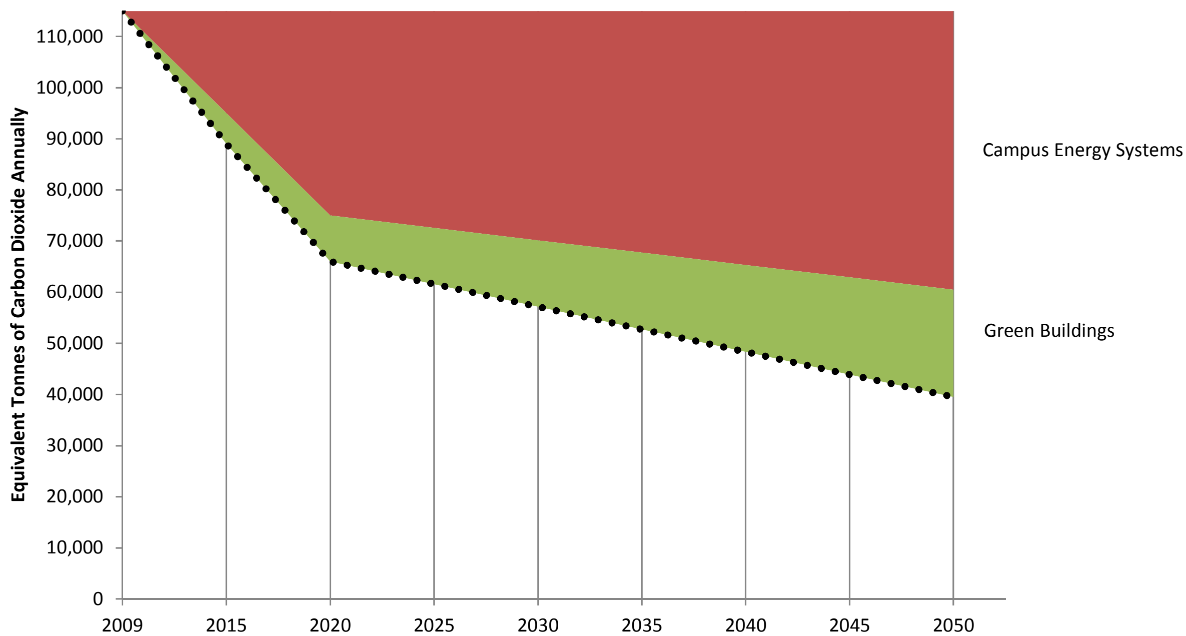
Note: Units of GHG emissions savings are tonnes eCO2.

Figure 1.1 GHG Emissions Reduction Targets



Although all the strategic areas are inter-related, the GHG emissions reduction actions of Campus Energy Systems and Green Buildings are directly related to the Campus Energy Master Plan. The total amount of GHG emissions reduction targets related to these two categories are **75,500 tonnes eCO2**. The GHG emissions reductions related to building systems are shown ***in Figure 1.2 GHG Emissions Reduction Targets – Building Systems.***

Figure 1.2 GHG Emissions Reduction Targets – Building Systems



Other Measures that would be categorized as 'Knowledge and Behaviour' strategies include Energy Awareness, Operator Training, and Enhanced Campus Utilization. These Measures have a combined opportunity quantified to be 4,570 tonnes eCO2 in the near-term future. This amount for 'Knowledge and Behaviour' strategies is not included in Figure 1.2 above or Figure 1.3 below.

Greenhouse Gas Emissions Reductions

The summary of all of the strategies, measures and changes are summarized in ***Table 1.9 and Figure 1.3 Projected GHG Emissions Reductions.***

Table 1.9 Projected GHG Emissions Reductions

Climate Change Strategies	Totals
Short Term Measures	11,965
Long Term Measures	4,640
RECAPP	3,025
Renewables	1,269
Central Plant NG Conversion	12,602
Cogeneration	20,000
Subtotal	53,501
NS Elect. Power Improvement	6,378
Total Savings	59,879
Campus Growth	- 19,993
Total Net Savings	39,886

Note: Units of GHG emissions savings are tonnes eCO2.

Figure 1.3 Projected GHG Emissions Reductions