Buildings

Massey Hall Energy and Water Audit

Prepared for: The Corporation of Massey Hall and Roy Thomson Hall

April 2014 | 8914003-001

MMM GROUP

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APPENDICES

MMM Group Limited

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April 22, 2014

Stephen Clarkin
Building Operations Manager
60 Simcoe St. Toronto, ON M5J 2H5

Dear Mr. Clarkin,

Please find enclosed the MMM Energy Audit for the building at 178 Victoria Street, Toronto. The audit evaluates and recommends energy saving opportunities and available rebates from various incentive programs. The audit also provides estimated projects cost, savings and expected payback periods. The details in this report are based on a comprehensive evaluation of historic energy consumption trends and a complete review of the existing building systems and their operation.

MMM Group has developed a holistic approach to identifying and recommending energy conservation measures which allows short payback measures to offset longer payback measures and this approach best positions the building against future increases in energy prices.

This audit was performed and reviewed by a Certified Professional Engineer in accordance with ASHRAE Level II Energy Audit requirements and upgraded to meet the OPA saveONenergy audit incentive requirements.

I trust our Energy Audit meets with your approval and acceptance.

Sincerely yours,

Maurice Safatly, P.Eng.

Manager

MMM Group Limited

1.0 EXECUTIVE SUMMARY

MMM Group was retained by The Corporation of Massey Hall and Roy Thomson Hall to perform an energy audit and to provide recommendations for energy saving opportunities within the facility located at 178 Victoria Street, Toronto.

The energy audit conducted was an ASHRAE Level II audit and included a walk-through of the facility, interviews with the facility operating personnel, review of utility bills, energy analysis for each Energy Conservation Measure (ECM), and a financial analysis including implementation cost estimates, cost savings, and simple payback. A summary of the findings are shown below:

Table 1.1: Energy and Cost Intensity Summary

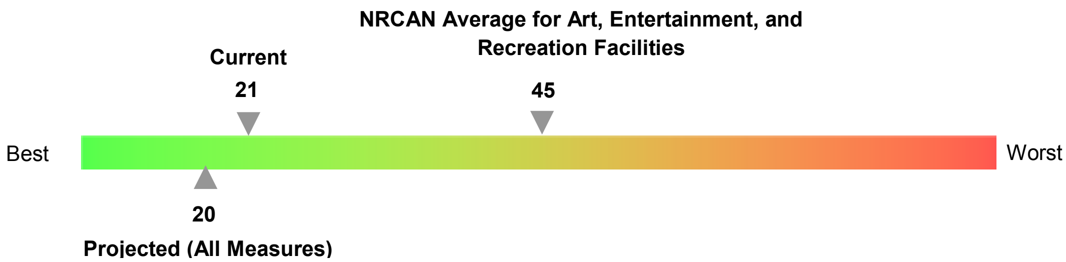
	Consumption		% Total Cost	Unit Cost		Total Cost ($)	Current		Projected all measures	
							ekWh/ft^2	$/ft^2	ekWh/ft^2	$/ft^2
Electricity	627,952	kWh	0.65	0.1633	$/kWh	$102,574	10.3	1.71	8.9	$1.48
Steam	1,888,322	lbs	0.21	0.0176	$/lbs.	$33,152	10.4	0.55	10.8	$0.57
Water	7,808	m^3	0.14	2.7557	$/m^3	$21,516	N/A	0.36	N/A	$0.31
Total						**$157,242**	**20.7**	**2.62**	**19.8**	**2.37**

Total (2012-2013): 21 ekWh/ft^2-year

-118% *Compared to*

Ontario Average: 45 ekWh/ft^2-year

Total Energy Consumption (ekWh/ft^2-year)



The following table summarizes the individual Energy Conservation Measures identified during the audit which are recommended for implementation. For ease of review, these measures have been separated into three categories depending on their initial capital cost. Full details of the energy analysis and implementation costing of each measure are included in the Energy Conservation Measure section.

Table 1.2: Recommended Energy Conservation Measures (ECMs)

ECM #	ECM Description	Dollars ($)	Implementation ($)	Potential Incentive ($)	Payback with Incentive (yrs.)
Category 1 ECMs (Implementation Cost < $10,000)					
C1.1	AC Unit Condenser Water Cooling Retrofit	2,286	4,000	0	1.7
C1.2	VFD on AC-1 Supply Fan	1,655	6,150	1,839	2.6
C1.3	Century Lounge Lighting Retrofit	1,121	2,320	920	1.2
C1.4	DHW Pipe Insulation	524	879	0	1.7
C1.5	Energy Miser for Gas Front Beverage Coolers	409	1,000	0	2.4
C1.6	Fan V-belt Replacement	15	50	0	3.3
Category 2 ECMs ($10,000 < Implementation Cost < $100,000)					
C2.1	Free Cooling for AC-2	2,084	11,000	2,315	4.2
C2.2	Replace Electrical DHW heaters with Steam heater	1,577	10,500	2,277	5.2
ECM Total		**9,671**	**35,899**	**7,351**	**3.0**

2.0 INTRODUCTION

MMM Group Limited (MMM Group) performed an ASHRAE Level II energy audit. The intent of this study was to evaluate the existing mechanical and electrical building systems and elements to determine possible energy management and conservation measures for the facility, and to qualify them in terms of efficiency, operation, cost effectiveness and environmental impact. We have referred to ASHRAE Procedures for Commercial Building Energy Audits and compiled a comparison matrix outlining the process and report tasks for all audit levels:

Table 2.1: ASHRAE - PROCEDURES FOR COMMERCIAL BUILDING ENERGY AUDITS, SECOND EDITION

PROCESS	AUDIT LEVEL		
	I	II	III
Conduct Preliminary Energy-Use Analysis (PEA)	●	●	●
Conduct walk-through survey	●	●	●
Identify low-cost/no-cost recommendations	●	●	●
Identify Capital improvements	●	●	●
Review mechanical and electrical (M&E) design and conditions and O&M practices		●	●
Analyze capital measures (savings and cost, including interactions)		●	●
Meet with owner/operators to review recommendations		●	●
Conduct additional testing/monitoring			●
Perform detailed system modeling			●
Provide schematic layouts for recommendations			●
REPORT	**AUDIT LEVEL**		
	I	**II**	**III**
Estimate savings from utility rate change	●	●	●
Compare EUI to EUI of similar sites	●	●	●
Summarize utility data	●	●	●
Estimate savings if EUI were to meet target	●	●	●
Calculate detailed end-use breakdown		●	●
Estimate Capital Project costs and savings		●	●
Complete building description and equipment inventory		●	●
Document general description of considered measures		●	●
Recommend measurement and verification (M&V) method		●	●
Perform financial analysis of recommended EEMs		●	●
Write detailed description of recommended measures			●
Compile detailed EEM cost estimates			●

2.1 METHODOLOGY

The analyses of the energy conservation opportunities consisted of the following general evaluations stages:

- Determine the energy requirements of the facility with regards to weather relative components, occupancy and operation.
- Evaluate the existing system components, and their respective energy consumption, in order to generate feasible energy conservation measures.
- Determine implementation costs associated with the prescribed energy conservation measures.
- Provide cost/benefit analyses, including payback calculations for the proposed energy conservation opportunities.

Equipment and system costing values are estimates, based on industry standards and RS Means costing database publications. Costs will need to be confirmed prior to implementation through a standard contractor tender process.

The energy analysis is based on the weather bin data analysis to determine the energy savings associated with proposed measures. In addition, proprietary energy modeling software was utilized.

The following utility bills were reviewed:

- Electrical Utility Bills January 2012 to December 2013
- Steam Utility Bills January 2012 to December 2013
- Water Utility Bills June 2012 to November 2013

The utility rate structure which will be used for the purpose of this report is the average value obtained from 24 months of utility bills, January 2012 through December 2013. The values are as follows:

Electricity Consumption	\$0.091 per KWh
Electricity Demand	\$10.18 per kW
Steam	\$0.018 per lbs.
Water	\$2.74 per m^3

2.2 GENERAL APPROACH

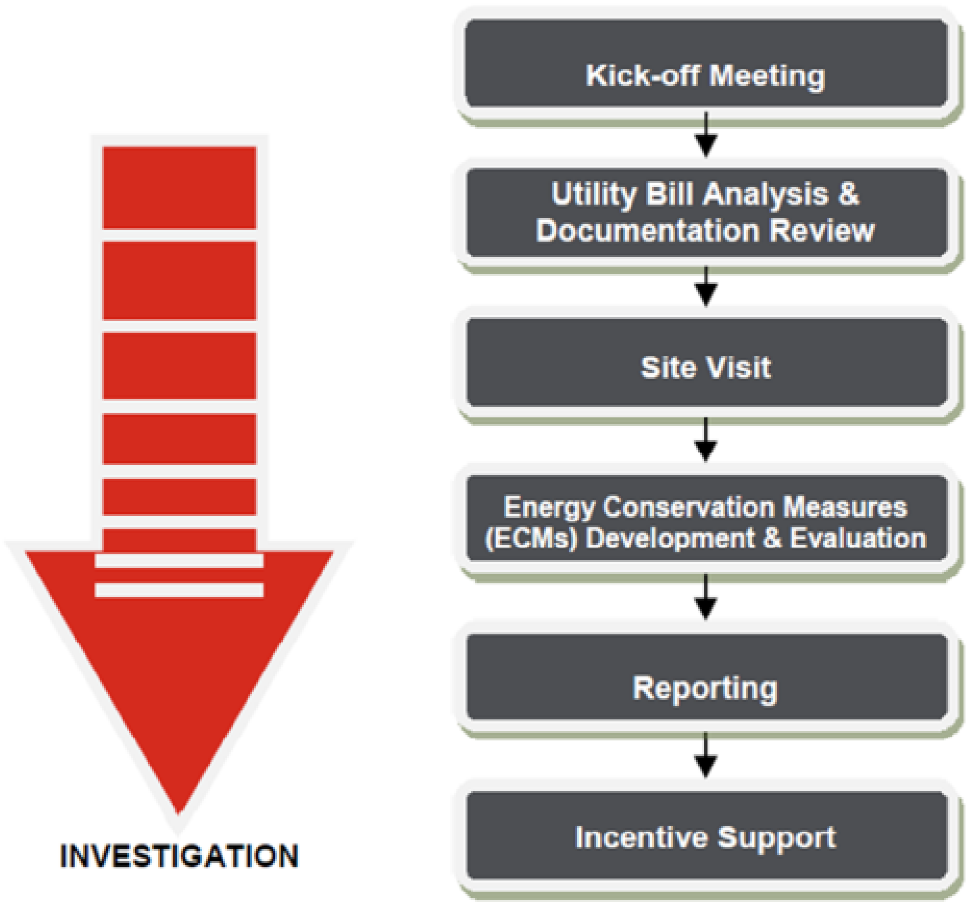
Site reviews were carried out on February 11, 2014 and February 20, 2014 to determine the physical and operational condition of the building systems. Interviews with maintenance personnel were conducted during the site reviews to understand the facility operation, details of any recent upgrades and/or modifications to the systems, plans for upcoming capital upgrades, and to identify current operational concerns.

The mechanical systems including heating system, cooling system, domestic cold water system, domestic hot water system, and plumbing fixtures were examined during the site visit. The mechanical systems are in general maintained in good condition.

Building lighting intensity was visually checked and is in the appropriate range.

During the site visit it was noticed that there is a comfort issue in the management office and in the corridors in the basement area.

The general approach taken to this energy audit project is presented below.



3.0 GENERAL BUILDING CHARACTRISITICS

Building Location
178 Victoria street,
Toronto, Ontario
M5B 1T7

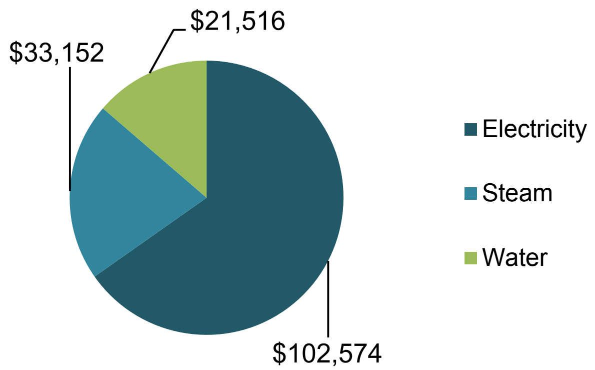
Year Constructed
1894

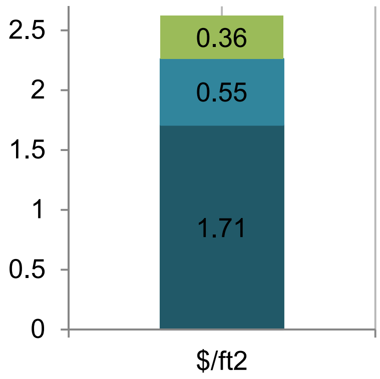
Building Gross Area
60,000 ft^2

Building Use
Performance Art Theater

Performance Summary
2013: 80
2012: 90

Capacity
2,752 seats





3.1 BUILDING ENVELOPE

3.1.1 Envelope

The building structure is steel frame construction. The exterior walls of the building consist of red brick masonry walls and stone block masonry. There are areas of stone detailing with classical elements on the façade.

The exterior doors and frames are a combination of hollow metal and wood doors. The windows are original to the building and they are single-layer stained glass windows.

3.2.1 Roofing

The roof of the building consists of a hipped roof with a gable along the north end as well as east and west slopes.

3.2 MECHANICAL SYSTEMS

A detailed list of all major mechanical equipment can be found in Appendix B - Equipment Schedule. The building mechanical equipment is mainly located in the basement. The following narrative outlines the operation of the major mechanical systems.

3.2.1 Cooling Plant

There is no central cooling plant in the building. The main source of cooling in the building is provided by two (2) air cooled air conditioning units (AC-1 and AC-2).

Cooling to the basement electrical room is provided by one (1) air conditioning unit with a water-cooled condenser. DCW is used to cool down the refrigerant. This unit is located in the ceiling space next to the temporary management office.

3.2.2 Heating Plant

There is no central heating plant in the building. The main source of the heat in the building is high pressure steam supplied by Enwave. The main steam supply and pressure reducing valves are located in the basement mechanical room. It provides low pressure steam to the perimeter radiators, AC-1 heating coil and lobby supply air handling unit.

Figure 3.1: Main Steam Pipe

Figure 3.2: Perimeter Steam Radiator

3.2.3 HVAC System

Heating, cooling and ventilation to the basement areas and auditorium is provided by AC-1. AC-1 is located in the basement and comes equipped with steam heating coils, a DX-cooling unit, a return fan and a supply fan. This unit can be running at either 100% fresh air or 100% return air. The air cooled condenser which serves AC-1 is located on the lower roof. Based on the staff interview the existing cooling (DX coils) will be replaced with chilled water supplied by a new air cooled chiller.

The new dressing rooms which were recently added to the building are equipped with VAV boxes and electric reheat coils; however they are not working efficiently as there is no VFD installed on the AC-1 supply fan.

The supply air to the century lounge is manually controlled by opening and closing the volume damper. Usually the damper is open only during the intermission and a few hours before the show.

Figure 3.3: Century Lounge Supply Duct

Figure 3.4: Century Lounge Supply Damper Control

Cooling to the Galleria and Balcony level as well as back stage area is provided by AC-2. AC-2 is located on the lower roof and is equipped with a DX cooling unit and supply fan.

AC-1 and AC-2 are only on when there is a show or maintenance crews are working.

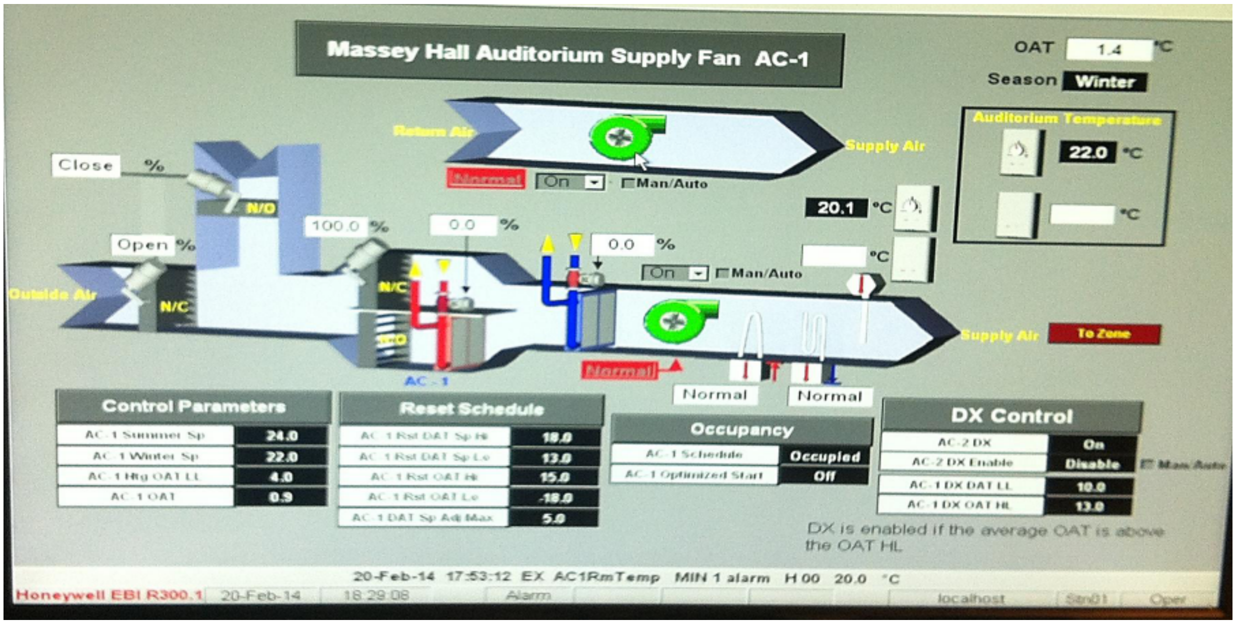


Figure 3.5: BAS Screenshot: AC-1 and AC-2

Heating to the Entrance lobby and foyer is provided by one AHU which is equipped with steam coils and a supply fan. The AHU is located in the small mechanical room near the foyer. The box office is conditioned via one Carrier water cooled heat pump.

Figure 3.6: Entrance Lobby and Foyer Supply Fan

Figure 3.7: Heat Pump

The general exhaust for the building is accomplished by one 7.5hp fan located on the higher roof. The washroom exhaust fan is located in the box office room.

Figure 3.8: General Exhaust Fan

Figure 3.9: Washroom Exhaust Fan

3.2.4 HVAC Controls

All HVAC equipment is controlled by a Honeywell building automation system (BAS), with head-end equipment located in the management office in the basement level.

The lights in the building are also controlled by BAS; most of the lights in the basement area are on one circuit and are ON approximately 15 hours/day. The Auditorium and chair lights are ON when there is an event.

Figure 3.10: BAS: Main Screen

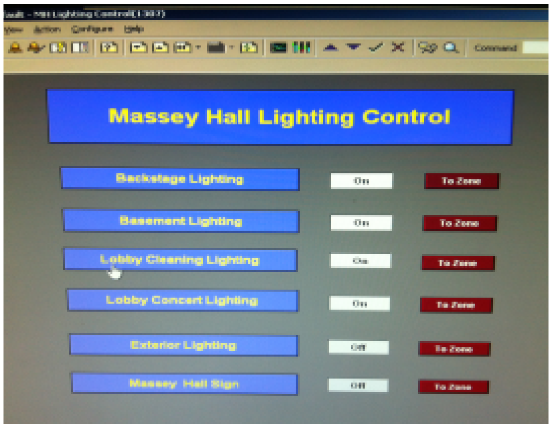


Figure 3.11: BAS: Lighting Control

3.3 LIGHTING SYSTEMS

Please refer to Appendix C - Lighting Schedule for a detailed list of the lighting fixtures and wattages.

The majority of the lights in the building are incandescent, which is the least efficient lighting type. The chair lights are a combination of 40W incandescent and tubular incandescent.

The recently renovated dressing rooms are equipped with T5 and CFL lamps which are controlled with occupancy sensors.

Most of the washrooms are illuminated via MR16 lamps which are on all the time.

Corridors and stairways are equipped with surface mounted fixtures and T8 lamps.

3.4 DOMESTIC WATER SYSTEMS

3.4.1 Domestic Cold Water System

The main domestic cold water pipe enters the building at the basement level. The main water meter is located in the mechanical room next to the foyer. There is no booster pump in the building.

Figure 3.12: Water meters

3.4.2 Domestic Hot Water

There are three (3) electrical domestic hot water heaters located in the basement which serve washrooms, showers, dressing rooms and century bar. The DHW heater 1 was installed in 2009 and has 4.5 kW input. DHW heater 2 and 3 have 2 kW input each. There is a small recirculating pump for DHW in the building.

Figure 3.13: Electrical DHW heaters

Figure 3.14: DHW recirculation pump

There is one (1) 3 kW DHW heater located in the balcony level left closet which serves the men's washroom and bar on the balcony level. The women's washroom on the balcony level is served by one (1) 1.5 kW DHW heater located in the balcony level right closet.

Figure 3.15: Electrical DHW heater in left balcony closet

Figure 3.16: Electrical DHW heater in right balcony closet

3.4.3 Plumbing Fixtures

The majority of the plumbing fixtures at the building are low flow type fixtures with automatic proximity sensors. This includes sinks, water closets, and urinals.

Figure 3.17: Typical Sink

Figure 3.18: Typical Toilet

4.0 UTILITY USAGE ANALYSIS

4.1 ENERGY INTENSITY

The calculation of energy performance and energy cost indices is based on building floor area, which allows for an immediate assessment of the facility in several ways. The assessments available from the energy performance and energy cost indices include the following:

- Evaluation of the building's energy performance against similar facilities;
- Comparison against past facility energy use;
- Means of evaluating the effectiveness of building retrofit energy saving measures.

Table 4.1 – Utility Summary and Building Energy Use Index

Utility Consumption and Green House Gas Emission (2 Year Summary)				
Building Area (ft^2)	**60,000**	**2012**	**2013**	**Average**
Energy				
Steam	Massey Hall Consumption (lbs)	1,890,946	1,712,007	1,801,476
	Massey Hall Consumption (MJ)	2,358,010	2,134,872	2,246,441
	Massey Hall Heating EUI (ekWh/ft^2-yr)	11	10	10
	NRCAN Average [1] EUI (ekWh/ft^2-year) (2010)	20	20	20
	Massey Hall GHG (Tonne CO_2e) [2]	195	177	186
Electricity	Massey Hall St Consumption (kWh)	683,627	557,216	620,421
	Massey Hall Consumption (MJ)	2,461,057	2,005,976	2,233,517
	Massey Hall EUI (ekWh/ft^2-yr)	11	9	10
	NRCAN Average [1] EUI (ekWh/ft^2-year) (2010)	25	25	25
	Massey Hall GHG (Tonne CO_2e) [3]	68	56	62
Total Site Energy	Massey Hall Consumption (MJ)	4,819,067	4,140,849	4,479,958
	Massey Hall EUI (ekWh/ft^2-yr)	22	19	21
	NRCAN Average [1] EUI (ekWh/ft^2-year) (2010)	45	45	45
Water				
Water	Consumption (m^3)	N/A	N/A	7,808
Usage/ft^2	Building	N/A	N/A	0.13
Average Utility Cost				
Steam	Massey Hall - ($/lb)	0.02	0.02	0.02
Electricity	Massey Hall. - ($/kWh)	0.17	0.16	0.16
	NRCan Energy Rates ($/kWh)(2010)[4]	0.12	0.12	0.12

Note:

(1) 2011 NRCAN EUI taken from "Arts, Entertainment and Recreation Secondary Energy Use by End-Use"
(2) 2010 DOE Voluntary Reporting of GHG, Appendix N
(3) Environment Canada: Greenhouse gas Intensity- Ontario
(4) 2010 NRCan Energy Rates taken from "Commercial/ Institutional Energy Prices and Background Indicators (500 kW/100,000kWh)"

As presented in the Utility Summary and building Energy Use Index table above we can see that when compared to Ontario averages provided by Natural Resources Canada, the building Energy Use Index (EUI) of Massey Hall is much lower than the average. However the energy consumption in the performance theatres are very much dependent on the number and type of the performances, therefore lower EUI than the Ontario Average doesn't necessarily indicate that the building is performing in a more efficient manner.

The energy use index for a similar building in London, Ontario is 13 $ekWh/ft^2$, which is much lower than Massey hall. Also the UK standards suggest 23 $ekWh/ft^2$ and the average energy consumption for performance halls in San Francisco is 23 $ekWh/ft^2$.

The water consumption in Massey Hall is higher than other comparable buildings. The reason is that almost 40% of the domestic cold water is used in the electrical room AC unit condenser loop. Please refer to Section 5 for related water saving measures.

4.2 ANNUAL ENERGY ALLOCATION

The annual energy allocation for the facility has been performed using equipment specifications, schedules, and set-points. Table 4.2 outlines the approximate annual energy consumption associated with the primary energy consumers at the facility.

Please note that Plug Load and Misc. includes all the beverage coolers, stage lights, computers, and lightings in the Albert building. Window shakers (A/C units) that used to serve Albert building are included in HVAC Fans load.

Table 4.2 – Annual Energy Allocation

	Electricity	Steam	Total	% of Total Use	Cost	
	kWh	Lbs.	MJ		$	%
Space Heating		1,888,322	2,354,738	51.3%	$33,152	24.6%
DHW	23,760		85,536	1.9%	$3,881	2.9%
Lighting	139,577		502,478	11.0%	$22,800	17.0%
HVAC Fans	362,280		1,304,207	28.4%	$59,177	44.0%
Plug Load and Misc.	94,804		341,296	7.4%	$15,486	11.5%
TOTAL	**620,421**	**1,888,322**	**4,588,254**	**100.0%**	**$134,496**	**100.0%**

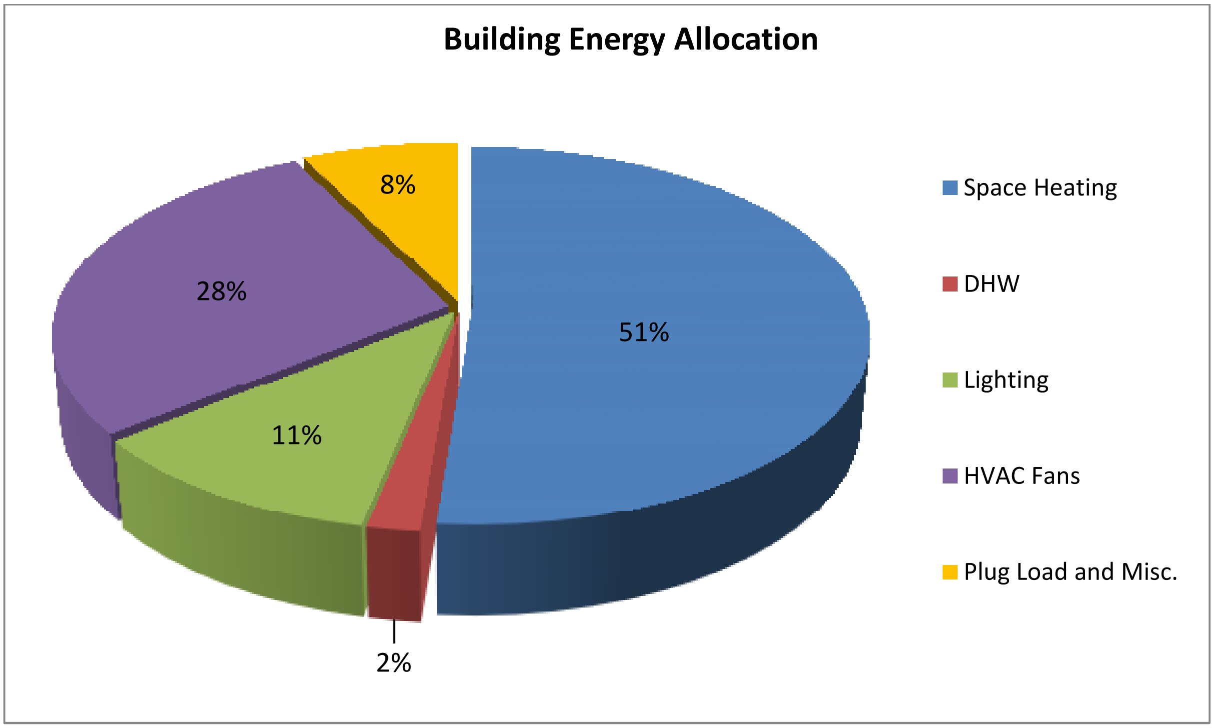


Figure 4.1 – Annual Energy Allocation

4.3 UTILITY CONSUMPTION AND COST SUMMARY

The information obtained from the utility bill analyses for the building assists in identifying areas of significant utility cost savings. Detailed summaries of energy usage at the facility are outlined below. The analysis includes graphical representation of energy use relating to patterns and anomalies observed in the monthly utility trends.

Weather data is represented as Heating and Cooling Degree Days in order to analyze energy use against daily mean temperatures for specific billing periods. Heating Degree Days (or Cooling Degree Days) are defined relative to a balance temperature. The balance temperature is the outside temperature, where for temperatures higher than it, cooling is required in the building, and at temperatures lower than it, the building requires heating. Environment Canada uses the traditional 18°C balance temperature (change-point temperature) in order to compute monthly Heating and Cooling Degree Days. However, the most appropriate building balance temperature depends on several characteristics of the building such as internal and external heat gain/loss.

4.4 ELECTRICAL USAGE ANALYSIS

Electricity is consumed by lighting, auxiliary equipment, auxiliary motors, DHW heating, and space cooling. Monthly electrical utility data at the building can be found in the appendices.

For the twenty-four (24) month period between January 2011 and December 2012 the building had an electricity consumption of approximately 1,255,903 kWh. The average blended electricity cost during the period between January 2011 and December 2012 was $0.163/kWh.

Figure 4.2 represents the electricity usage during the period of January 2011 to December 2012. Electricity consumption is relatively constant during the year and is not highly dependent on the weather. Electricity consumption is mainly impacted by the number and type of the shows. As shown in figure 4.2, electricity consumption is very high in early 2012. Based on the interview with the building operator, prior to July 2012, building had been operated with different lighting and HVAC equipment schedules which caused higher usage during the period.

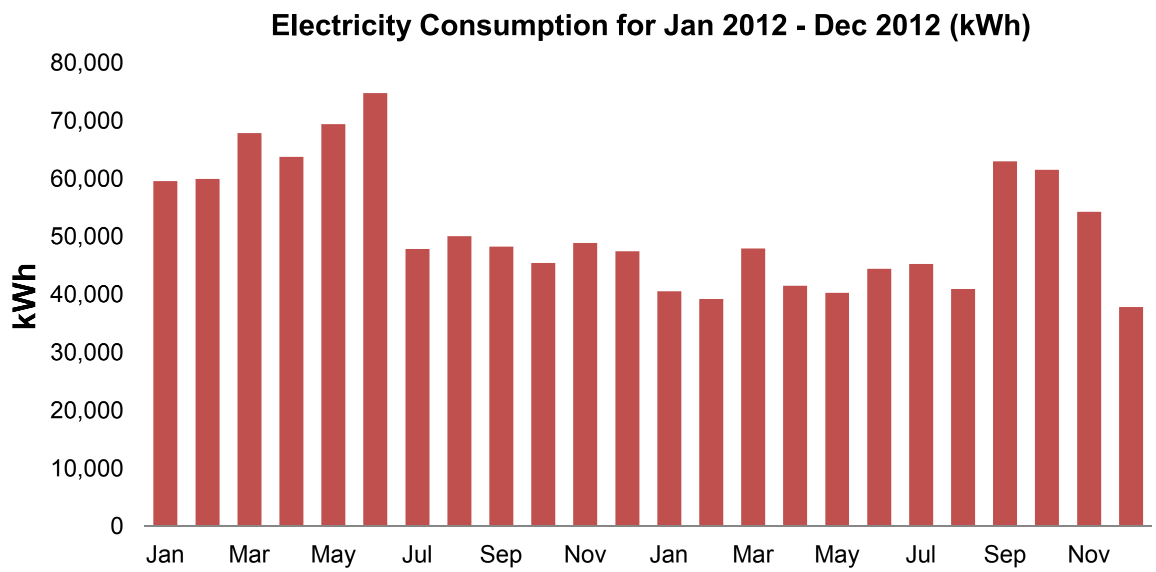


Figure 4.2 – Electrical Consumption

4.5 STEAM USAGE ANALYSIS

Steam at the building is consumed by space heating. Table D.2 (Appendix D) outlines the steam utility data at the building from January 2012 to December 2012, adjusted according to monthly periods.

Figure 4.3 represents the steam usage profile, from which we can infer that the steam consumption at Massey Hall follows a classic “bell-shaped” pattern, with peak consumption during the winter months and zero consumption during the summer months.

To examine the interactions between the building’s natural gas consumption and heating degree days, a linear regression analysis was performed. The linear regression analysis of steam indicates a very strong relationship between heating degree days and the steam consumption. The balance temperature is 10°C gives the highest R^2 value. Considering the function of the building and high heat generation from the occupants, the lower balance temperature appears to be reasonable.

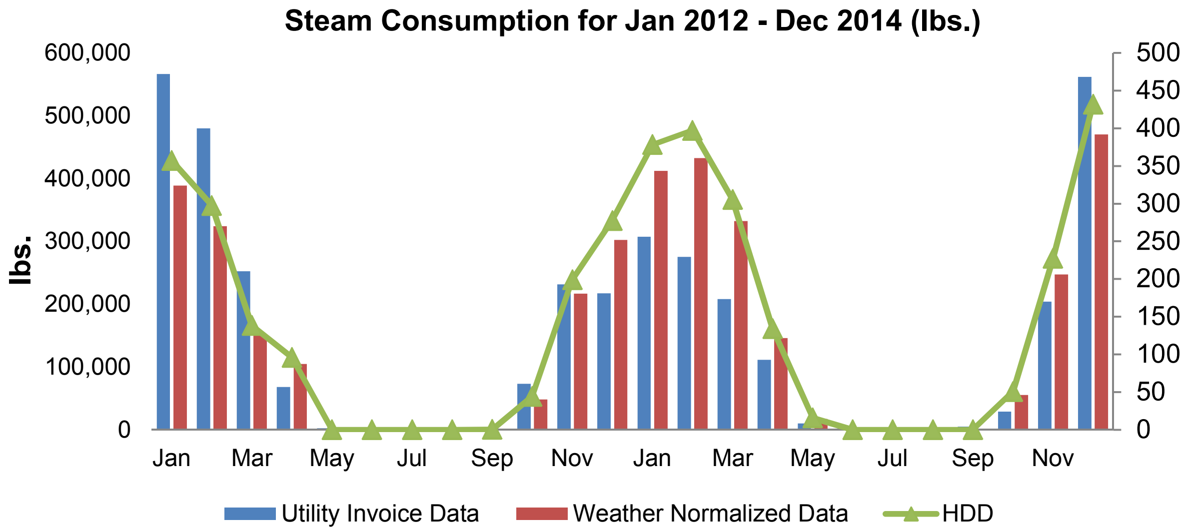


Figure 4.3 – Natural gas consumption

4.6 WATER USAGE ANALYSIS

The water consumption at the facility is to support space cooling and domestic activities. Table D.3 (Appendix D) outlines the water consumption at the building from June of 2012 November of 2013. The water consumption was relatively constant throughout a year. The water consumption appears to be mainly affected by number of performances but hardly on the weather factor.

Figure 4.4 represents the water usage during the time period from June 2012 to November 2013.

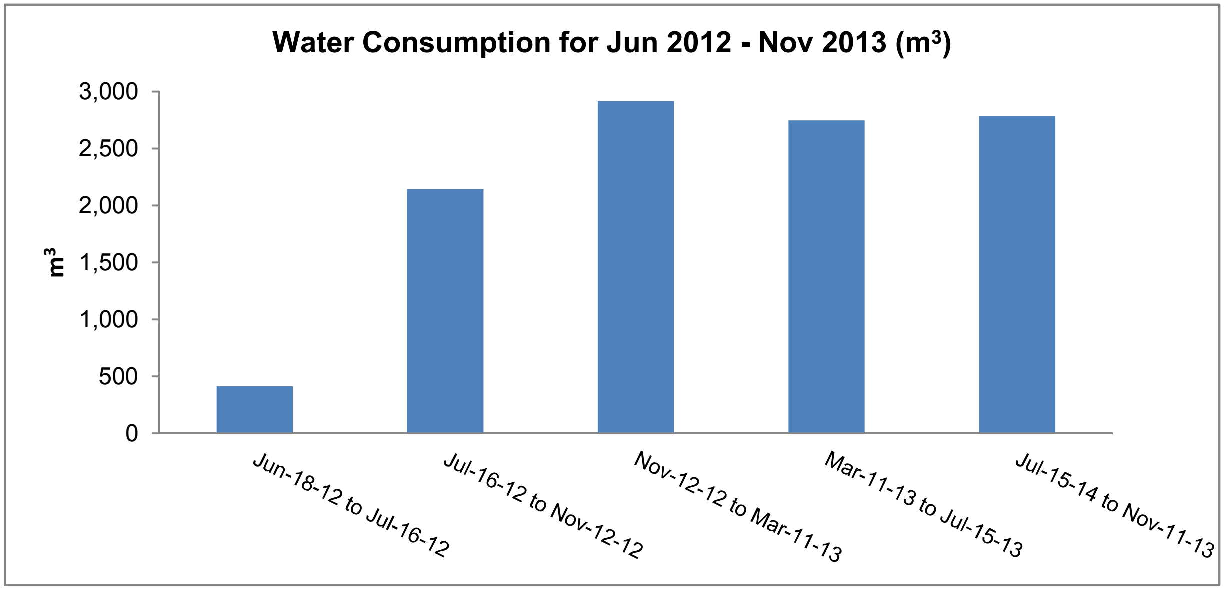


Figure 4.4 – Water Consumption

5.0 ENERGY CONSERVATION MEASURES

5.1 SUMMARY OF ENERGY CONSERVATION MEASURES

Table 5.1 summarizes all of the energy conservation measures identified through the audit process.

Table 5.1: Recommended Energy Conservation Measures (ECMs)

All ECMs		Projected Utility Saving					Implementation ($)	Potential Incentive ($)	Payback with Incentive (yrs.)
ECM #	ECM Description	Steam (lbs)	Water (m^3)	Electricity (kW)	Electricity (kWh)	Dollars ($)			
Category 1 ECMs (Implementation Cost < $10,000)									
C1.1	AC Unit Condenser Water Cooling Retrofit	0	993	0	-5,000	2,286	4,000	0	1.7
C1.2	VFD on AC-1 Supply Fan	0	0	0	18,389	1,655	6,150	1,839	2.6
C1.3	Century Lounge Lighting Retrofit	0	0	2	9,161	1,121	2,320	920	1.2
C1.4	DHW Pipe Insulation	0	0	0	5,821	524	879	0	1.7
C1.5	Energy Miser for Gas Front Beverage Coolers	0	0	0	4,544	409	1,000	0	2.4
C1.6	Fan V-belt Replacement	0	0	0	168	15	50	0	3.3
Category 2 ECMs ($10,000 < Implementation Cost < $100,000)									
C2.1	Free Cooling for AC-2	0	0	0	23,152	2,084	11,000	2,315	4.2
C2.2	Replace Electrical DHW heaters with Steam heater	-73,050	0	7	22,773	1,577	10,500	2,277	5.2
ECM Total		**-73,050**	**993**	**9**	**79,008**	**9,671**	**35,899**	**7,351**	**3.0**

Figure 5.1 shows the total cost reductions for the energy conservation measures (ECMs) in Table 5.1.

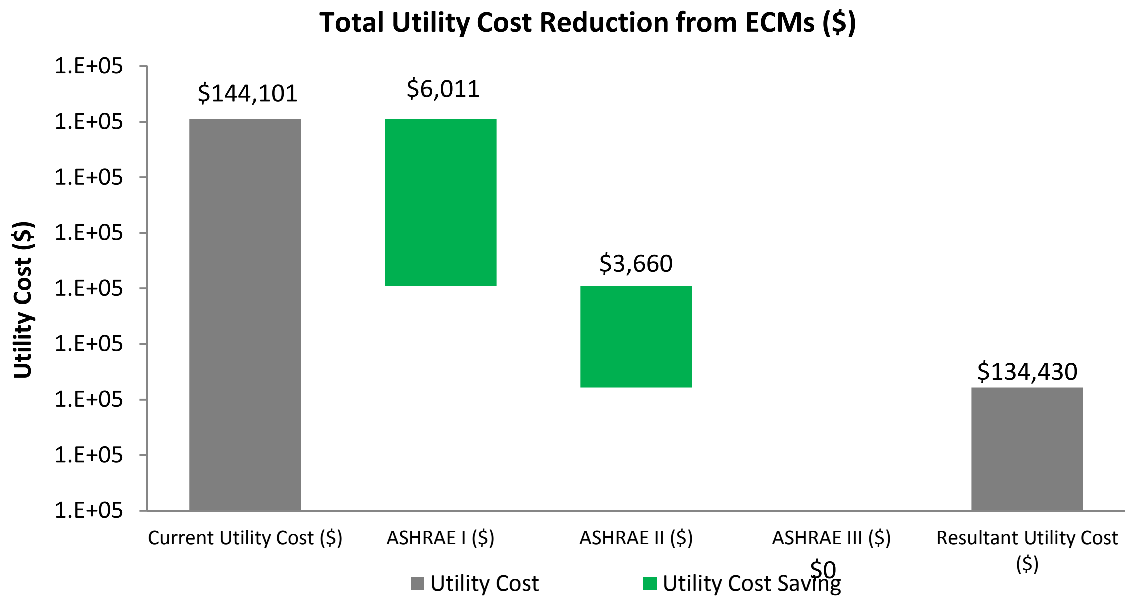


Figure 5.1: Total ECM and REO Reduction (Dollars)

The current GHG emission in Figure 5.2 below is calculated using the buildings utility consumption only. The savings are based on the proposed ECMs in Table 5.1.

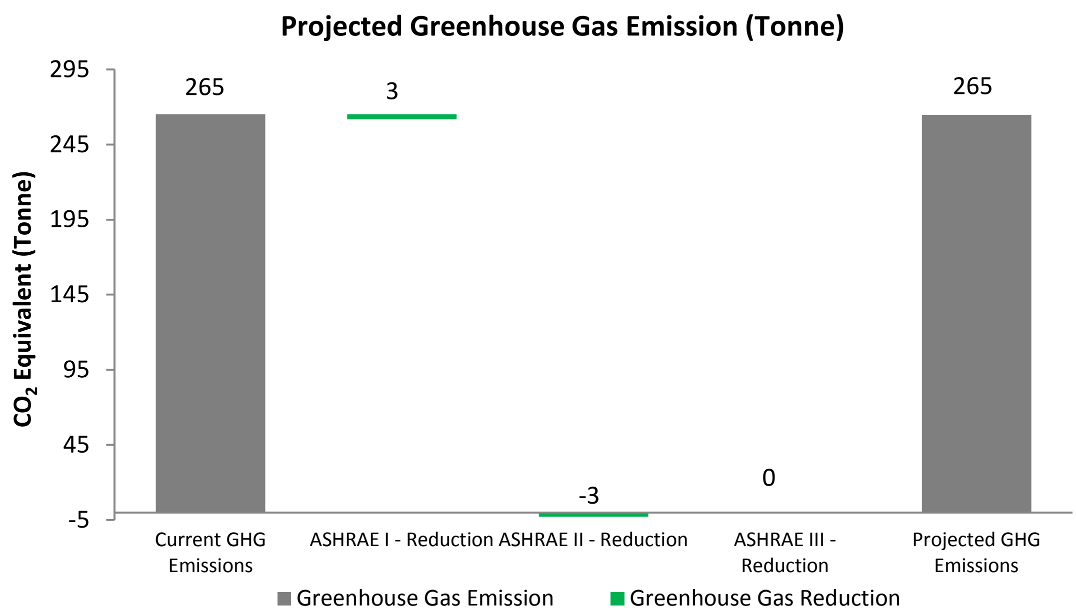


Figure 5.2: Projected Green House Gas Emission (GHG) CO2 Equivalent

5.2 RETRO-COMMISSIONING

Re-commissioning, Retro-commissioning (RCx), or existing building commissioning is an event in the life of a building that applies a systematic investigation process for improving and optimizing the building's operation and maintenance. It is typically an independent process that focuses on the building's energy using equipment such as the HVAC and other mechanical equipment, lighting equipment, and related controls. It may or may not emphasize bringing the building back to its original intended design specifications. In fact, during the process, the retro-commissioning team may find that the original specifications no longer apply.

The process may result in recommendations for capital improvements, but its primary focus is to optimize the building systems via tune-up activities, improved operation and maintenance (O&M), and diagnostic testing.

Many building operational issues can only be uncovered through the retro-commissioning process: a thorough investigation of the HVAC systems and equipment through a series of functional testing, diagnostic monitoring and trending.

The retro-commissioning process involves a coordinated effort between the retro-commissioning provider and building owner staff. The process includes reviewing building documentation, conducting interviews and field investigations, monitoring and analyzing building systems, developing a findings list with supporting energy saving calculations, and assisting the client with selecting measures for implementation.

Many building operational issues can only be uncovered by subjecting the facility to a retro-commissioning process; a thorough investigation of the HVAC systems and equipment through a series of functional testing, diagnostic monitoring and trending.

Our past retro-commissioning project experiences have yielded a utility consumption savings ranging from a minimum of 8% to a maximum of 30%. The following table outlines the typical costs, savings, and paybacks associated with retro-commissioning projects.[i]

	Range	Median	
Project cost	$0.15 -$0.60/ft^2	$0.30/ft^2	$3.23/m^2
Annual cost savings	$0.10 - $0.78/ft^2	$0.29/ft^2	$3.12/m^2
% Energy savings	9% - 31%	16%	
Payback period	0.4 - 2.4 years	1.1 years	

[i] Mills, Evan, "Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse-gas Emissions", Lawrence-Berkley National Library, 2009.

5.3 CATEGORY 1 – ENERGY CONSERVATION MEASURES

The Energy Conservation Measures (ECMs) described below are classified as Category 1 ECMs. Category 1 ECMs are low cost measures which range in cost from $0 to $10,000.

Table 5.3 – Proposed Energy Conservation Opportunities (Category 1)

Category 1 - ECMs		Projected Savings					Implementation ($)	Potential Incentive ($)	Simple Payback with Incentive (yrs.)
ECM #	ECM Description	Water (m^3)	Natural Gas (m^3)	Electricity (kW)	Electricity (kWh)	Dollar ($)			
C1.1	AC Unit Condenser Water Cooling Retrofit	993	0	0	-5,000	2,286	4,000	0	1.7
C1.2	VFD on AC-1 Supply Fan	0	0	0	18,389	1,655	6,150	1,839	2.6
C1.3	Century Lounge Lighting Retrofit	0	0	2	9,161	1,121	2,320	920	1.2
C1.4	DHW Pipe Insulation	0	0	0	5,821	524	879	0	1.7
C1.5	Energy Miser for Gas Front Beverage Coolers	0	0	0	4,544	409	1,000	0	2.4
C1.6	Fan V-belt Replacement	0	0	0	168	15	50	0	3.3
ECM Total		**993**	**0**	**2**	**33,083**	**6,011**	**14,399**	**2,759**	**1.9**

Table 5.4 – Proposed Energy Conservation Opportunities (Category 1)

Category 1 - ASHRAE Level I: Low Cost/No Cost Measures					
		All ECM		**ECM (Payback with Incentive < 5yrs.)**	
		Savings Amount	Savings ($)	Savings Amount	Savings ($)
Savings	Steam (lbs.)	0	$0	0	$0
Savings	Water (m^3)	993	$2,736	993	$2,736
Savings	Electricity Peak (kW)	2	$297	2	$297
Savings	Electricity (kWh)	33,083	$2,977	33,083	$2,977
Savings	Total Savings ($)	$6,011		$6,011	
Implementation Cost		$14,399		$14,399	
Potential Incentive		$2,759		$2,759	
Total GHG Reduction (CO_2 Tonne Equivalent)		3.3		3.3	
Simple Payback Period		Without Incentive	With Incentive	Without Incentive	With Incentive
		2.4	1.9	2.4	1.9

ECM #C1.1 – AC Unit Condenser Water Cooling Retrofit

Summary and Recommendation

Currently the cooling to the basement electrical room is provided by one water-cooled AC unit. This unit comes equipped with an open condenser loop which uses city water to cool down the refrigerant. During the site visit the auditor was informed that a new air cooled chiller will be installed to provide chilled water to AC-1 cooling coil.

It is recommended that Massey Hall utilizes the chilled water which is already available for use in the AC-1 cooling coil to the electrical room AC condenser loop during the summer. This retrofit requires adding a 3-way control valve to switch between city water and chilled water during winter and summer, respectively, and in addition some piping modifications will be required.

This retrofit will have a significant effect on water savings but will slightly increase the chiller load. The following table outlines the approximate implementation cost, savings, available incentive, and payback period associated with the retrofit. The cost includes control devices, additional piping, and labour.

ECM #	C1.1	AC Unit Condenser Water Cooling Retrofit	
		Saving Amount	Savings ($)
Savings	Steam (lbs.)	0	$0
	Water (m^3)	993	$2,736
	Electricity Peak (kW)	0	$0
	Electricity (kWh)	-5,000	-$450
	Total Savings ($)	$2,286	
Implementation Cost		$4,000	
Potential Incentive		$0	
Total GHG Reduction (CO_2 Tonne Equivalent)		-0.5	
Simple Payback Period		Without Incentive	With Incentive
		1.7	1.7

ECM #C1.2 – VFD on AC-1 Supply Fan

Summary and Recommendation

Through the recent renovation for the air distribution system, AC-1 was converted from a constant air volume (CAV) system to variable air volume (VAV) by adding VAV boxes to the new dressing rooms in the basement. This VAV system will vary the supply air volume based on the space temperature resulting in fan and cooling energy savings; however during the site visit it was noticed that the AC-1 supply fan was not equipped with variable frequency drive (VFD).

The VFD will adjust the fan speed based on the required static pressure in the duct; therefore, whenever less air flow is required by VAV boxes, the fan speed will decrease which will result in electricity savings.

The savings resulting from installing a VFD on the AC-1 supply fan was calculated by comparing the fan energy consumption for a system in which airflow is controlled by outlet dampers and a system controlled by VFD. The cost includes adding a VFD, installing a pressure sensor, control and labour.

The following table outlines the approximate implementation cost, savings, available incentive, and payback period associated with this retrofit.

ECM #	C1.2	VFD on AC-1 Supply Fan	
		Saving Amount	Savings ($)
Savings	Steam (lbs.)	0	$0
	Water (m^3)	0	$0
	Electricity Peak (kW)	0	$0
	Electricity (kWh)	18,389	$1,655
	Total Savings ($)	$1,655	
Implementation Cost		$6,150	
Potential Incentive		$1,839	
Total GHG Reduction (CO_2 Tonne Equivalent)		1.8	
Simple Payback Period		Without Incentive	With Incentive
		3.7	2.6

ECM #C1.3 – Century Lounge Lighting Retrofit

Summary and Recommendation

Currently, century lounge is illuminated with dimmable 100W incandescent lights. The lights are controlled by BAS and are ON for approximately 15hours/day. It is highly recommended that these lights be replaced with 19W dimmable LEDs. This will result in demand and electricity consumption as well.

Please note that the cost includes lamp replacement only and it was assumed that existing fixtures can be used with the LED lamps.

The following table outlines the approximate implementation cost, savings, available incentive, and payback period associated with the lighting retrofit.

ECM #	C1.3	Century Lounge Lighting Retrofit	
		Saving Amount	Savings ($)
Savings	Steam (lbs.)	0	$0
	Water (m^3)	0	$0
	Electricity Peak (kW)	2	$297
	Electricity (kWh)	9,161	$824
	Total Savings ($)	$1,121	
Implementation Cost		$2,320	
Potential Incentive		$920	
Total GHG Reduction (CO_2 Tonne Equivalent)		0.9	
Simple Payback Period		Without Incentive	With Incentive
		2.1	1.2

ECM #C1.4 – Domestic Hot Water Pipe Insulation

Summary and Recommendation

While on site it was noticed that there was no insulation provided on most of the domestic hot water piping. Typically the domestic hot water piping is insulated within the building to minimize the heat loss to the surrounding spaces. It was estimated that approximately 66 feet of domestic hot water piping were not insulated in the basement mechanical room. By providing proper insulation to the exposed piping the pipe heat loss could be reduced, resulting in energy savings.

The following table outlines the approximate implementation cost, savings, available incentive, and payback period associated with this retrofit.

ECM #	C1.4	DHW Pipe Insulation	
		Saving Amount	Savings ($)
Savings	Steam (lbs.)	0	$0
	Water (m^3)	0	$0
	Electricity Peak (kW)	0	$0
	Electricity (kWh)	5,821	$524
	Total Savings ($)	$524	
Implementation Cost		$879	
Potential Incentive		$0	
Total GHG Reduction (CO_2 Tonne Equivalent)		0.6	
Simple Payback Period		Without Incentive	With Incentive
		1.7	1.7

ECM #C1.5 – Energy Miser for Gas Front Beverage Coolers

Summary and Recommendation

Typically beverage coolers operate 24/7 to maintain the contents at serving temperature. This is not necessary since the building is not occupied during night time and maintaining beverages at serving temperature during unoccupied times wastes energy. An energy miser connects the machine to an infrared sensor that detects when no one is around and turns the off the power. During unoccupied periods the miser unit will periodically allow for brief cooling cycles to meet the minimum requirements set by the beverage manufacturers for their drinks' sale.

This energy conservation measure makes a lot of sense in art performing buildings since no one is around during long stretches of time at night.

The following table outlines the approximate installation costs, savings, available incentive, and payback period associated with the installation of energy misers on 5 beverage coolers. A similar payback period is expected for additional coolers or vending machines that are fitted with an energy miser.

ECM #	C1.5	Energy Miser for Gas Front Beverage Coolers	
		Saving Amount	Savings ($)
Savings	Steam (lbs.)	0	$0
	Water (m^3)	0	$0
	Electricity Peak (kW)	0	$0
	Electricity (kWh)	4,544	$409
	Total Savings ($)	$409	
Implementation Cost		$1,000	
Potential Incentive		$0	
Total GHG Reduction (CO_2 Tonne Equivalent)		0.5	
Simple Payback Period		Without Incentive	With Incentive
		2.4	2.4

ECM #C1.6 – Replace V-Belt with Cog-Belts

Summary and Recommendation

All motor drive systems have inherent inefficiencies due to friction losses. Standard V-belts tend to stretch, slip, bend and compress, which leads to a loss of efficiency. Under well-maintained conditions, a V-belt will run at approximately 92% efficiency. Replacing these belts with cog-style belts can result in savings of approximately 2%, and upgrading to high-torque belts can result in up to 6% additional savings over the base case. Cog-style belts also require less maintenance and have a substantially longer life expectancy over V-belts. As per NRCan, a typical payback period for cog-belt replacement ranges from six months to three years.

During the site visit it was noticed a lobby unit supply fan is equipped with V-belts. The savings calculation is only for replacing the V-belts for the lobby unit fan; however, it is highly recommended that all of the V-belts be replaced with cog-belts. The savings are based on a 2% increase of efficiency. Due to the longer life of the belts, there will also be some inherent labor savings.

The following table outlines the approximate implementation cost, savings, available incentive, and payback period associated with the V-belt replacement.

ECM #	C1.6	Fan V-belt Replacement	
		Saving Amount	Savings ($)
Savings	Steam (lbs.)	0	$0
	Water (m^3)	0	$0
	Electricity Peak (kW)	0	$0
	Electricity (kWh)	168	$15
	Total Savings ($)	$15	
Implementation Cost		$50	
Potential Incentive		$0	
Total GHG Reduction (CO_2 Tonne Equivalent)		0.0	
Simple Payback Period		Without Incentive	With Incentive
		3.3	3.3

5.3 CATEGORY 2 – ENERGY CONSERVATION MEASURES

The Energy Conservation Measures (ECMs) described below are classified as Category 2 ECMs. Category 2 ECMs are medium cost measures which range in cost from $10,001 to $100,000.

Table 5.5 – Proposed Energy Conservation Opportunities (Category 2)

Category 2 - ECMs		Utility and GHG Reduction					Implementation ($)	Potential Incentive ($)	Simple Payback with Incentive (yrs.)
ECM #	ECM Description	Water (m^3)	Natural Gas (m^3)	Electricity (kW)	Electricity (kWh)	Dollar ($)			
C2.1	Free Cooling for AC-2	0	0	0	23,152	2,084	11,000	2,315	4.2
C2.2	Replace Electrical DHW heaters with Steam heater	0	0	7	22,773	1,577	10,500	2,277	5.2
ECM Total		**0**	**0**	**7**	**45,925**	**3,660**	**21,500**	**4,593**	**4.6**

Table 5.6 – Proposed Energy Conservation Opportunities (Category 2)

Category 2 - ASHRAE Level II					
		All ECM		**ECM (Payback with Incentive < 5yrs.)**	
		Savings Amount	Savings ($)	Savings Amount	Savings ($)
Savings	Water (m^3)	0	$0	0	$0
	Natural Gas (m^3)	0	$0	0	$0
	Electricity Peak (kW)	7	$872	0	$0
	Electricity (kWh)	45,925	$4,133	23,152	$2,084
	Total Savings ($)	$3,660		$2,084	
Implementation Cost		$21,500		$11,000	
Potential Incentive		$4,593		$2,315	
Total GHG Reduction (CO_2 Tonne Equivalent)		2.3		2.3	
Simple Payback Period		Without Incentive	With Incentive	Without Incentive	With Incentive
		5.9	4.6	5.3	4.2

ECM #C2.1 – Free Cooling for AC-2

Summary and Recommendation

AC-2 provides cooling to the auditorium and is only ON when there is a performance. During the site visit it could not be confirmed whether AC-2 is capable of running in the free cooling mode during the winter. For analysis of this measure, it is assumed that AC-2 has a fixed outdoor air damper position, bringing in a fixed amount of outdoor air regardless of the outdoor temperature.

Free cooling is a method of using outdoor air instead of mechanical cooling when ambient air is below a set temperature. This can be achieved by modulating the outdoor air damper, allowing cool outdoor air into the space and exhausting an equal amount of warm inside air out to the atmosphere. The building with a constant cooling load throughout the year can get the most benefit from the free cooling strategy since free cool air is readily available instead of mechanical cooling which requires energy.

Bin table was used to calculate the saving resulting from operating AC-2 in free cooling mode when outdoor air condition allows. The cost includes installing a new modulating damper and actuators for outdoor and return air control, new economizer controls, and labour.

The following table outlines the approximate implementation cost, savings, available incentive, and payback period associated with this retrofit.

ECM #	C2.1	Free Cooling for AC-2	
		Saving Amount	Savings ($)
Savings	Steam (lbs)	0	$0
	Water (m^3)	0	$0
	Electricity Peak (kW)	0	$0
	Electricity (kWh)	23,152	$2,084
	Total Savings ($)	$2,084	
Implementation Cost		$11,000	
Potential Incentive		$2,315	
Total GHG Reduction (CO_2 Tonne Equivalent)		2.3	
Simple Payback Period		Without Incentive	With Incentive
		5.3	4.2

ECM #C2.2 – Replace Electrical DHW heaters with Steam heater

Summary and Recommendation

Currently DHW to the building is provided by three (3) electrical domestic hot water heaters located in the basement. Massey Hall is paying a fixed charge (approximately $900/month) for steam during the summer months even though steam is not used in the building. This means that steam is readily available without any extra charge to use for the DHW heating load in summer. It is recommended that the three domestic hot water heaters be replaced with one steam to hot water heat exchanger.

The efficiency of electric DHW heaters is actually higher than that of steam to hot water conversion heat exchangers. However, due to the cost of electricity, electric heaters are about twice as expensive to operate on a per BTU basis. In addition, removing electric heaters reduces electrical demand, potentially relieving the grid during peak consumption period.

The following table outlines the approximate implementation cost, savings, available incentive, and payback period associated with this retrofit.

ECM #	C2.2	Replace Electrical DHW heaters with Steam heater	
		Saving Amount	Savings ($)
Savings	Steam (lbs)	-73,050	-$1,344
	Water (m^3)	0	$0
	Electricity Peak (kW)	7	$872
	Electricity (kWh)	22,773	$2,050
	Total Savings ($)	$1,577	
Implementation Cost		$10,500	
Potential Incentive		$2,277	
Total GHG Reduction (CO_2 Tonne Equivalent)		0.0	
Simple Payback Period		Without Incentive	With Incentive
		6.7	5.2

5.4 CATEGORY 3 – ENERGY CONSERVATION MEASURES

The Energy Conservation Measures (ECMs) described below are classified as Category 3 ECMs. Category 3 ECMs are high cost measures which have a cost higher than $100,000.

There were no Category 3 ECMs identified for this building.

5.5 WATER CONSERVATION MEASURES

During the site inspection the energy audit team investigated the domestic water system within the facility. The team noticed that the electrical room AC unit uses domestic water for once through (open loop) cooling. Please refer to ECM#1.1 for more details.

5.6 ADDITIONAL ENERGY CONSERVATION MEASURES

The auditors identified several additional ECMs that were not evaluated due to several limiting factors such as poor financial performance, possible code violations, and limited available information. The following is a list of identified but unevaluated ECMs:

- Replacing all incandescent bulbs with CFL/LED as they burn out;
- Installing control valves for steam radiators;
- Installing weather stripping for the main entrance door;
- Combing AC-1 heating coil fins.

6. CONCLUSION

Through our investigations at Massey Hall, we have identified eight (8) energy conservation measures (ECMs). The measures have been classified under three (3) different categories. Category one (1) ECMs cost at most $10,000 to implement. Category two (2) measures cost up to $100,000 to implement. Category three (3) measures cost over $100,000 to implement.

Six (6) Category (I) One ECMs have been identified;

- Approximate total projected annual savings of $5,961;
- Total implementation cost for these ECMs is $14,399;
- Expected payback period of 2 years with incentives.

Two (2) Category (II) Two ECMs have been identified;

- Approximate total projected annual savings of $3,660;
- Total implementation cost for these ECMs is $21,500;
- Expected payback period of 4.6 years with incentives.

No Category (III) Three ECMs have been identified.

Appendix-A – Glossary of Terms

ASHRAE

- American Society of Heating, Refrigeration, and Air Conditioning Engineers

British Thermal Units (BTU)

- The unit of heat in the imperial system can be defined in two ways:
- The amount of heat required to raise the temperature of one pound of water through 1^{o}F (58.5^{o}F - 59.5^{o}F) at sea level (30 inches of mercury).
- 1 BTU = 1055.06 J = 107.6 kpm = 2.931 10^{-4} kWh = 0.252

Kilowatt hour (kWh)

- Is the amount of power consumed/generated over a period of one hour

Kilowatt (kW)

- Is a measure of electric power

DDC

- Direct Digital Controls

ECM

- Energy Conservation Measure

Gigajoule

- The unit of heat in the SI-system the Joule is:
- The mechanical energy which must be expended to raise the temperature of a unit weight (2 kg) of water from 0^{o}C to 1^{o}C, or from 32^{o}F to 33^{o}F.
- 1 J (Joule) = 0.1020 kpm = 2.778 10^{-7} kWh = 2.389 10^{-4} kcal = 0.7376 ft.lbf = 1 kg.m2/s2 = 1 watt second = 1 Nm = 1 ft.lb = 9.478 10-4 Btu

RS Means

- RS Means is a division of Reed Business Information that provides cost Information to the construction industry so contractors in the industry can provide accurate estimates and projections for their project costs

Simple Payback

- It is the number of years for a payback on an investment to occur ignoring any inflation pressures. This does not take into account engineering costs. The calculation is as follows:
- Simple Payback = Construction Cost / Yearly energy savings in dollars

HVAC

- Heating Ventilation and Air-conditioning

LED

- Light Emitting Diode

Appendix-B – Equipment List

System	Location	Equipment	Manufacturer	Model Number	Serial Number	Performance	Year installed	Physical Condition
HVAC	Basement	AC-1	Engineered Air			Supply fan 15 HP, Motor insulation F Steam heating coil/ DX cooling coil	1989	DX coil is going to be replaced
HVAC	Lower Roof	AC-1 Air Condenser	N/A	N/A	N/A	N/A	1989	Going to be replaced
HVAC	Lower Roof	AC-2	Engineered Air	FW-30-903	14726	30,000 CFM, Supply Fan 20 HP 9 x condenser fan, 1HP compressor 36 FLA, 575 V	1989	Good
Exhaust	Upper Roof	General Exhaust	Engineered Air	LM-8	14726 - 1	12,000 CFM Blower Motor 7.5 HP	1989	Fair
DHW	Basement	Electrical Heater	Giant	172ETE-3F8M-E8	A 5599935	73.7 US Gal, 4.5 kW	2009	Good
DHW	Basement	Electrical Heater	John Wood	JWE1202A	0103 333207	454 L, 6 kW	N/A	Good
DHW	Basement	Electrical Heater	Giant	1122B-1-3	A8539369	120 US Gal, 3 kW	2011	Good
HVAC	Mechanical Room	Lobby Supply Fan	LOREN COOK Company	24. CpS		Supply Fan 7.7 HP, Motor Insulation B	N/A	Good
HVAC	Mechanical Room	Heat Pump	Carrier	50RHR012ZCC30130	0901V6872	Refrigerant R22 Compressor RLA 5.3	N/A	Good
Exhaust	Basement Box Office Room	Exhaust Fan	Fan: Twin City Motor: Century AC Motor	Motor: C426	Motor: BW3-23	3/4 HP	N/A	Fair
DHW	Left Balcony Closet	Electrical Heater	Rheem	RR41OT	0199J22413	175 L, 3 kW	N/A	Good
DHW	right Balcony Closet	Electrical Heater	Rheem	RE10	1983001887	38 L, 1.5 kW	N/A	Good

Appendix-C – Lighting Schedule

Floor	Area	# of fixture	Type of fixture	Lamp type	Lamp Wattage	Lamp/Fixture
Basement	AC-1 Room	3	Surface Mounted	Incandescent	150 W	1
Basement	AC-1 Room	1	Surface Mounted	T8	32 W	1
Basement	Management Office	4	Pole/ Surface Mounted	Incandescent	40 W	1
Basement	Century Lounge	29	Suspended	Incandescent	100 W	1
Basement	Century Lounge	30	Pot Light	MR16	50 W	1
Basement	Steam Room	1	Surface Mounted	Incandescent	40 W	1
Basement	South Corridor	9	Surface Mounted	T8	32 W	1
Basement	DHW Heater Room	1	Surface Mounted	Incandescent	40 W	1
Basement	Dressing Room	4	Pot Light	CFL	14 W	3
Basement	Dressing Room	20	Surface Mounted	Incandescent	40 W	1
Basement	Dressing Room- WC	2	Pot Light	CFL	14 W	3
Basement	Dressing Room- WC	1	Surface Mounted	T5	28 W	1
Basement	Production A	2	Suspended	T5	28 W	1
Basement	Dressing Room 1	4	Suspended	T5	28 W	1
Basement	Dressing Room 1	20	Surface Mounted	Incandescent	40 W	1
Basement	Dressing Room 1- WC	1	Pot Light	CFL	14 W	3
Basement	Dressing Room 1- WC	1	Suspended	T5	28 W	1
Basement	Dressing Room 2	4	Suspended	T5	28 W	1
Basement	Dressing Room 2	20	Surface Mounted	Incandescent	40 W	1

Floor	Area	# of fixture	Type of fixture	Lamp type	Lamp Wattage	Lamp/Fixture
Basement	Dressing Room 2- WC	1	Pot Light	CFL	14 W	3
Basement	Dressing Room 2- WC	1	Suspended	T5	28 W	1
Basement	Catering	5	Surface Mounted	Incandescent	150 W	1
Basement	Catering	1	Suspended	T5	28 W	1
Basement	West Corridor	3	Surface Mounted	T8	32 W	2
Basement	Production B	1	Suspended	T5	28 W	1
Basement	Woman WC	14	Pot Light	MR16	35 W	1
Basement	Men WC	6	Surface Mounted	T8	32 W	1
Basement	Men WC	10	Pot Light	MR16	35 W	1
Basement	Family WC	3	Pot Light	MR16	35 W	1
Basement	North Corridor	24	Pot Light	MR16	50 W	1
Basement	Foyer	36	Pot Light	MR16	50 W	1
Basement	Mechanical Room	1	Surface Mounted	T8	32 W	1
Ground	Auditorium	30	Globe	Incandescent	150 W	1
Ground	Auditorium	64	Surface Mounted	Incandescent	100 W	1
Ground	Auditorium	16	Surface Mounted	Incandescent	40 W	1
Ground	Main Lobby	6	Surface Mounted	Halogen	90 W	1
Ground	Main Lobby	2	decorative	Halogen	90 W	1
Ground	Main Lobby	2	Surface Mounted	Incandescent	150 W	1
Ground	Corridor	4	Surface Mounted	T8	32 W	1

Floor	Area	# of fixture	Type of fixture	Lamp type	Lamp Wattage	Lamp/Fixture
Ground	Chair light	160	N/A	Incandescent	1.5 W	1
Balcony	Lounge	2	Surface Mounted	CFL	14 W	3
Balcony	Lounge	16	Surface Mounted	T8	32 W	1
Balcony	Chair light	140	N/A	Incandescent	8 W	1
Gallery	West lobby	1	Surface Mounted	CFL	42 W	6
Gallery	East lobby	1	Surface Mounted	CFL	42 W	6
Gallery	Woman WC	7	Pot Light	MR16	35 W	1
Gallery	Stair tube light	55	N/A	Incandescent	2 W	1
N/A	NW Stairway to Balcony Level	4	Surface Mounted	T8	32 W	1
N/A	SW Stairway to Balcony Level	4	Surface Mounted	T8	32 W	1
N/A	NE Stairway to Balcony Level	4	Surface Mounted	T8	32 W	1
N/A	SE Stairway to Balcony Level	4	Surface Mounted	T8	32 W	1
N/A	NW Stairway to gallery Level	6	Surface Mounted	T8	32 W	1
N/A	SW Stairway to gallery Level	6	Surface Mounted	T8	32 W	1
N/A	NE Stairway to gallery Level	6	Surface Mounted	T8	32 W	1
N/A	SE Stairway to gallery Level	6	Surface Mounted	T8	32 W	1
N/A	N/A	8	Exit Sign	LED	3 W	1
N/A	Auditorium	25	Exit Sign	N/A	N/A	N/A
Ground	Main Lobby	4	Exit Sign	CFL	9 W	2

Appendix-D – Utility Data

Table D.1 – Electrical Consumption

Utility Invoice Data								
Month	Period Start	Period End	No. of Days	Meter Reading Usage (kWh)	Demand (kW)	Demand (kVA)	Period Adjusted Usage (kWh)	Charge (Tax Excluded)
Jan-12	12/23/11	23/01/12	31	58,360	214	245	59,559	8,659
Feb-12	1/23/12	23/02/12	31	63,006	218	263	59,961	9,413
Mar-12	2/23/12	23/03/12	29	63,868	216	292	67,860	9,413
Apr-12	3/23/12	23/04/12	31	66,676	265	352	63,817	11,494
May-12	4/23/12	23/05/12	30	61,491	191	242	69,442	9,908
Jun-12	5/23/12	23/06/12	31	86,410	345	410	74,798	13,573
Jul-12	6/23/12	23/07/12	30	45,802	320	399	47,882	9,615
Aug-12	7/23/12	23/08/12	31	49,471	289	371	50,079	9,121
Sep-12	8/23/12	23/09/12	31	51,826	320	416	48,320	9,629
Oct-12	9/23/12	23/10/12	30	42,294	238	295	45,501	8,072
Nov-12	10/23/12	23/11/12	31	50,668	210	269	48,911	8,720
Dec-12	11/23/12	23/12/12	30	48,508	188	236	47,498	8,214
Total 2012								
Jan-13	12/23/12	23/01/13	31	39,945	171	200	40,542	4,908
Feb-13	1/23/13	23/02/13	31	42,259	165	195	39,299	5,791
Mar-13	2/23/13	23/03/13	28	44,496	205	255	47,953	6,045
Apr-13	3/23/13	23/04/13	31	44,183	216	266	41,536	6,577
May-13	4/23/13	23/05/13	30	37,519	287	371	40,329	6,352
Jun-13	5/23/13	23/06/13	31	44,812	326	414	44,499	7,866
Jul-13	6/23/13	23/07/13	30	48,223	315	383	45,316	9,279
Aug-13	7/23/13	23/08/13	31	32,339	305	379	40,964	6,106
Sep-13	8/23/13	23/09/13	31	65,762	352	433	63,007	11,601
Oct-13	9/23/13	23/10/13	30	60,926	280	356	61,601	9,298
Nov-13	10/23/13	23/11/13	31	57,704	224	285	54,329	7,775
Dec-13	11/23/13	12/23/13	30	49,357	188	228	37,840	7,718
Total 2013								
Total Year 1	Jan-12	Dec-12	366	688,379	251	316	683,627	115,831
Total Year 2	Jan-13	Dec-13	366	567,524	253	314	557,216	89,317
Average				627,952	252	315	620,421	102,574

Table D.2 – Steam Consumption

Steam Utility Invoice Data					Weather Normalized Usage	
Month	Meter Reading Usage (lbs)	Period Adjusted Usage (lbs)	Usage (MJ)	Charge [$] (GST Exc)	HDD [°C]	HDD Relative (lbs)
Jan-12	602,783	566,251	706,115	8,670	357	388,787
Feb-12	496,440	479,892	598,425	7,286	298	323,946
Mar-12	258,580	252,503	314,871	4,189	138	150,633
Apr-12	72,452	67,924	84,701	1,765	96	104,549
May-12	2,646	2,563	3,196	856	0	0
Jun-12	0	0	0	822	0	0
Jul-12	0	0	0	822	0	0
Aug-12	0	0	0	822	0	0
Oct-12	0	0	0	822	0	499
Oct-12	75,673	73,232	91,320	1,807	44	48,179
Nov-12	239,230	231,513	288,697	3,643	199	216,604
Dec-12	224,071	217,069	270,685	3,466	278	302,210
Total 2012						
Jan-13	317,123	307,213	383,094	$4,554	378	411,929
Feb-13	285,298	275,460	343,499	$4,182	397	432,454
Mar-13	214,806	208,093	259,492	$3,358	305	332,381
Apr-13	115,009	111,299	138,790	$2,191	134	146,198
May-13	10,503	10,175	12,688	$969	16	17,138
Jun-13	0	0	0	$847	0	0
Jul-13	0	0	0	$847	0	0
Aug-13	0	0	0	$847	0	0
Sep-13	5,340	5,168	6,444	$909	0	0
Oct-13	29,906	28,971	36,127	$350	51	55,172
Nov-13	210,708	203,911	254,277	$3,558	227	247,401
Dec-13	616,076	561,716	700,460	$8,722	432	470,317
Total 2013						
					Total (2 Years) (m3)	3,648,398
Total Year 1	1,971,875	1,890,946	2,358,010	34,971	Average (2 Years) (m3)	1,824,199
Total Year 2	1,804,769	1,712,007	2,134,872	31,332	Average cost (2 years) ($)	32,026
Average	1,888,322	1,801,476	2,246,441	33,152	MJ/Year	2,274,776
					%	100.00%

Table D.3 – Water Consumption

From	To	Meter #	Days	m^3	Charge [$] (GST Exc.)
18/06/12	16/07/12	70258150.00	28	415	1,087
16/07/12	12/11/12	70258150.00	119	2,144	5,619
12/11/12	11/03/13	70258150.00	119	2,916	8,046
11/03/13	15/07/13	70258150.00	126	2,748	7,851
15/07/13	11/11/13	70258150.00	119	2,788	7,965

End of Report