MCGILL UNIVERSITY SERVICES | UTILITIES AND ENERGY MANAGEMENT

→ need info from June

Energy Consumption 2006-2011

Presented to McGill University Centre

20 years payback for replacing HVAC

Report by Felicia Parr

8/26/2011

Revision 1 by Jerome Conraud, Jr. Eng.

11/07/2011

re: entire ventilation system – Ron Proulx would lead (from Operations)

weekly meetings w/ Operations when they schedule on things

McGill

EXECUTIVE SUMMARY

McGill spends over 20 million dollars in energy expenditures annually. While this budget is central, some administrative units such as yours have to pay for their energy bills. As a utility services provider and as the warden of energy efficiency on campus, our team set out to write a five-year consumption report for all these administrative units.

The purpose of this report is twofold: we wish to be more transparent about our activities and improve our partnership with our clients, but this endeavour also aims to give you a better understanding of your energy use and expenditures. Additionally, this report will help you control your cost and reduce your energy footprint. The report comprises sections explaining how your bills are calculated as well as a five-year outlook on your energy use.

Some of the key comments of this report are:

- Complete data for the University Centre is only available from FY 2009-2010 onward due to missing data for power and electricity from 2006-2008. Therefore, it is hard to conclude on whether energy use is up or down.
- There is no consumption data for chilled water in FY 2008-2009.
- Consumption data compiled in this report is relatively close to—albeit a little higher than—BPR's 2010 energy audit report of the building with the exception of chilled water consumption which appears to be twice higher than BPR's estimate.
- The energy consumption of your building is now publicly displayed on McGill's energy dashboard which you can access from the following link: mcgill.pulseenergy.com
- Over the five-year period, an estimated 12% of the bills contained errors. U&EMgmt intends to correct this situation by automating the billing process to avoid human interaction, and thus, potential errors. Quality control elements will be implemented to reduce and track errors.

The report was prepared by BEng – Mechanical student Felicia Parr during her summer internship under the supervision of Energy Manager Jerome Conraud, Jr. Eng.

Table of Contents

List of Tables

List of Figures

List of Equations

1. University Centre Overview

The University Centre, usually known as the William Shatner building and which hosts SSMU, is composed of two electrical meters as shown in Figure 1, 150-MECL-SS1(050)-2 and 165-MECL-SS1(B28)-1, which is subtracted because the electricity is supplied to Peterson Hall.

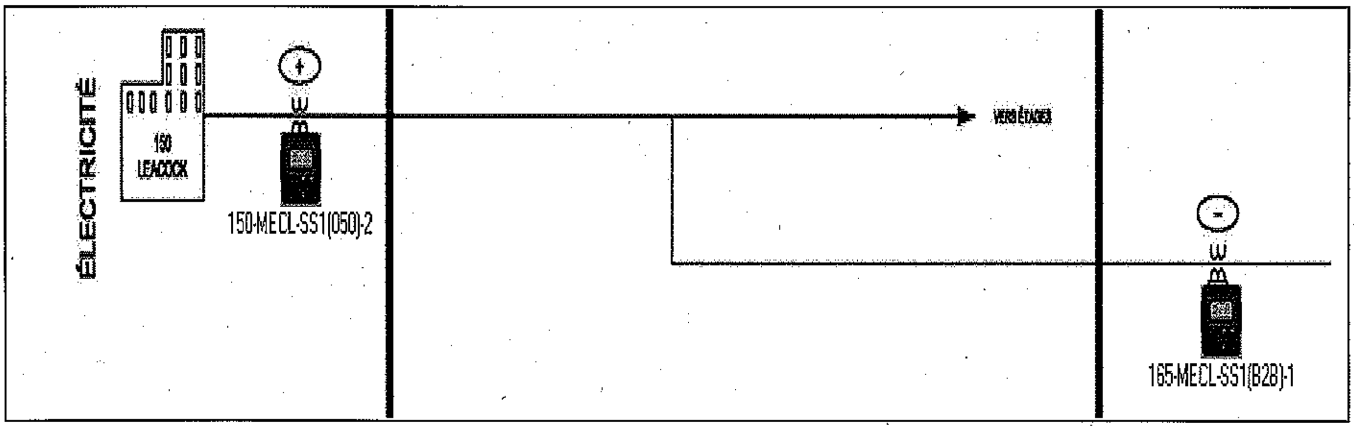


Figure 1 - Electrical Meter Diagram

There is one steam meter, 172-CV-SS2(SB15)-1, and one condensate meter, 172-CC-SS2(SB15)-1, shown in Figure 2 and Figure 3, respectively.

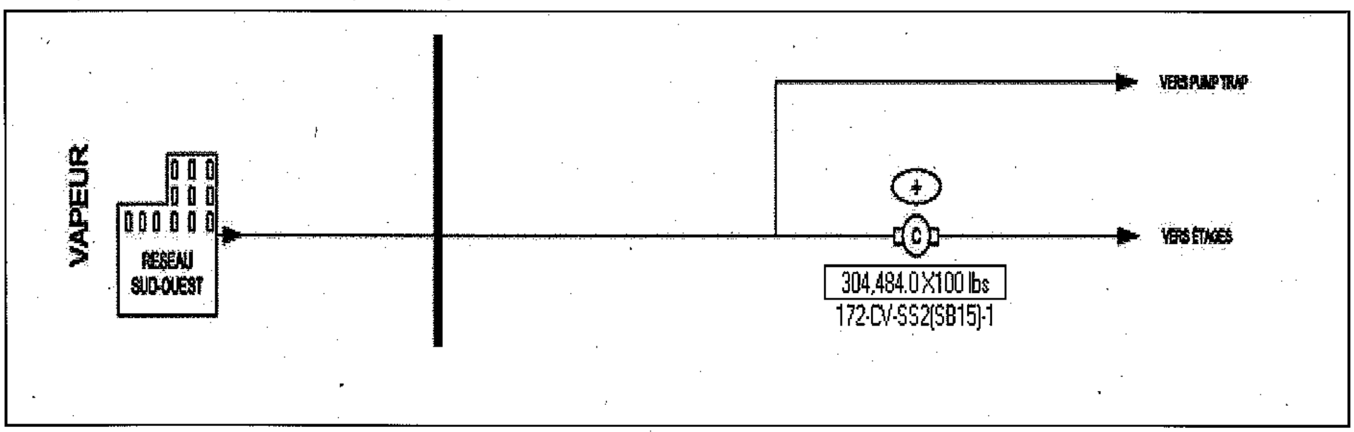


Figure 2 - Steam Meter Diagram

Steam
electricity
distilled water

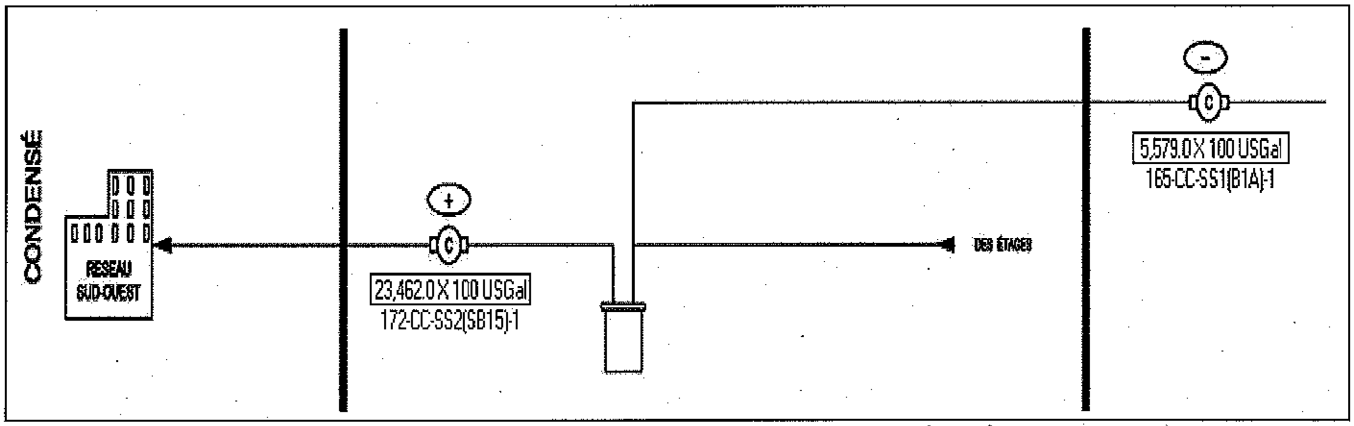
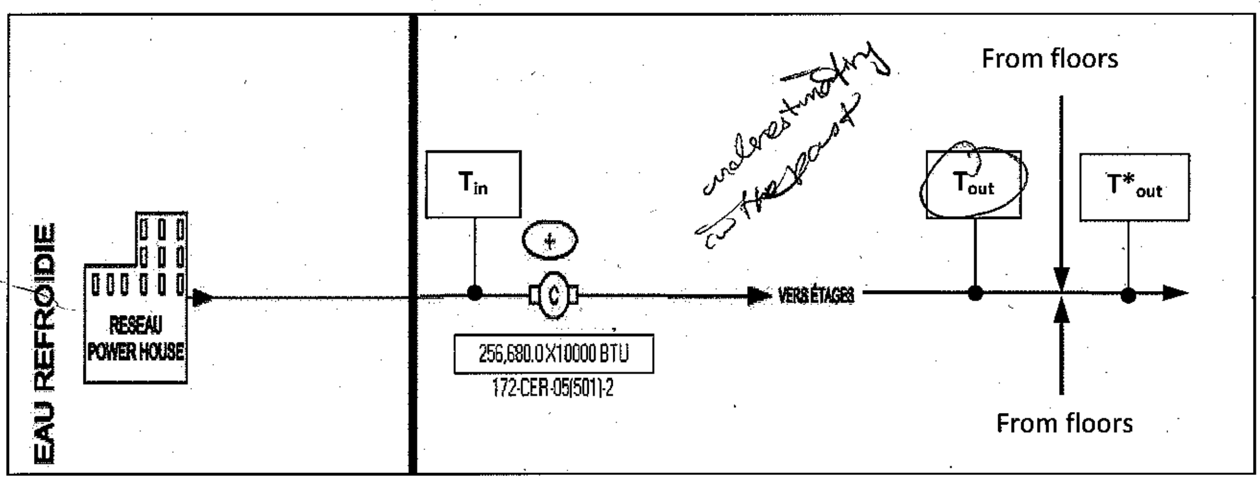


Figure 3 - Condensate Meter Diagram → Steam condenses in water (needed more in summer)

Finally, the University Centre has two chilled water meters, 172-CER-05(501)-2 and 172-CER-05(501)-1, shown in Figure 4.

In 2010-2011, U&EMgmt performed a review of all existing metering installations in order to validate and certify each setup much to the fashion of big utility companies such as Hydro Québec. During this review, U&EMgmt noticed that the sensor that reads the temperature of the chilled water flowing out of the building (T_{out}) was not located at the right location to correctly estimate the total chilled water use of the building. The proper location to read all the chilled water flowing out of the building is labelled on Figure 4 as T^*_{out}. The direct consequence of this is that the chilled water consumption for the building has most likely been underestimated until now. This fall, U&EMgmt will make the necessary modifications to the existing setup to correct the situation and ensure chilled water energy use is correctly metered in the future. More information on the impact of this change on your monthly invoice is detailed in the Money Matters section of this report.



underestimating in the past

Figure 4 - Chilled Water Diagram

chilled water meter – currently calibrated but not validated

2. Determination of Cost Overview

1) Electricity

Three important pieces of information are obtained from the electrical meters: the power demand in kW, the energy consumed in kWh and the apparent power in kVA. We are interested in the peak power demand over a whole month for both kW and kVA. To calculate the cost for power demand, the maximum value between the peak monthly power demand in kW and 95% of the peak monthly apparent power (kVA) is taken, multiplied by the number of days in a month, divided by 30, and multiplied by the unit power demand cost from Hydro Quebec, which varies yearly. This seemingly complicated formula reflects Hydro Quebec's rate. This is shown in Equation 1.

$$MAX(Power\ in\ kW, 0.95 * Apparent\ Power\ in\ kVA) * \frac{\#days\ in\ a\ month}{30} * rate\,\frac{\$}{kW}$$

Equation 1 - Demand Cost

The cost for energy is simply the energy value in kWh multiplied by the unit cost per kWh, which also varies yearly, shown in Equation 2.

$$Energy\ Consumption\ (kWh) * \ rate\,\frac{\$}{kWh}$$

Equation 2 - Energy Cost

Finally, the costs for energy and power can be added and the total cost for electricity consumption is found as shown in Equation 3. Electricity is billed according to rate "L" for Hydro Québec.

$$Total\ Cost = Power\ Demand\ Cost + Energy\ Consumption\ Cost$$

Equation 3 - Total Cost

2) Steam & Condensate

The cost of steam is calculated in a similar manner: the maximum value between steam in lbs and condensate in lbs is read off the steam and condensate meters and is multiplied by the unit cost per 1,000 lbs.

Steam meters are located at the inlet of the buildings while condensate meters are typically located at the outlet. As a consequence, condensate meters read values smaller than those read by the steam meters at the inlet of the buildings due to the various kinds of losses occurring in the building (sterilization processes, driers, leaks, etc). Moreover, the steam flow rate during the summer months are generally very low and steam meters are consequently out of the operating range. To make up for the inherent flaws of steam and condensate meters, we always take the maximum value between steam and condensate return meter. This is shown in Equation 4.

$$MAX(steam\ in\ lbs, condensate\ in\ lbs) * rate \frac{\$}{1{,}000 lbs}$$

Equation 4 - Steam Cost

The unit cost per 1,000 lbs varies per month and is based on variable costs and fixed costs defrayed by McGill to produce and distribute steam on the Downtown Campus. Fixed costs include cost of equipment, cost of maintenance, materials, labour, etc. Variable costs are directly related to the amount of steam consumed in that month and include mainly the cost of natural gas. The more steam consumed, the less expensive the cost.

3) Chilled Water

University Centre is provided in steam by an adsorption chiller (i.e. a chiller that runs on steam). The cost of chilled water is calculated by converting BTU to pounds (lbs) by dividing by 960 and then multiplying it by the steam rate as shown in Equation 5.

$$\frac{Chilled\ water\ BTU}{960} * rate \frac{\$}{1{,}000\ lbs}$$

Equation 5 - Chilled Water Cost

A project is under way to replace the current adsorption chiller for an electric chiller that would be in operation as of May 2012. Further to increasing energy efficiency, this option will be advantageous to our clients as the cost of electricity is much lower than the average summer steam rate. Consequently, Equation 5 will not hold anymore; U&EMgmt will notify University Centre's Building Director of the change when it occurs.

3. Analysis of Energy Consumed over a 5 Year Period

Part 1) Consumption Overview

Figure 5 and Table 1 show electricity and cost over a five year period. It can be seen that energy and cost is steadily increasing, meaning measures must be taken in order to reduce energy consumption and therefore, cost.

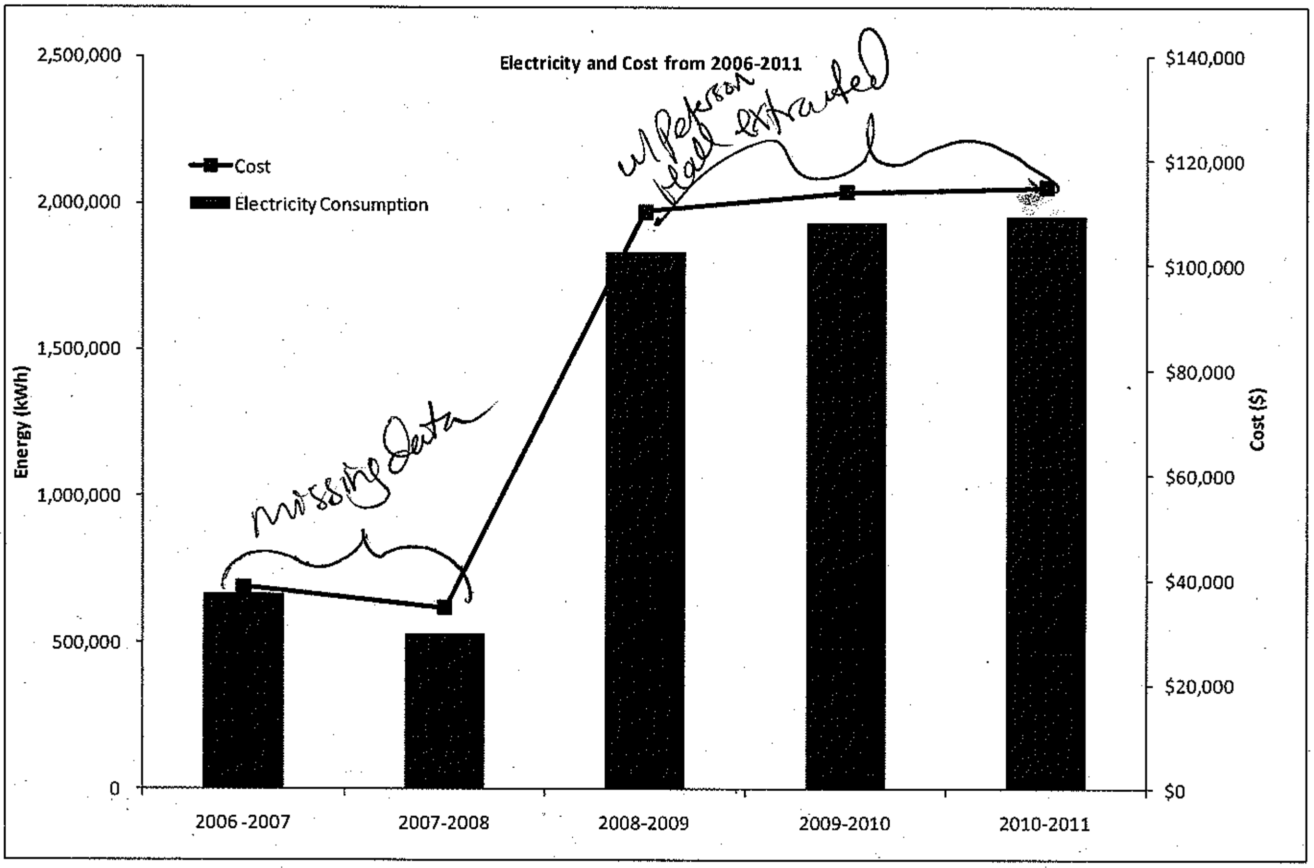


Figure 5 - Energy Consumption (kWh) and Cost 2006-2011

Summary of Consumption	2006-2007[1]	2007-2008[2]	2008-2009	2009-2010	2010-2011
Total Power Demand kW	**1,501**	**1,352**	**3,853**	**3,912**	**3,905**
Total Energy Demand kWh	**667,190**	**531,706**	**1,832,582**	**1,932,060**	**1,954,722**
Total Electricity Cost	**$38,698**	**$34,719**	**$110,251**	**$114,024**	**$114,938**

Table 1 - Energy Demand, Power Demand and Cost 2006-2011

[1] Note that 2006-2007 shows significant less consumption of energy due to missing data.
[2] Note that 2007-2008 shows significant less consumption of energy due to missing data.

Figure 6 and Table 2 show information on steam/condensate and cost over the last five years. It can be seen that the steam consumption, as well as cost, has been decreasing substantially. This is a good sign and measures taken to reduce steam and condensate consumption should be continued as they are now.

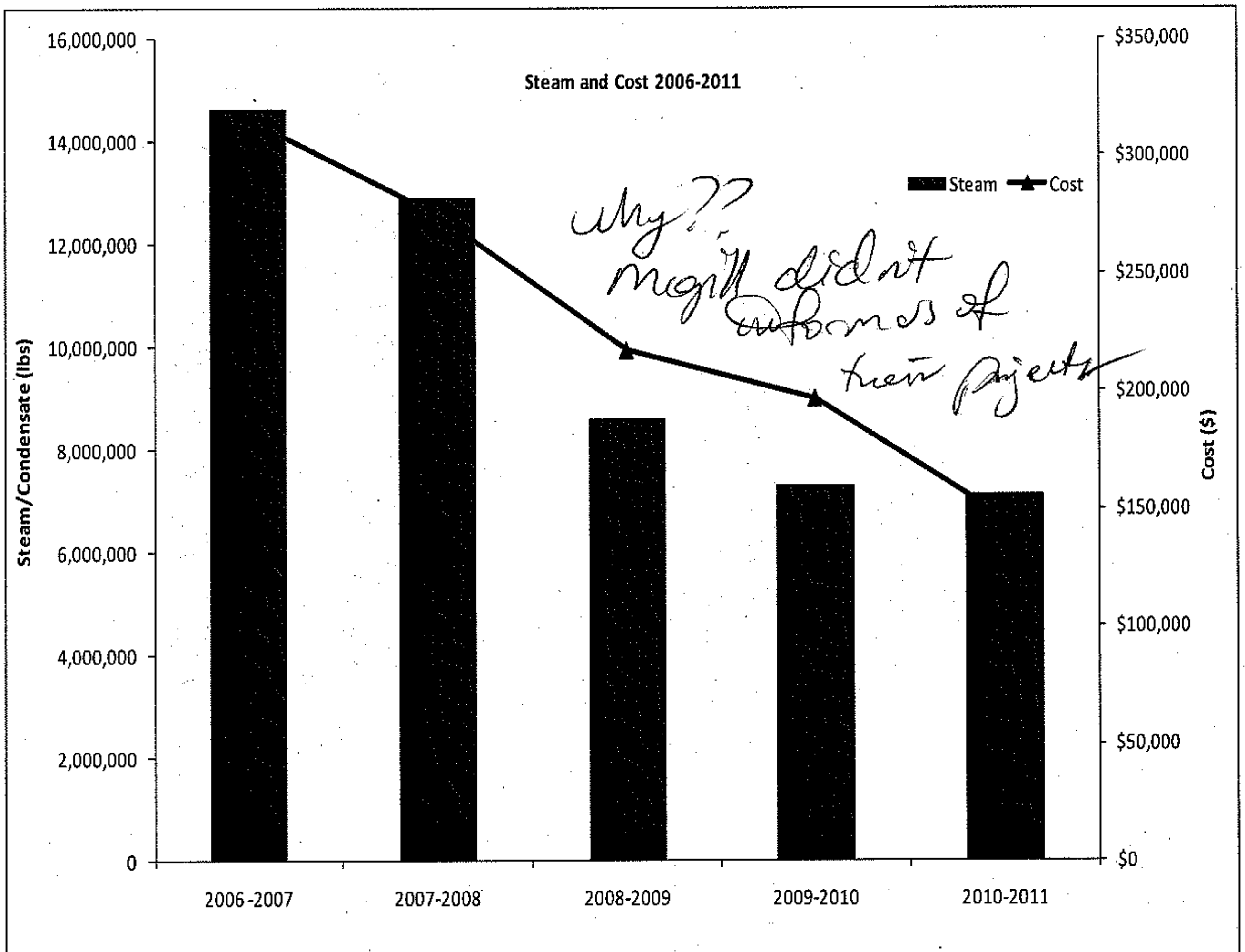


Figure 6 - Steam, condensate (lbs) and Cost 2006-2011

Summary of Consumption	2006-2007	2007-2008	2008-2009[3]	2009-2010	2010-2011
Total Steam Demand lbs	8,422,900	6,935,918	8,582,441	5,941,600	5,947,000
Total Condensate lbs	14,595,478	12,882,137		7,290,246	7,125,308
Total Steam Cost	$315,732	$274,677	$216,889	$196,500	$145,925

Table 2 - Steam, Condensate and Cost 2006-2011

[3] Note that the condensate meter was not functioning for most of 2008-2009.

Figure 7 and Table 3 shows no relationship over the past five years. It seems to decrease sharply in 2008-2009 and then increase by a large amount in the subsequent years.

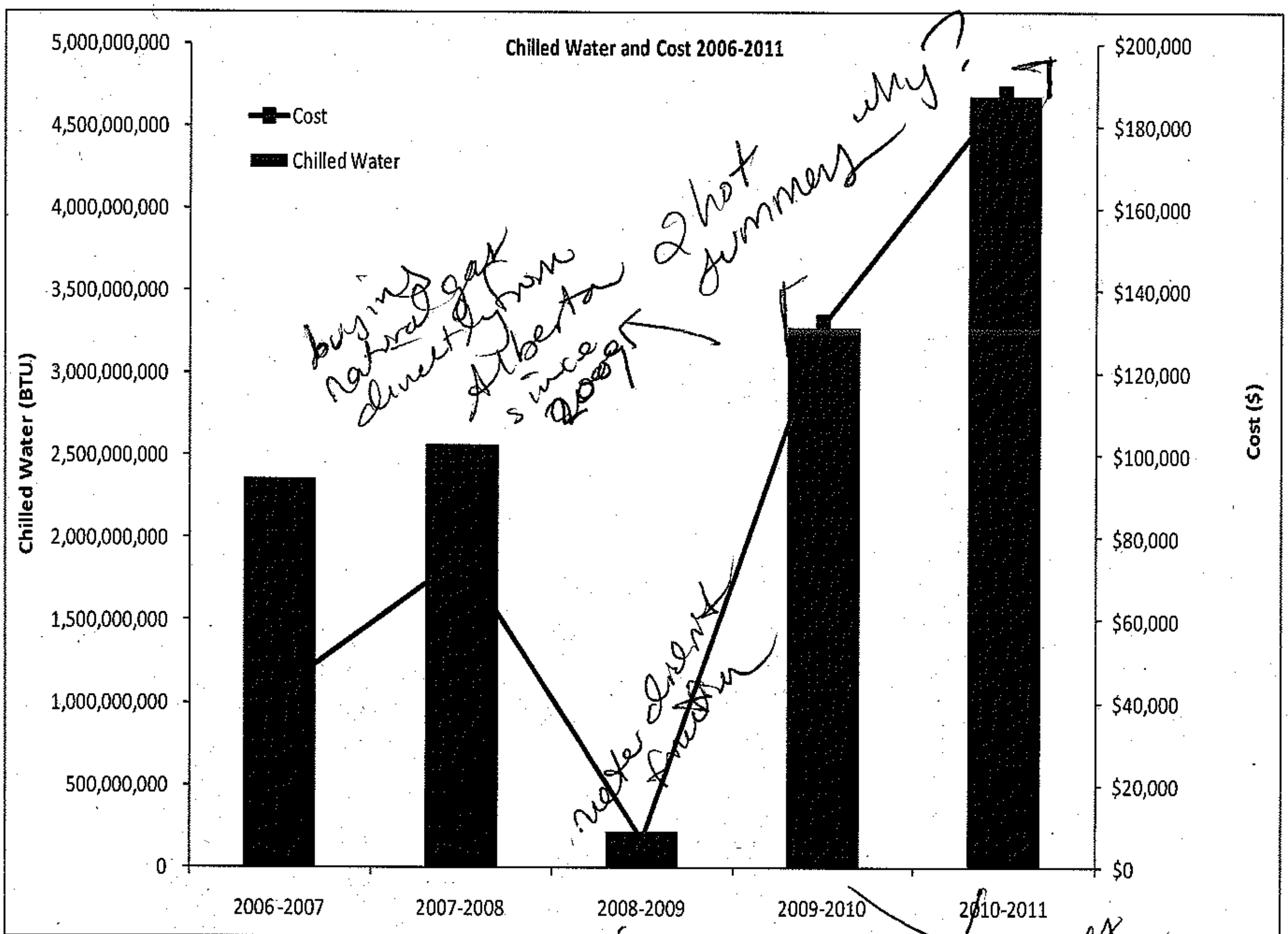


Figure 7 - Chilled Water consumption (BTU) and Cost 2006-2011

Summary of Consumption	2006-2007	2007-2008	2008-2009[4]	2009-2010	2010-2011
Chilled Water (BTU)	**2,361,180,000**	**2,565,270,000**	**218,420,000**	**3,279,080,000**	**4,680,150,000**
Chilled Water Cost	**$43,098**	**$75,368**	**$6,533**	**$131,873**	**$187,899**

Table 3 - Chilled Water consumption (BTU) and Cost 2006-2011

The sharp increase in the cost of chilled water during the summer months is a correlate of McGill's new natural gas purchasing strategy. With this new strategy, natural gas in the summer costs much more than it used to; conversely, it costs much less than it used to in the winter when

[4] There are no readings for chilled water in 2008-2009, which explains the sharp decrease in price and BTU.

consumption is at its peak. Globally, the savings realized during the winter months more than make up for the higher summer rate.

The purchasing of natural gas comprises several services: 1) physical gas, which is produced in Alberta, 2) transport of this gas from Alberta's natural gas fields until the Province of Québec, and 3) distribution services. The first two items (physical gas and transport) can be purchased to providers other than Gaz Métro at a more interesting price. However, due to the provincial jurisdiction, Gaz Métro is the sole authorized service provider for the last item (distribution). As of July 2009, in order to save on energy expenditures, McGill started to purchase natural directly from producers located in Alberta – we used to purchase natural gas directly from Gaz Métro before. By virtue of the law, McGill still purchases distribution services from Gaz Métro. The impact of switching from Gaz Métro to gas producers located in Alberta is better explained in the table below. In a nutshell, McGill pays more than before in the summer, less than before in the winter, and on the overall, less than before on average.

Item	Before July 2009	After July 2009
Physical Gas and Transport	From Gaz Métro. Monthly bill calculated based on the actual monthly consumption.	From Shell (producer). Monthly bill calculated based on an average monthly consumption (i.e. total annual consumption divided by 12 billing periods).
Distribution	From Gaz Métro. Monthly bill calculated based on the actual monthly consumption.	From Gaz Métro. Monthly bill calculated on the actual monthly consumption.

Table 4 - Change in Natural Gas Purchasing Strategy

Part 2) Comparison with BPR's 2010 Report

For comparison purposes, U&EMgmt used the energy audit report of the University Centre written by BPR in 2010[5]. Table 5 below shows the estimate of energy use and cost summarized in *Tableau 9 – Consommation énergétique pour l'année 2008-2009* in the energy audit report written by BPR in 2010. We used the values in this report as a basis for comparison.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Reference Energy Use	1,607,132	90,160	2,366,525,000	60,871	8,243,994	205,688	16,717	356,719

Table 5 - Estimate Energy Use from BPR's 2010 Report

[5] BPR 2010, *Étude énergétique – University Centre*, n° projet BPR 04218, n° projet McGill WO931354, Rev C 19 mars 2010

The following tables show how energy use and cost varied for each utility, using BPR's report as a reference year. The most salient points of these comparisons are the significant difference between BPR's estimated chilled water consumption and cost with the actual consumption read off the meter (see Table 7) and calculated by U&EMgmt (see explanations in previous section). There also are significant differences between BPR's report and actual metered data for total energy use. Several parameters can explain these differences, starting with changes in weather conditions and operations of the building.

BPR	1,607,132	--	90,160	--
2008-2009	1,832,582	14%	110,251	22%
2009-2010	1,932,060	20%	114,024	26%
2010-2011	1,954,722	22%	114,938	27%

Table 6 - Annual Electricity Consumption and Cost Compared to Reference

BPR	2,366,525,000	--	60,871	--
2008-2009[6]	218,420,000	n/a	6,533	n/a
2009-2010	3,279,080,000	39%	131,873	117%
2010-2011	4,680,150,000	98%	187,899	209%

Table 7 - Annual Chilled Water Consumption and Cost Compared to Reference

BPR	8,243,994	--	205,688	--
2008-2009	9,396,188	14%	216,889	5%
2009-2010	9,656,576	17%	196,500	-4%
2010-2011	7,137,454	-13%	145,925	-29%

Table 8 - Annual Steam Consumption and Cost Compared to Reference

BPR	16,171	--	356,719	--
2008-2009[7]	15,519	-4%	333,673	-6%
2009-2010	19,347	20%	442,397	24%
2010-2011	18,577	15%	448,762	26%

Table 9 - Annual Total Energy Use and Cost Compared to Reference

[6] 2008-2009 has missing data for chilled water
[7] 2008-2009 has missing data for chilled water

Part 3) Breakdown per Utility

The following pie charts illustrate how much energy was used per utility and what the percentage of the total cost was per utility in 2009-2010 and 2010-2011.

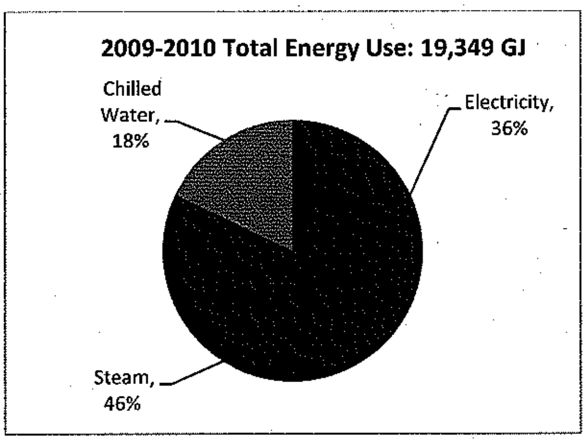


Figure 8 - Breakdown of Energy Use per Utility (FY09-10)

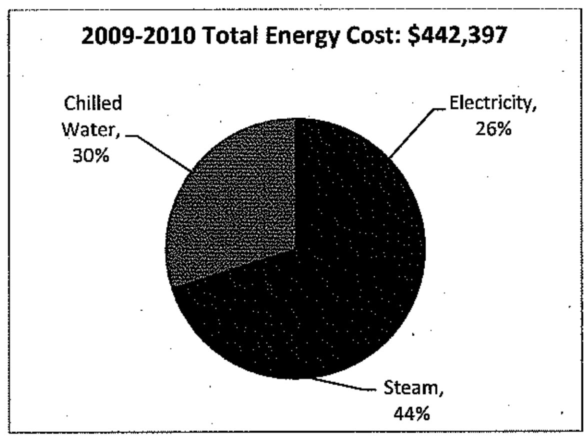


Figure 10 - Breakdown of Energy Cost per Utility (FY 09-10)

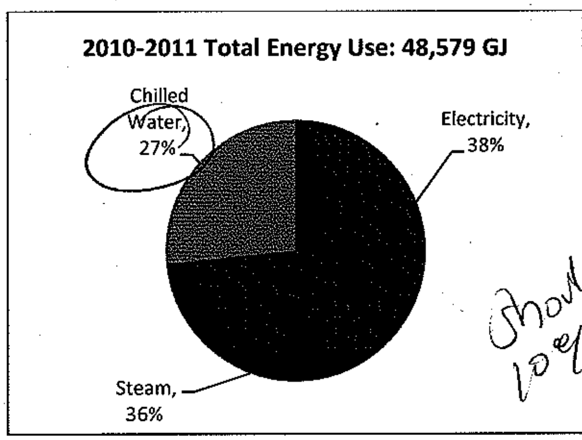


Figure 9 - Breakdown of Energy Use per Utility (FY10-11)

should be 10% or less

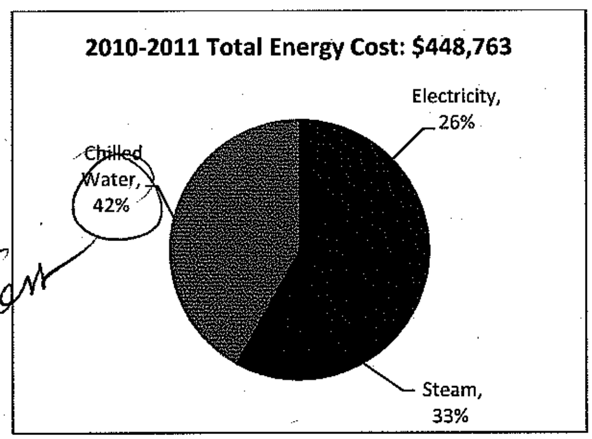


Figure 11 - Breakdown of Energy Cost per Utility (FY 10-11)

4. Greenhouse Gas Emissions

The following table shows the greenhouse gas emissions per utility for the University Centre. Additionally, it illustrates the number of cars and trees which would be equivalent to the total amount of GHG emissions released by the building. For instance, for FY 08-09, the University Centre emitted as much CO2 as 146 six cars would have during the same year. Likewise, it would have taken 16,583 mature trees to capture the CO2 emitted by the University Centre during that year.

	GHG Emissions for Electricity (t CO2 eq)	GHG Emissions for Natural Gas (t CO2 eq)	GHG Emissions for Chilled Water (t CO2 eq)	Total GHG Emissions (t CO2 eq)	Equivalent Number of Cars	Equivalent Number of Trees
FY 08-09[8]	4	601	42	647	146	16,583
FY 09-10	4	493	615	1,112	252	28,512
FY 10-11	4	459	837	1,300	294	33,332

Table 10 - Greenhouse Gas Emissions per Utility

[8] Note that GHG emissions are underestimated due to missing data for chilled water in 2008-2009.

5. Check the Pulse of Your Building

Figure 12 is a snapshot of McGill's Energy Dashboard portraying a month's worth of energy consumption in the University Centre. The Dashboard is a perfect tool to let us know when and how much energy was consumed. The data for steam, electricity and total energy in GJ can be displayed with the aid of this software.

It is important to have a tool such as the dashboard in order to clearly see the effect certain events have on energy consumption.

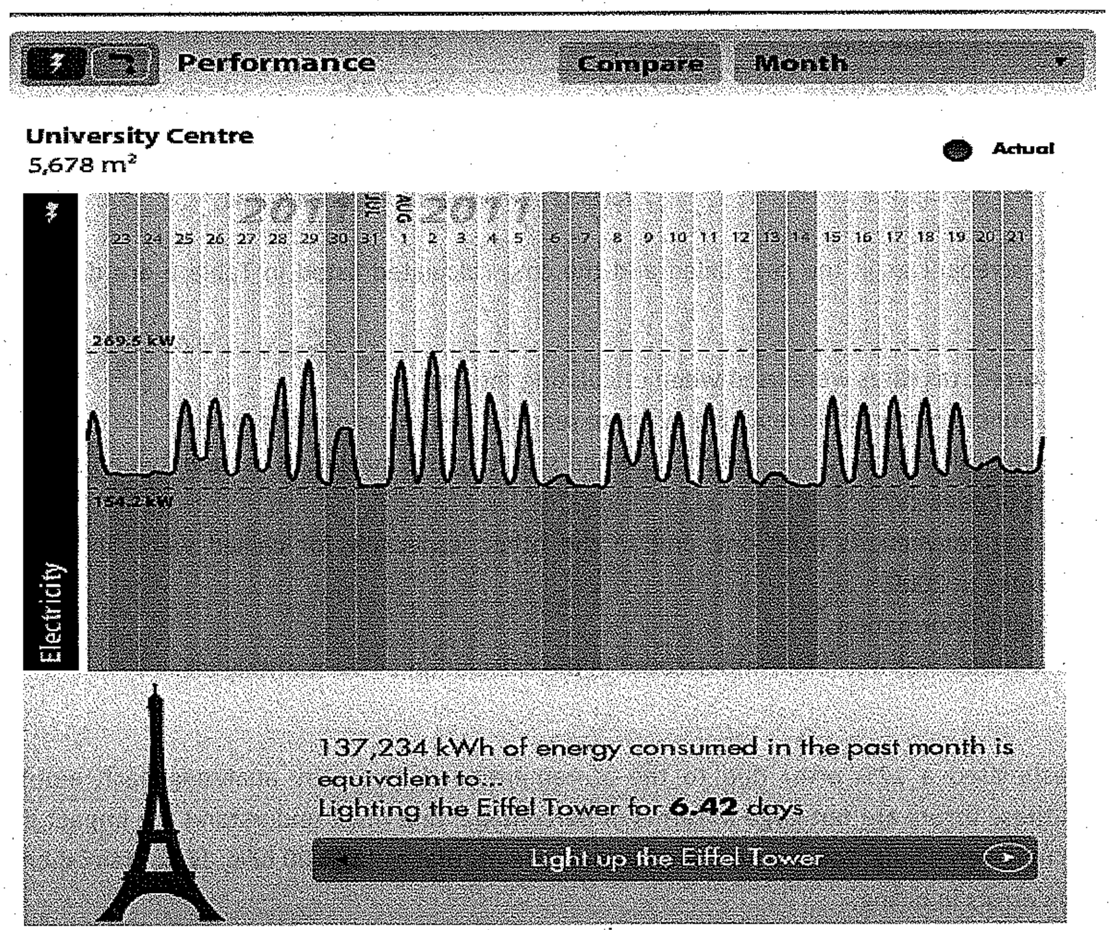


Figure 12 - Snapshot of University Centre on the Pulse Energy Dashboard

Link to the Pulse Energy Dashboard for the University Centre:

http://mcgill.pulseenergy.com/dashboard/#/location/1006

6. Money Matters

The following tables show how much was billed to each building, each year, as well as the right amount or "calculated cost" (i.e. what should have been charged). The "Price Difference" column is the value obtained by subtracting "calculated cost" with "cost billed". A positive "price difference" translates into a cost billed smaller than the true, calculated cost. Note that "calculated cost" includes any adjustment that might have been made to correct then-identified billing errors.

Table 6 shows how much was billed to each building, each year, as well as the right amount or "calculated cost" (i.e. what should have been charged).

2008-2009	$333,674	$324,884	-$8,790
2009-2010	$442,397	$477,333	$34,936
2010-2011	$448,763	$459,876	$11,113

Table 11 - Differences in Prices 2008-2011

The large discrepancies in the cost billed and the cost calculated listed in Table 6 are due to several factors:

1- Incorrect tax rates were used when calculating the cost.
2- Malfunctioning meters resulting in a zero reading, and therefore a zero cost.
3- Wrong calculations were performed when selecting the maximum value between peak kW and 95% of peak kVA.
4- Wrong conversions from one unit to the other, especially for chilled water in the summer months of 2009.
5- Missing information.
6- One meter was not taken into account in the calculation of the monthly bill.

We estimated a 12% error due to the aforementioned errors by analyzing each monthly bill. Although these errors are not large in terms of percentage, one must understand the impact even one error can make on billing. For example, a 12% error means that out of 100 bills, 12 contained errors and resulted in errors in billing.

McGill Utilities and Energy Management aims to prevent these discrepancies in the future by implementing an automated computer system and eliminating any calculations performed by humans. To this end, Utilities and Energy Management is doing due diligence by investigating several software solutions available on the market and meeting requirements identified by the team.

Figure 13 portrays the variation in cost per 1,000 lbs, cost per GJ and cost per 1,000,000 BTU over a three year period in each building and Figure 14 portrays the variation in cost per kWh. The University Centre sees less than a 10% variation and decrease in cost over the three years for electricity, whereas the cost for chilled water sees an increase and variation up to 50% over the three years. Steam sees no real pattern and the total energy in GJ displays consistent behaviour.

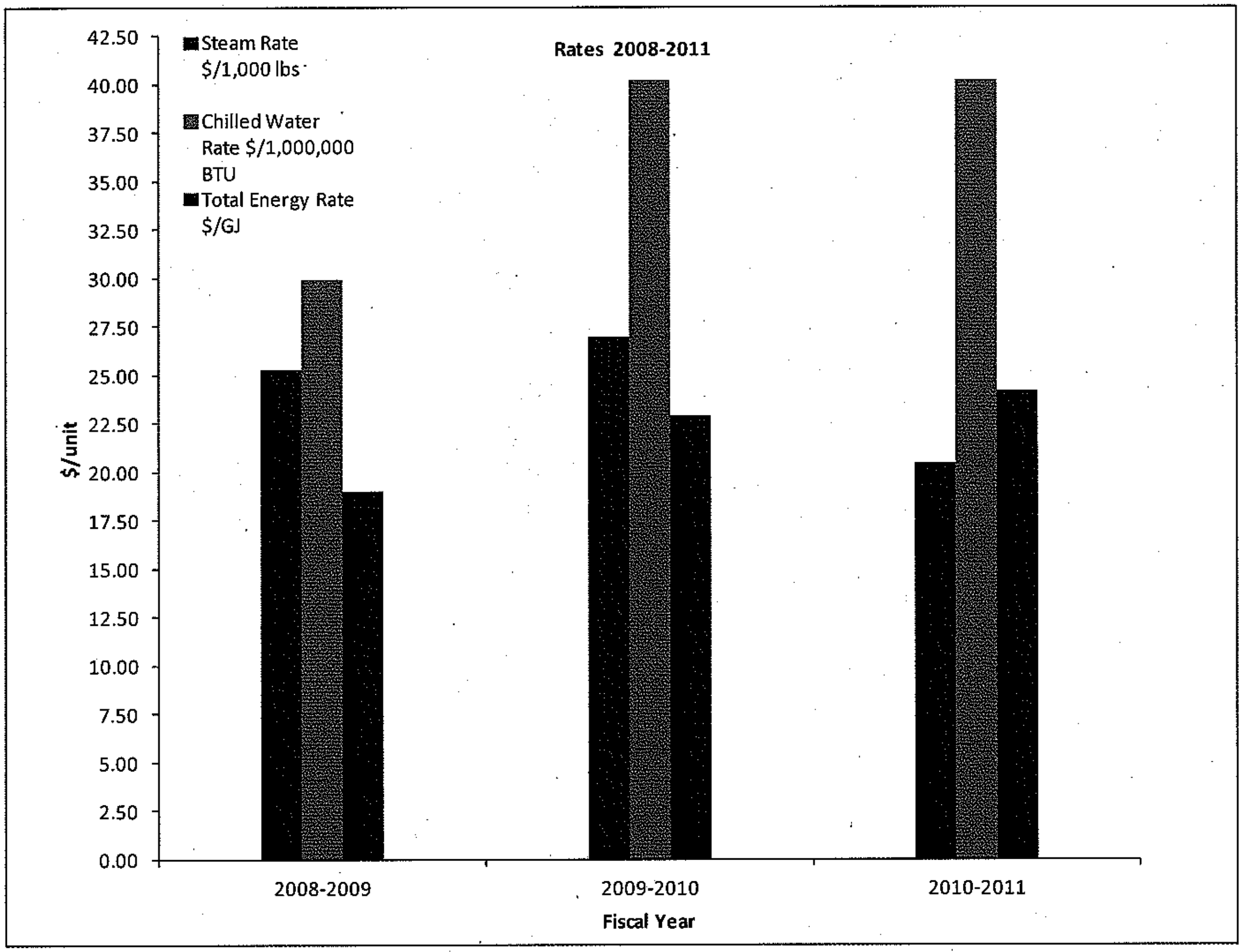


Figure 13 - Rates per Unit

As explained before, the high cost of chilled water in the summer is attributable to the new natural gas purchasing strategy and to the low demand for steam on campus during the summer months. This situation will be corrected next year as the adsorption (i.e., steam powered) chiller will be replaced by an electric chiller. The unit cost of chilled water ($/BTU) will be much lower than it now is and even if the chilled water use of the building increases (which is bound to happen given that one of the two temperature sensors was not located at the right place until recently), the total cost for chilled water will be much lower than it has been for the past two years.

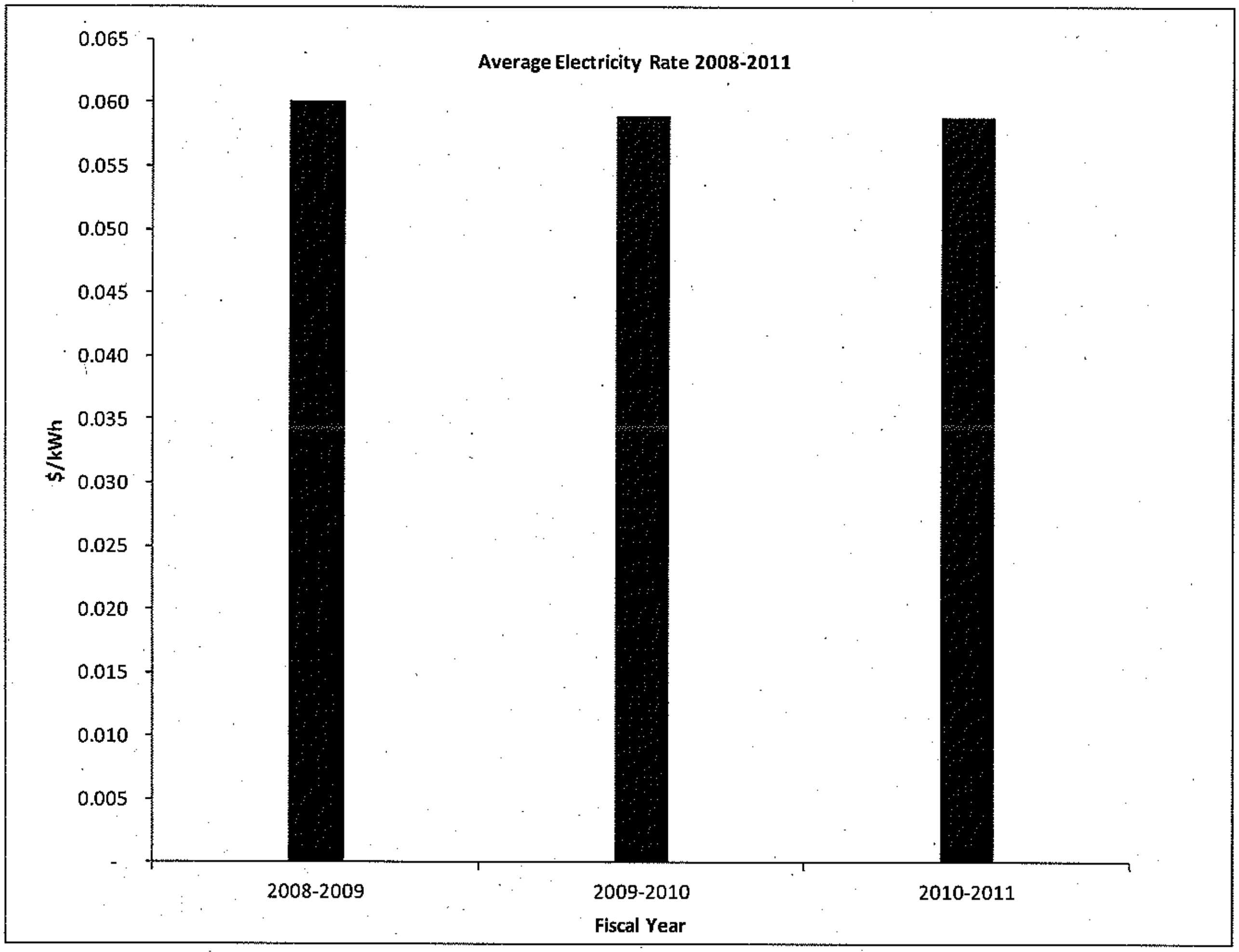


Figure 14 - $/kWh Variation

7. Where Do You Currently Stand in Terms of Energy?

The amount of energy per building in the University Centre in GJ (gigajoules) was divided by the area of the building in order to analyze how much energy per square meter was being used per year. This information was then compared to "norm" to benchmark against buildings with the same location.

This comparison helps us better understand where we rank in terms of energy consumption. This "norm" was obtained from the statistics on energy use in the "commercial/institutional sector" Natural Resources Canada 2008. The energy intensity for University Centre is shown in Figure 15 and it can be observed that our energy intensity is greater than the "norm" in the commercial/institutional sector.

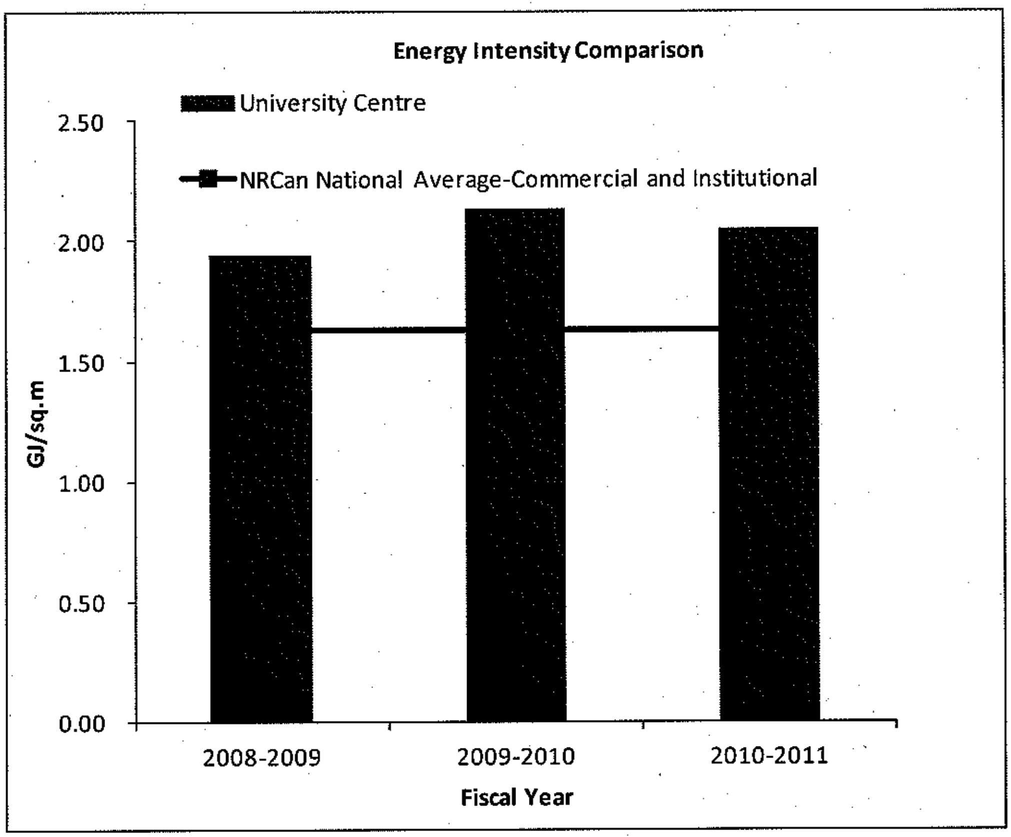


Figure 15 - Energy Intensity

Appendices

1. Monthly detail of metered data from 2006-2007 until 2010-2011.
2. Calculation of greenhouse gas emissions from 2008-2009 until 2010-2011.

Year	Energy Type	Jun			ANNUAL TOTALS	
2006-2007	Peak Power Demand (kW)	387			Total kW	1,501
	Peak Apparent Power Demand (kVA)	405			Total kVA	1,569
	Demand Cost	$ 5,202	$		Total Power Cost	$ 20,417
	Total Energy Demand (kWh)	173,924			Total kWh	667,190
	Energy Cost	$ 4,766	$		Total Electricity Cost	$ 18,281
	Steam lbs	-		,200	Total Steam	8,422,900
	Condensate lbs	9,159		,371	Total Condensate	14,595,478
	Steam/Condensate Cost	$ 157	$	,061	Total Steam Cost	$ 315,732
	Chilled Water in BTU	490,860,000		,000	Total BTU	2,361,180,000
	Chilled Water Cost	$ 8,774	$	,890	Total BTU Cost	$ 43,098
	Total Cost	$ 18,899	$	,951		
	Total Cost + Taxes	$ 19,516	$	,951		
2007-2008	Peak Power Demand (kW)	n/a		301	Total kW	1,352
	Peak Apparent Power Demand (kVA)	n/a		343	Total kVA	1,494
	Demand Cost	n/a		,591	Total Power Cost	$ 19,484
	Total Energy Demand (kWh)	n/a		,395	Total kWh	531,706
	Energy Cost	n/a		,231	Total Electricity Cost	$ 15,235
	Steam lbs	-		,218	Total Steam	6,935,918
	Condensate lbs	163,190		,141	Total Condensate	12,882,137
	Steam/Condensate Cost	$ 5,521	$	345	Total Steam Cost	$ 274,677
	Chilled Water in BTU	572,130,000		-	Total BTU	2,565,270,000
	Chilled Water Cost	$ 20,162	$	-	Total BTU Cost	$ 75,368
	Total Cost	$ 25,683	$	,167		
	Total Cost + Taxes	$ 25,683	$	,681		
2008-2009	Peak Power Demand (kW)	278		294	Total kW	3,853
	Peak Apparent Power Demand (kVA)	320		325	Total kVA	4,275
	Demand Cost	$ 4,132	$	,326	Total Power Cost	$ 55,824
	Total Energy Demand (kWh)	131,372		,289	Total kWh	1,832,582
	Energy Cost	$ 3,902	$	,553	Total Electricity Cost	$ 54,428
	Steam lbs	7,200		,100	Total Steam	6,263,600
	Condensate lbs	-		,573	Total Condensate	8,582,441
	Steam/Condensate Cost	$ 239	$	,696	Total Steam Cost	$ 216,889
	Chilled Water in BTU	-		-	Total BTU	218,420,000
	Chilled Water Cost	$ -	$	-	Total BTU Cost	$ 6,533
	Total Cost	$ 8,273	$	,575		
	Total Cost + Taxes	$ 8,741	$	,092		
2009-2010	Peak Power Demand (kW)	284		294	Total kW	3,912
	Peak Apparent Power Demand (kVA)	318		325	Total kVA	4,300
	Demand Cost	$ 4,050	$	,348	Total Power Cost	$ 56,573
	Total Energy Demand (kWh)	93,508		,128	Total kWh	1,932,060
	Energy Cost	$ 2,777	$	,280	Total Electricity Cost	$ 57,451
	Steam lbs	-		,700	Total Steam	5,941,600
	Condensate lbs	130,718		,789	Total Condensate	7,290,246
	Steam/Condensate Cost	$ 4,572	$	,801	Total Steam Cost	$ 196,500
	Chilled Water in BTU	34,990,000		,000	Total BTU	3,279,080,000
	Chilled Water Cost	$ 1,275	$	,134	Total BTU Cost	$ 131,873
	Total Cost	$ 12,674	$	,562		
	Total Cost + Taxes	$ 13,072	$	,065		
2010-2011	Peak Power Demand (kW)	297			Total kW	3,905
	Peak Apparent Power Demand (kVA)	328			Total kVA	4,272
	Demand Cost	$ 4,290	$		Total Power Cost	$ 56,492
	Total Energy Demand (kWh)	158,748			Total kWh	1,954,722
	Energy Cost	$ 4,747	$		Total Electricity Cost	$ 58,446
	Steam lbs	-			Total Steam	5,947,000
	Condensate lbs	16,652			Total Condensate	7,125,308
	Steam/Condensate Cost	$ 595	$		Total Steam Cost	$ 145,925
	Chilled Water in BTU	1,006,460,000	1,		Total BTU	4,680,150,000
	Chilled Water Cost	$ 37,432	$		Total BTU Cost	$ 187,899
	Total Cost	$ 47,063	$			
	Total Cost + Taxes	$ 47,590	$			

note: 2008-2009 sees a sharp decrease in chilled water consumpt

Prepare by JConraud, Jr. Eng. and Felicia Parr, BEng - Mechanical
04/11/2011

GHG Emissions

	Electricity (kWh)	Steam (lb)	Chilled Water (BTU)
FY 08-09	1,832,582	8,582,441	218,420,000
FY 09-10	1,932,060	7,290,246	3,279,080,000
FY 10-11	1,954,722	7,125,308	4,680,150,000

	GHG Emissions for Electricity (t CO2 eq)	GHG Emissions for Natural Gas (t CO2 eq)	GHG Emissions for Chilled Water (t CO2 eq)	Total GHG Emissions (t CO2 eq)	Equivalent Number of Cars	Equivalent Number of Trees
FY 08-09	4	601	42	647	146	16,583
FY 09-10	4	493	615	1,112	252	28,512
FY 10-11	4	459	837	1,300	294	33,332

E.g.: University Centre's GHG emissions in FY 08-09 are equivalent to the amount of GHG emitted by 146 cars during that

E.g.: During FY 08-09, it took 16,583 mature trees to capture the GHG emitted by University Centre.

Conversion factor - BTU (chilled water) to lb of steam

	BTU
1 lb	360

Conversion factor - lb of steam to m³ of natural gas

1 m³ in	eqals XX lb
FY 08-09	27.00
FY 09-10	27.96
FY 10-11	29.34

GHG emission factor - natural gas

	Emission Factor (g/m³)	100-Year Global Warming Potential	tons of CO2 eq
CO2	1,878	1	1.88E-03
CH4	0.037	25	9.25E-07
N2O	0.035	298	1.04E-05

GHG emission factor - electricity

	Emission Factor* (g/m³)	100-Year Global Warming Potential**	tons of CO2 eq
CO2	2	1	2.00E-06
CH4	0.000	25	7.50E-09
N2O	0.000	298	2.98E-08

References

GHG Emissions Typical Car/yr	23.9 mpg and 12,000 mi per year --> 502 US gal/yr
	8.8 kgCO2 eq/US gal gasoline --> 4.41841 t CO2 eq/yr
	http://www.epa.gov/oms/climate/420f05004.htm http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/sttstc/nrgycnvrsntbl/nrgycnvrsntbl-eng.html#s4ss7 http://www.epa.gov/oms/climate/420f05004.htm

GHG Sequestration Potential	0.039 tCO2 eq/tree
	http://www.epa.gov/cleanenergy/energy-resources/refs.html

Natural Gas GHG Emission Factor	*Source: May 2011 http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=AC287641-1
	**Source: http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=CAD07259-1 (IPCC GWPs - 100-Yr Time Horizon - Fourth Assessment Report)

- proper scheduling - and lowering the setpoint
- CO_2 monitoring → need to add that
- Freshair - taking humidity into account

Year	Energy Type	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	ANNUAL TOTALS	
2006-2007	Peak Power Demand (kW)	387	349	368	397	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Total kW	1,501
	Peak Apparent Power Demand (kVA)	405	367	383	414	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Total kVA	1,569
	Demand Cost	$ 5,202	$ 4,856	$ 5,095	$ 5,264	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Total Power Cost	$ 20,417
	Total Energy Demand (kWh)	173,924	175,974	178,305	138,987	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Total kWh	667,190
	Energy Cost	$ 4,766	$ 4,822	$ 4,886	$ 3,808	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Total Electricity Cost	$ 18,281
	Steam lbs	-	-	-	-	457,200	816,300	1,457,300	1,733,300	1,727,000	1,415,200	710,400	106,200	Total Steam	8,422,900
	Condensate lbs	9,159	-	-	1,665	613,626	1,198,944	2,216,381	2,758,404	3,008,184	2,620,192	1,643,552	525,371	Total Condensate	14,595,478
	Steam/Condensate Cost	$ 157	$ -	$ -	$ 31	$ 10,387	$ 28,752	$ 44,773	$ 56,078	$ 63,403	$ 59,334	$ 37,756	$ 15,061	Total Steam Cost	$ 315,732
	Chilled Water in BTU	490,860,000	638,660,000	498,640,000	314,600,000	114,420,000	6,280,000.00	-	-	-	-	-	297,720,000	Total BTU	2,361,180,000
	Chilled Water Cost	$ 8,774	$ 9,167	$ 8,089	$ 6,004	$ 2,017	$ 157	$ -	$ -	$ -	$ -	$ -	$ 8,890	Total BTU Cost	$ 43,098
	Total Cost	$ 18,899	$ 18,844	$ 18,070	$ 15,106	$ 12,404	$ 28,909	$ 44,773	$ 56,078	$ 63,403	$ 59,334	$ 37,756	$ 23,951	Total Cost	$ 397,528
	Total Cost + Taxes	$ 19,516	$ 19,444	$ 18,688	$ 15,668	$ 12,404	$ 28,909	$ 44,773	$ 56,078	$ 63,403	$ 59,334	$ 37,756	$ 23,951	Total Cost w/Taxes	$ 399,925
2007-2008	Peak Power Demand (kW)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	354	354	342	301	Total kW	1,352
	Peak Apparent Power Demand (kVA)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	387	387	377	343	Total kVA	1,494
	Demand Cost	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$ 4,848	$ 5,036	$ 5,009	$ 4,591	Total Power Cost	$ 19,484
	Total Energy Demand (kWh)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	61,490	176,011	148,811	145,395	Total kWh	531,706
	Energy Cost	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$ 1,728	$ 4,946	$ 4,330	$ 4,231	Total Electricity Cost	$ 15,235
	Steam lbs	-	-	-	-	114,300	848,700	1,466,900	1,383,200	1,313,000	1,314,500	494,100	1,218	Total Steam	6,935,918
	Condensate lbs	163,190	-	-	24,978	470,419	1,802,579	2,978,210	2,868,307	2,065,681	1,937,460	561,172	10,141	Total Condensate	12,882,137
	Steam/Condensate Cost	$ 5,521	$ -	$ -	$ 680	$ 10,346	$ 37,980	$ 59,007	$ 58,835	$ 45,257	$ 42,037	$ 14,668	$ 345	Total Steam Cost	$ 274,677
	Chilled Water in BTU	572,130,000	665,420,000	700,020,000	490,360,000	137,340,000	-	-	-	-	-	-	-	Total BTU	2,565,270,000
	Chilled Water Cost	$ 20,162	$ 20,453	$ 17,693	$ 13,914	$ 3,146	$ -	$ -	$ -	$ -	$ -	$ -	$ -	Total BTU Cost	$ 75,368
	Total Cost	$ 25,683	$ 20,453	$ 17,693	$ 14,594	$ 13,492	$ 37,980	$ 59,007	$ 58,835	$ 51,833	$ 52,019	$ 24,008	$ 9,167	Total Cost	$ 384,765
	Total Cost + Taxes	$ 25,683	$ 20,453	$ 17,693	$ 14,594	$ 13,492	$ 37,980	$ 59,007	$ 58,835	$ 52,216	$ 52,600	$ 24,552	$ 9,681	Total Cost w/Taxes	$ 386,787
2008-2009	Peak Power Demand (kW)	278	277	292	322	342	344	324	354	350	351	325	294	Total kW	3,853
	Peak Apparent Power Demand (kVA)	320	315	333	360	377	375	355	386	383	383	363	325	Total kVA	4,275
	Demand Cost	$ 4,132	$ 4,219	$ 4,440	$ 4,655	$ 5,024	$ 4,825	$ 4,734	$ 5,143	$ 4,600	$ 5,068	$ 4,657	$ 4,326	Total Power Cost	$ 55,824
	Total Energy Demand (kWh)	131,372	134,255	134,040	145,303	154,899	143,056	174,297	185,739	164,654	163,829	147,848	153,289	Total kWh	1,832,582
	Energy Cost	$ 3,902	$ 3,987	$ 3,981	$ 4,316	$ 4,600	$ 4,249	$ 5,177	$ 5,516	$ 4,890	$ 4,866	$ 4,391	$ 4,553	Total Electricity Cost	$ 54,428
	Steam lbs	7,200	-	-	-	197,500	549,100	1,207,700	1,632,700	1,150,800	915,400	435,100	168,100	Total Steam	6,263,600
	Condensate lbs	-	-	-	-	~~(42,463)~~	~~(17,485)~~	1,511,169	2,500,298	1,919,976	1,554,464	860,908	295,573	Total Condensate	8,582,441
	Steam/Condensate Cost	$ 239	$ -	$ -	$ -	$ 6,254	$ 13,332	$ 34,916	$ 53,554	$ 44,332	$ 34,559	$ 21,008	$ 8,696	Total Steam Cost	$ 216,889
	Chilled Water in BTU	-	-	-	218,420,000	-	-	-	-	-	-	-	-	Total BTU	218,420,000
	Chilled Water Cost	$ -	$ -	$ -	$ 6,533	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	Total BTU Cost	$ 6,533
	Total Cost	$ 8,273	$ 8,206	$ 8,421	$ 15,503	$ 15,879	$ 22,405	$ 44,826	$ 64,213	$ 53,823	$ 44,493	$ 30,056	$ 17,575	Total Cost	$ 333,674
	Total Cost + Taxes	$ 8,741	$ 8,684	$ 8,911	$ 16,026	$ 16,439	$ 22,934	$ 45,404	$ 64,834	$ 54,376	$ 45,071	$ 30,583	$ 18,092	Total Cost w/Taxes	$ 340,098
2009-2010	Peak Power Demand (kW)	284	284	314	322	341	344	332	358	357	347	336	294	Total kW	3,912
	Peak Apparent Power Demand (kVA)	318	318	349	360	374	373	363	389	387	380	367	325	Total kVA	4,300
	Demand Cost	$ 4,050	$ 4,313	$ 4,648	$ 4,657	$ 4,999	$ 4,853	$ 4,812	$ 5,163	$ 4,809	$ 5,092	$ 4,830	$ 4,348	Total Power Cost	$ 56,573
	Total Energy Demand (kWh)	93,508	170,623	135,802	146,830	172,463	169,238	162,084	178,923	172,381	187,560	199,523	143,128	Total kWh	1,932,060
	Energy Cost	$ 2,777	$ 5,068	$ 4,033	$ 4,361	$ 5,122	$ 5,026	$ 4,814	$ 5,314	$ 5,120	$ 5,571	$ 5,966	$ 4,280	Total Electricity Cost	$ 57,451
	Steam lbs	-	-	-	-	-	199,600	1,372,800	1371400	1,351,000	857,600	659,500	129,700	Total Steam	5,941,600
	Condensate lbs	130,718	-	-	36634.4	871,732	1,059,900	1,800,081	1,953,280	1,799,249	1,105,693	~~(1,706,830)~~	239,789	Total Condensate	7,290,246
	Steam/Condensate Cost	$ 4,572	$ -	$ -	$ 1,156	$ 21,829	$ 25,464	$ 28,367	$ 31,239	$ 31,248	$ 21,991	$ 19,833	$ 10,801	Total Steam Cost	$ 196,500
	Chilled Water in BTU	34,990,000	927,460,000	1,076,370,000	384,770,000	2,520,000	-	-	-	-	-	61,520,000	791,450,000	Total BTU	3,279,080,000
	Chilled Water Cost	$ 1,275	$ 42,558	$ 36,270	$ 12,644	$ 66	$ -	$ -	$ -	$ -	$ -	$ 1,927	$ 37,134	Total BTU Cost	$ 131,873
	Total Cost	$ 12,674	$ 51,938	$ 44,951	$ 22,817	$ 32,016	$ 35,344	$ 37,993	$ 41,715	$ 41,176	$ 32,653	$ 32,556	$ 56,562	Total Cost	$ 442,397
	Total Cost + Taxes	$ 13,072	$ 52,485	$ 45,457	$ 23,343	$ 32,605	$ 35,919	$ 38,554	$ 42,326	$ 41,755	$ 33,274	$ 33,185	$ 57,065	Total Cost w/Taxes	$ 449,037
2010-2011	Peak Power Demand (kW)	297	297	289	322	335	448	443	376	373	370	355		Total kW	3,905
	Peak Apparent Power Demand (kVA)	328	330	324	357	369	482	478	407	407	401	389		Total kVA	4,272
	Demand Cost	$ 4,290	$ 4,445	$ 4,379	$ 4,663	$ 4,942	$ 6,290	$ 6,414	$ 5,533	$ 4,993	$ 5,455	$ 5,088		Total Power Cost	$ 56,492
	Total Energy Demand (kWh)	158,748	157,598	162,604	170,492	175,420	225,578	210,712	185,725	165,259	183,122	159,463		Total kWh	1,954,722
	Energy Cost	$ 4,747	$ 4,712	$ 4,862	$ 5,098	$ 5,245	$ 6,745	$ 6,300	$ 5,553	$ 4,941	$ 5,475	$ 4,768		Total Electricity Cost	$ 58,446
	Steam lbs	-	-	-	-	-	844,500	1,637,300	880,100	876,200	1,124,500	584,400		Total Steam	5,947,000
	Condensate lbs	16,652	-	-	833	591,146	1,092,371	1,759,284	960,820	927,516	1,112,354	664,332		Total Condensate	7,125,308
	Steam/Condensate Cost	$ 595	$ -	$ -	$ 33	$ 17,045	$ 23,996	$ 32,466	$ 16,238	$ 16,138	$ 23,059	$ 16,356		Total Steam Cost	$ 145,925
	Chilled Water in BTU	1,006,460,000	1,636,210,000	1,451,830,000	575,400,000	10,120,000	130,000	-	-	-	-	-		Total BTU	4,680,150,000
	Chilled Water Cost	$ 37,432	$ 66,035	$ 60,317	$ 23,808	$ 304	$ 3	$ -	$ -	$ -	$ -	$ -		Total BTU Cost	$ 187,899
	Total Cost	$ 47,063	$ 75,191	$ 69,558	$ 33,602	$ 27,536	$ 37,034	$ 45,181	$ 27,324	$ 26,072	$ 33,989	$ 26,212		Total Cost	$ 448,763
	Total Cost + Taxes	$ 47,590	$ 75,725	$ 70,096	$ 34,170	$ 28,130	$ 37,793	$ 45,921	$ 28,032	$ 26,705	$ 34,687	$ 26,841		Total Cost w/Taxes	$ 455,689

note: 2008-2009 sees a sharp decrease in chilled water consumption due to missing data during the summer months.