ENERGY ASSESSMENT REPORT

Palace Theatre, London, Ontario

June 16, 2014

Prepared by:

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1. Executive Summary

A comprehensive ASHRAE Level II energy audit was conducted by Blue Sky Energy Engineering & Consulting Inc. on April 25th, 2014 of the Palace Theatre facility. Palace Theatre, built in 1980, is located on 710 Dundas St, London, Ontario. The primary objective of this study was to uncover energy conservation opportunities within the facility that will lead to tangible energy and cost savings.

The following report is divided into several sections:

Section 2, Facility Description, provides a summary of the current facility, complete with descriptions of the main mechanical and control systems, lighting, building envelope, plug loads and operations.

Section 3, Current Energy Performance, discusses current utility rates, historical consumption patterns and a facility energy balance. Natural gas consumption is compared to local weather data and the subsequent regression analysis forms the basis of a facility energy baseline.

Section 4, Energy Conservation Measures, discusses the studied and recommended energy conservation measures (ECM) broken down by system.

Section 5, Points for Consideration, lists items worth reviewing but require additional investigation.

Section 6, Next Steps.

Sixteen (16) conservation opportunities are reviewed in this report with one additional item for your consideration. Of the list, 14 energy conservation measures (ECMs) have been recommended and if executed have a combined savings of over $5,300/year with an ROI of just over 3.7 years. Table 1 (next page) summarizes the recommended ECMs with estimated savings, costs and available government incentives. A simple rate of return has been calculated for each item and listed on the table (before and after incentives). The cost and savings estimates are accurate to within +/- 30% and =/- 50% respectively as required by the Ontario Power Authority (OPA) requirements.

Included in this report are available government incentives from the **Ontario Power Authority's (OPAs) saveONenergy program.** In order to take advantage of these financial incentives, it is important to work with London Hydro to ensure that approvals are obtained from the program before work is undertaken.

Please note that stage lighting was not included in this study. It is recommended however, to review new technologies in this area as significant electrical consumption results from theatre lighting.

There are several opportunities at Palace Theatre to improve the energy performance of the facility. Of the recommended ECMs, the items with the largest impact are the following:

- Lighting retrofits
- Insulation: supply air ducting
- Building Envelope: weather stripping, insulation around exhaust fans
- Controls: Temperature setbacks in Box Office and Procunier Room

Type	Description	Annual Utility Reduction / Savings			Estimated Cost $	Simple Payback (Yrs.)	Incentive $	Payback c/w Inc.
		Type	kW, kWh, m^3	$				
Heating / Cooling	Install Insulation on Supply Air Ducting in Fly Loft	Elect. Gas	626 kWh 948 m^3	$334	$1,250	3.7	N/A	N/A
	Install Ceiling Fan in Main Theatre	Elect. Gas	-34 kWh 4,000 m^3	$1,185	$6,885	5.8	$1,950	4.2 yrs
	Repair insulation on outside cooling coil lines	Elect.	418 kWh	$47	$130	2.8	N/A	N/A
Controls	Temperature setbacks in Theatre, Box Office and Procunier room	Elect. Gas	1,044 kWh 1,143 m^3	$458	$750	1.6	N/A	N/A
Building Envelope	Building Infiltration Reduction: Windows, Doors, Fire Hatch and Exhaust Fans	Elect. Gas	626 kWh 569 m^3	$263	$500	1.9	N/A	N/A
	High Efficiency Window Replacement	Elect. Gas	251 kWh 274 m^3	$110	$1,304	11.9	N/A	N/A
Lighting[1]	Retrofit T12 Lamps with T8 bulbs and ballasts.	Elect.	0.97 kW 973 kWh	$172	$1,400	8.1	$476	5.4 yrs
	Replace T8 lamps with higher efficiency T8 bulbs (28W) – assume 100 bulbs	Elect.	0.28 kW 659 kWh	$92	$205	2.2	$97[2]	1.1 yrs
	Replace/Install 9 Occupancy Sensors	Elect.	1864 kWh	$210	$540	2.6	$160[3]	1.8 yrs
	Replace all Incandescent Lights	Elect.	6.5 kW 8,524 kWh	$1,376	$2,764	2.0	$830	1.4 yrs
	Stage Working Lights: replace halogen 750W with 4-lamp High Output T5 fixture	Elect.	0.52 kW 644 kWh	$106	$250	2.4	N/A	N/A
	Overnight Shutdown of Concession Stand Lights	Elect.	561 kWh	$63	0	Immediate	N/A	N/A
	Retrofit Incandescent Exit Signs with LED (5 signs)	Elect.	0.12 kW 1,007 kWh	$121	$275	2.3	$40	1.9 yrs
Water	Low flow toilets	Water	396 m^3	$760	$5,500	7.2	N/A	N/A
	Aerators on Sink Faucets	Elect. Water	577 kWh 72 m^3	$200	$55	< 1.0	N/A	N/A

Table 1: Summary of Recommended Energy Conservation Measures

The savings listed above are specific to each measure and do not account for possible interactions if multiple projects are undertaken.

[1] A small business incentive is available for retrofits of lighting in both of the front spaces (Procunier room and Box Office). The incentive pays for up to $1,500 of lighting upgrades. See London Hydro for more information.

[2] This incentive will need to be combined with other lighting incentives to qualify in order to meet a $100 minimum request per application.

[3] Please note only four rooms met the minimum 300W requirement for occupancy sensor incentives ($40/sensor).

2. Facility Description

General Overview:

The Palace Theatre, located on 710 Dundas St., London, Ontario was built in 1929. The 15,100 ft^2 facility (12,500 ft^2 main floor + 2,600 ft^2 upper levels), is used as a theatre space, with a main theatre and two smaller front units used as a box office and and a small theatre / event space (Procunier room) respectively. The front face of the building is protected as a heritage façade.

The theatre box office is open from 9:00am -5:00pm (summer hours 10:00am – 4:00pm) Monday to Saturday. Three (3) full time staff work in the facility with 2-3 volunteers. The main theatre averages three performances a week (with additional time for rehearsals) and is closed in the summer from mid June to the end of August. The Procunier room is used as a smaller theatre space and averages 50 – 100 performances and rehearsals from September to April. Over the summer months, the Procunier room is used for a youth program every day from Monday to Friday. Table 2 below, lists several of the buildings basic features.

Item	Details
Address	710 Dundas St., London
Site Contact	Frank Hopkins, 226-984-1227
Facility Type	Theatre
Year of Construction	1929
Area	15,100 ft^2 (12,500 ft^2 main floor + 2,600 ft^2 upper levels)
Floors	Front sections and main theatre are one level. A second floor is over the lobby (tech room and public W/R) and a second and third floors are located at the back of the stage area (change rooms).
Lighting	Various. T8, T12, CFLs, PAR30, Incandescent bulbs, 500W Stage Lighting
Primary Heating System	1000 MBH natural gas forced air furnace (Enmar Heating) serves the main theatre space and two packaged indoor natural gas units (Goodman, 95% AFUE) heat the office/theatre spaces at the front of the building.
Supplementary Heating System(s)	Electric unit heaters warm the upstairs change rooms and an electric wall unit heats the front entrance. Two 7.6kW electric DHW tanks supply the building's north and south ends respectively.
Cooling System	One 40 ton Trane air cooled chiller (scroll compressor) is used in summer for the main theatre spaces. Two packaged air conditioners (Goodman, SEER=13.0) are used to condition the two front spaces (office and theatre).
Mechanical Ventilation	One fan (7.5hp, 16,000CFM) supplies air to the main theatre, lobby, and back stage spaces. The front office and theatre are served by the packaged units noted above.

Table 2: Summary of Palace Theatre Main Systems

HVAC Systems:

The main theatre is conditioned by a 1000 MBH outdoor, natural gas direct fired furnace (Enmar Heating, model# DIDM-100, 80% efficiency, 2005) and a 40 Ton, four stage Trane air cooled chiller (model# RAUC C40EBN03BD, 4 stage, EER=11.5, over 10yrs old), both located at the back of the building. The control system, Barber Coleman Network 8000, located in the 'Green Room' is quite old and unfortunately no specifications are available in the building or online. Although the staff manually manages the heating and cooling system in a economical manner, programmed temperature setbacks are currently not used. The temperature setpoints for the theatre are 22C in the winter and 26C in the summer. Additional electric resistance unit heaters are located in the upstairs change rooms and in by the front door of the theatre in the lobby.

As the main theatre is mostly unused in the summer, the chilling system is typically turned off by staff. A four (4) hour override switch is located in the Green room which turns on the system manually (the staff employ this about 1 hour before the space is used to cool down the space). The front spaces (Box Office and Procunier room) are cooled by packaged 3 Ton A/C units (Goodman, Model GSX0361C, SEER/EER = 13/11)

The attic of the theatre (fly loft) where the lights are mounted and controlled is unventilated and is very hot in the summer as well shoulder seasons (spring and fall). It is anticipated that the temperature in the fly loft will reduce in the summer once the new roof (with increased insulation) is installed this year.

The box office space and the Procunier room are served by two identical forced air natural gas HVAC units located inside (Goodman, Model# GMH95, AFUE = 96.1, less than 10yrs old). The units are assumed to be 46,000 BTU/hr units as no documentation is available nor markings on the units. Each are single zone controled by a single thermostat. The thermostats are not programmed with temperature setbacks but staff typically drop the temperature of the Procunier room down to 19.5C (67F) when not in use. Staff mentioned that the temperature setpoint varies in the winter. If staff are working in the conference room and back office of the box office area, which is typically cooler than the front office, the setpoint is raised.

Domestic hot water is provided by two electric hot water heaters (Usine Giant, Model 152E-3FM-OH, 40 Imp. Gal, 2 elements 3.8kW/each). One located in the back basement of the main theatre serves the change rooms and north end of the building. The second hot water tank serves the box office, Procunier room, lobby, public washrooms and east end of the building.

Building Envelope:

The building walls are cavity wall construction with 4 layers of brick at its base reducing to 2 layers at the top supported by a steel frame. Several outside walls and windows in the north end change room area and basement have installed plug in exhaust fans. The structure supporting the unit area between the unit and brick or window frames are filled with wood but are uninsulated.

The front (south end) flat roof was recently replaced and reinsulated with R20 (~2.5" of Polyisocyanurate). The main theatre roof (north end) is a sloped attic design currently planned to be replaced and reinsulated in 2014. This roof includes automatic fire doors which will automatically open in a fire. It was observed that these fire doors were uninsulated and were not completely sealed from the elements (light could be seen between the frame and the doors).

The windows are a combination of original and single glazed units. Some spaces have manual window shades and blinds. The window in the general manager's office (back end of the box office) was cracked and would be subject to significant air infiltration at that spot as well as heat loss through the single paned window surface. Doors to the outside are insulated metal doors with the exception of the lobby which are double paned windowed doors.

Lighting:

Lighting is a mixture of incandescent bulbs, Fluorescent T8s and T12, compact fluorescent bulbs and PAR 30 spotlights mixed throughout the building with 750W theatre lighting in the Procunier room and main Theatre. Some spaces have occupancy sensors but most are not functioning properly and need to be replaced.

3. Current Energy Performance

3.1. Site Energy Pricing

Historical billing data, from January 2012 to March 2014, was furnished by Palace Theatre from London Hydro and Union Gas bills for electricity and natural gas respectively. The following section outlines the historical energy use and energy costs for the sources mentioned above.

Cost of Electricity 2014:

Main Theatre Electricity (Account 248996-4645802):

Consumption Charge with Adjustment:	(Block 1: ≤ 750kWh): $.0863/ kWh
	(Block 2: over 750kWh): $.1003/ kWh
Regulatory and Debt Retirement Charge:	$0.0128 / kWh
Fixed Monthly Charge:	$150.00
Peak Monthly Demand Charge:	$5.32 / kW

Front Section A (Account 112662-2655689):

Consumption Charge:	On-Peak: $0.129/kWh, Mid-Peak: $0.109/kWh, Off-Peak: $0.072/kWh
Regulatory and Debt Retirement Charge:	$0.0132 / kWh

Front Section B (Account 112662-2655704):

Consumption Charge:	On-Peak: $0.129/kWh, Mid-Peak: $0.109/kWh, Off-Peak: 0.072/kWh
Regulatory and Debt Retirement Charge:	$0.0129 / kWh

Cost of Natural Gas 2014:

Consumption	$0.2066/m^3 (before April 1st, 2014)
	$0.2973/m^3 (after April 1st, 2014)
Fixed Monthly Charge:	$21 / month

Summary of Energy Bills:

The Theatre paid a total of $22,374 in 2012 and $24,400 in 2013 for electricity and natural gas combined. This translates to an increase of approximately 9.1% from 2012 to 2013. Water was an additional fee of $3,216 for 2012 and approximately $2,610 for 2013. Part of the increase can be explained by increases in energy pricing (see discussion below) and part by increases in energy consumption (discussed in subsequent sections). Table 3 below summarizes the Theatre's annual costs by energy type and the division is shown in Figure 1.

Year	Electricity	Natural Gas	Total	Water
2012	$18,861	$3,513	$22,374	$3,216
2013	$19,746	$4,653	$24,400	$2,610
Change	4.7%	32.5%	9.5%	(18.8%)

Table 3: Total Energy Costs by Year

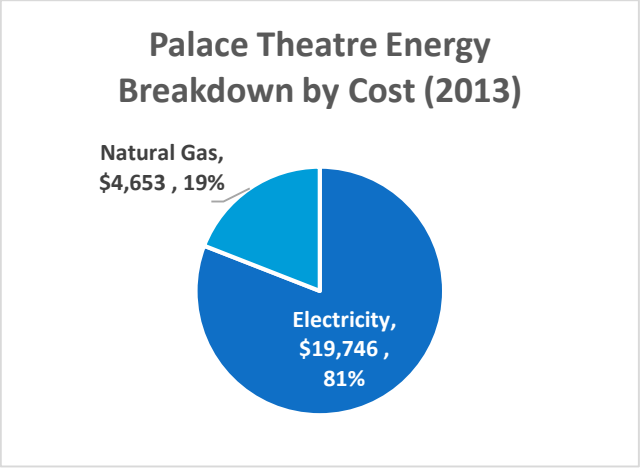


Figure 1: Total Energy Cost 2013 Broken Down by Source

Electricity costs are expected to increase over 20%, or roughly 4% per year, over the next five years according to Ontario's Long Term Energy Plan report published in 2013. This further supports the need to carefully manage electricity use. Natural gas prices, although relatively low compared to historical averages, have begun to rise as illustrated by significant increases in spot market prices through the winter of 2013/2014. As a result, Union Gas applied to the Ontario Energy Board and was approved for a 28% increase in natural gas rates. The natural gas rate increase came into effect in April 2014 and will most likely be in place to the end of Q4, 2014.

3.2. End Use Breakdown

Electricity End Use Breakdown

The on-site audit of equipment inventory, energy monitoring data, drawings and staff interviews were the basis of the following breakdown. Please see Figure 2 below which illustrates the electrical energy breakdown by equipment type and function. The HVAC system is the largest component and includes the main air handling supply fan, chiller, two packaged HVAC units and the unit heaters. The breakdown was based on

equipment in operation during the audit, and therefore is representative of a winter period breakdown. It would be expected that the HVAC consumption would be a larger factor in the summer period due to increases in chiller load.

Please note in the figure below, DHW is short form for Domestic Hot Water system.

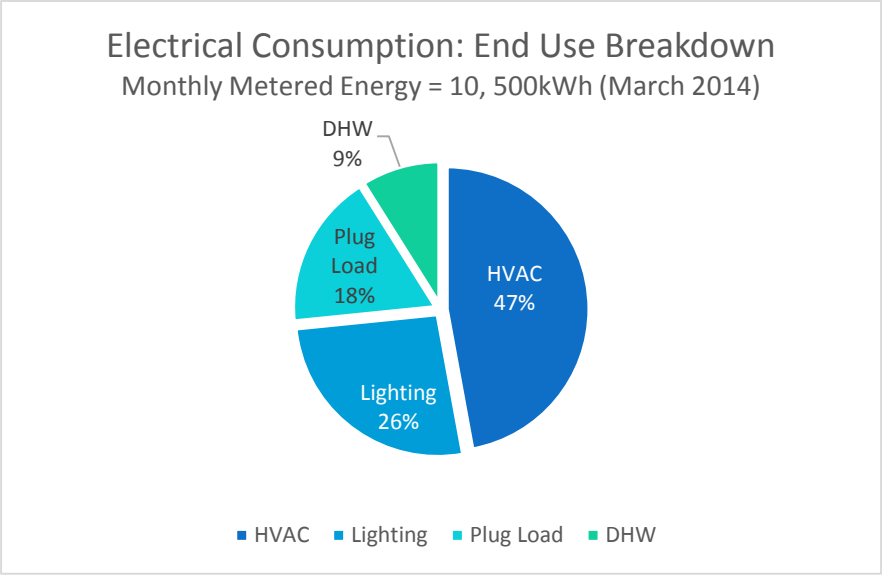


Figure 2: Electricity Consumption Breakdown by Equipment Type

3.3. Site Historical Energy Use

The historical energy consumption data from January 2012 onward was taken from utility bills furnished by the Theatre Staff. The total energy use for 2012 and 2013 by energy type is shown in Table 4 and Figure 3 below. Energy intensity is a measure of total energy per square foot (ekWh/ft2) and is often used to benchmark or compare buildings. The Palace Theatre has an energy intensity of 24.2 ekWh/ft2. This intensity number is quite good and may reflect the reduced operating hours in the summer time when air conditioning would be at its peak.

Please note that the term equivalent kWh (or *ekWh*) is used to denote the total energy consumed from both electricity and natural gas. For future reference, the conversion from m^3 of natural gas to ekWh used throughout this report is the following:

- 1 m^3 natural gas = 37.5 MJ = 10.4 ekWh

Year	Electricity (kWh)	Natural Gas (m^3)	Elect. + Nat. Gas (ekWh)	Water (m^3)
2012	125,821	17,236	305,074	1,229
2013	128,854	22,897	366,982	507

Table 4: Total Annual Energy Consumption by Source

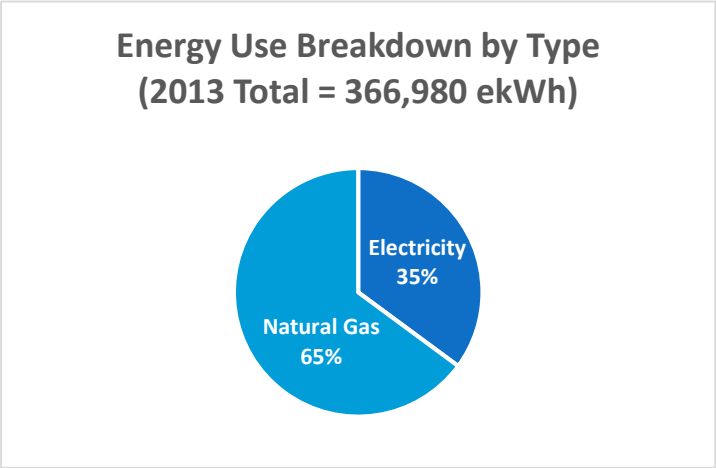


Figure 3: Total Annual Energy Consumption (ekWh) Broken Down by Source (2013)

It is interesting to note that although 65% of the total energy is provided by Natural Gas, it only represents 19% of the total energy bill.

Historical Trends in Electricity:

Electrical Consumption:

The historical electrical energy consumption data from utility bills is illustrated in the Figures below. The theatre currently has three energy meters. One meter (700434) measures electricity consumed in the Main Theatre space, lobby and back stage. A second meter (605952) measures electricity consumed in the Procunier room, and a third meter (601290) for the front Box Office. Historical electricity use is graphed separately for each of the three metered spaces in Figure 4, 5 and 6 below. Figure 7 is an illustration of total combined electricity use for the facility (2013) as well as breakdowns of the three (3) individual meters.

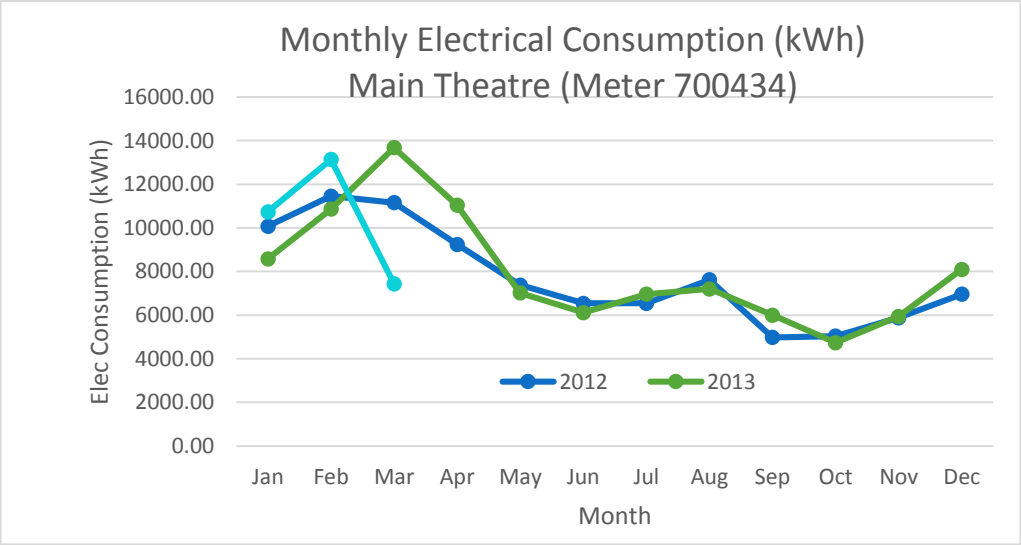


Figure 4: Historical Monthly Electricity Consumption (kWh): Main Theatre

The peaks in electricity from January to April reflect the Palace theatre's production season in which theatre lighting is a large consumer. Electrical unit heaters in the change rooms and a baseboard located in the lobby

also contribute significantly in winter months. The summer has a smaller rise in electricity use in the July / August period which is most likely influenced by the use of the chiller to condition the space. It is not a significant a rise in the summer due to the limited operating hours of the theatre at that time. The staff only run the chiller when the space is occupied.

It would be useful for the staff to complete an assessment both in the daytime and at night, during the summer months when the theatre is not in use. The objective would be to look for systems (lighting, A/C, exhaust fans etc.) that are left on when the building is not in use. There may be opportunities to shut down systems, for instance the domestic hot water tanks, if they are not required for extended periods.

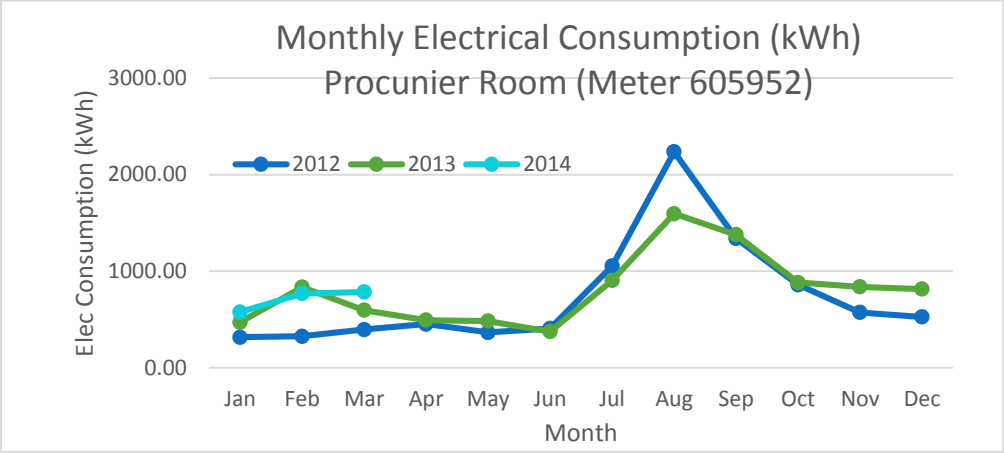


Figure 5: Historical Monthly Electricity Consumption (kWh): Procunier Room

The electrical consumption peaks (July to September) in the figure above for the Procunier room are caused by the use of air conditioning as well as increased lighting used due to the summer youth programs.

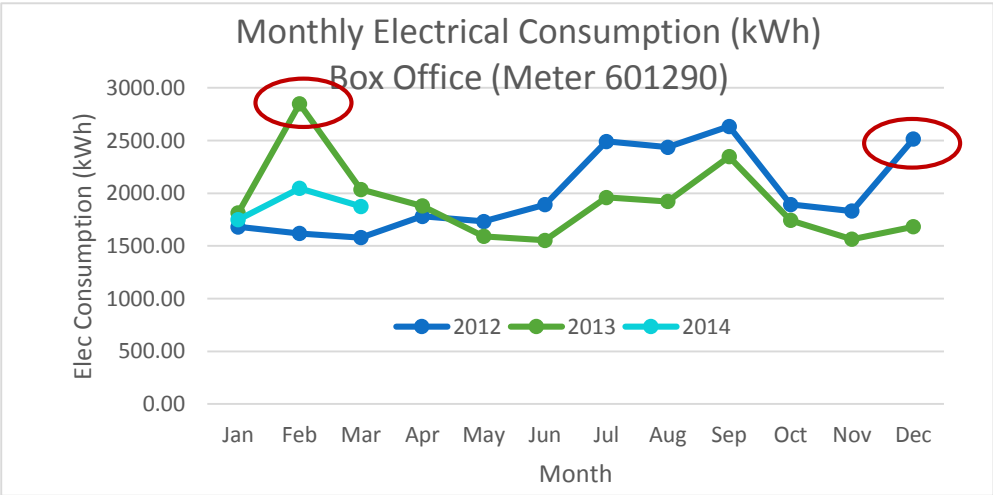


Figure 6: Historical Monthly Electricity Consumption (kWh): Box Office

The box office shows a rise in electricity use in the summer months correlating with increase air conditioning needs. Two peaks cannot be explained by the auditing team: December 2012 and February 2013. It may

be worthwhile for the staff at the Palace Theatre to determine the reason for the elevated consumption to ensure that, if preventable, they can be avoided in the future.

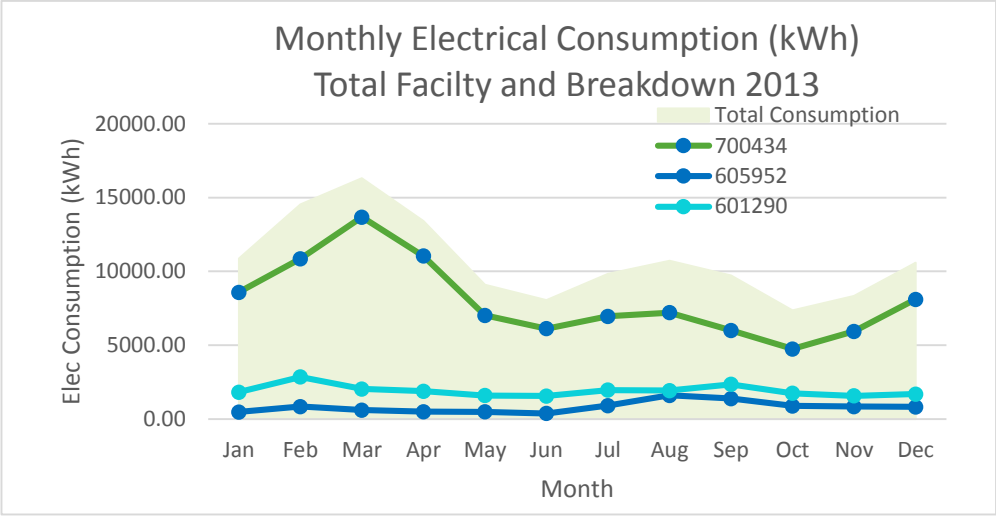


Figure 7: 2013 Monthly Electricity Consumption (kWh): Total Facility

The Theatre electrical consumption should vary significantly with cooling load and therefore would be expected to be lower in the winter and higher in the summer. The general trend on the graph above however illustrates a large electrical consumption in the December to April period which corresponds to the production season and is most likely due to stage lighting and electric heating.

Electrical Demand:

Unfortunately, the measured demand information was not available from the utility and therefore a detailed weekly, monthly and annual analysis was not completed. Palace Theatre is charged a monthly fee for the peak 15 minute electrical demand registered on the main theatre hydro meter each month. It is therefore important understand the trends in monthly / hourly demand to see if there are opportunities to reduce the peaks.

Electrical Power Factor:

Power factor is a calculated value which compares the measured real power or kW load, drawn by the facility, to kVa, which is a measure of apparent power. Differences in real and apparent power (measured by volt amps) occur because of inefficiencies in electrical transmission through specific systems in the facility. If the power factor drops below 0.9, the utility companies charge an adjustment fee.

The billing information from London Hydro shows that the power factor for the Palace Theatre is well above 0.9 and therefore is not a concern.

Historical Trends in Natural Gas Consumption:

The historical natural gas consumption is shown in Figure 8 below. This data was collected from Union Gas Energy utility bills from January 2012 onward. Natural gas is used for heating all parts of the building. The graph below correlates closely with the outdoor air temperature, increasing consumption in the colder months and then dropping significantly in the summer when it is not in use.

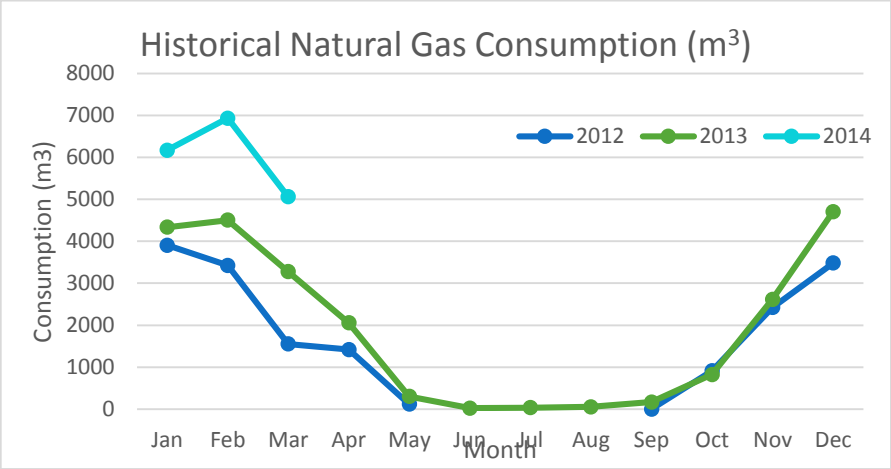


Figure 8: Historical Natural Gas Consumption

Natural Gas Baseline Analysis:

When reviewing energy consumption and efficiency for a particular facility, management is usually interested in several key points.

- the ability to evaluate or predict future trends in energy use
- determine the base load of natural gas which is due to non-weather (heat, cool, humidify) dependent energy use
- to determine the degree of dependence between natural gas use and weather.

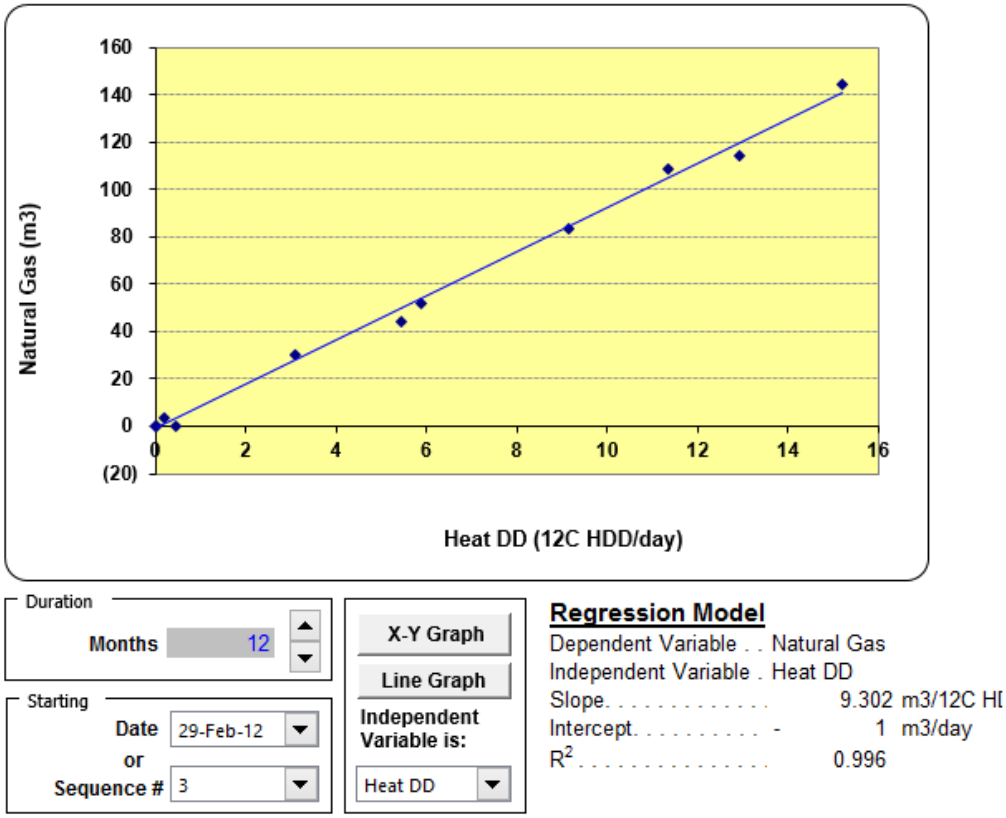
The relationship between energy consumption and weather is determined using a statistical method called regression. Without this analysis, energy use could vary from month to month, and it would not be apparent whether it was due to an operational change, a new installation of equipment or a warmer than normal winter month.

This analysis is very useful as it provides a basis from which energy project can be evaluated to determine future savings. Essentially, regression analysis attempts to measure the degree of correlation between the dependent (electricity or steam use) and independent variable (weather), to establish a predictive relationship. For this facility, the analysis was completed for natural gas consumption only as weather will affect natural gas consumption in the winter.

The regression analysis of natural gas consumption vs. weather data yielded a very good correlation (coefficient $R^2 = 0.996$). As one would expect, it can be concluded that the variation in natural gas consumption

is highly correlated to changes in outdoor air temperatures over the period of the analysis (February 2012 to December 2013).

Below is an illustration of the line of best fit from monthly natural gas consumption (Mlbs) and temperature data (Heating/Cooling Degree Day (HDD/CDD)). The HDD and CDD data was obtained from the London Airport weather station. The intercept of the line of best fit and Natural gas axis (axis y) is close to zero. This indicates that natural gas is not being used at inappropriate times and all of the supply is being burned for heating.



The linear regression yielded the following relationship:

$$Y = 9.30\,x + 1.0$$

Y = daily natural gas consumption (kWh)
x = Heating Degree Days (HDD) for day
Base Natural Gas Consumption (kWh) = 1.0 m3/day
Heating Load Constant = 9.30

Figure 9: Linear analysis for the period of Nov. 2012 – Dec. 2013

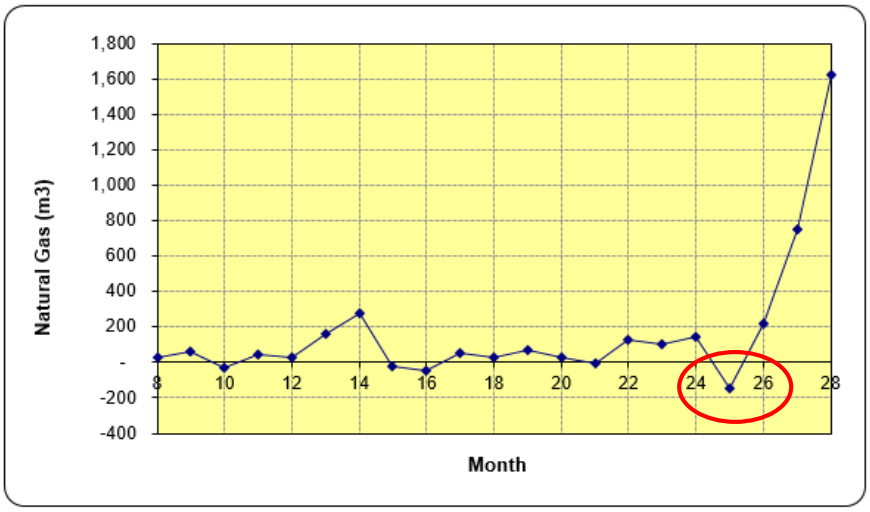
Y represents the facility electricity consumption in m^3, and x is the total heat & cooling degree days for the day. The formula tells us that the plant requires $9.30m^3$ of natural gas for every heating degree day (HDD) measured outside, and there is no significant non-heating related base load for the facility.

Cumulative Sum Analysis –Natural Gas

Cumulative Sum (CUSUM) analysis is a tool that uses the regression analysis above to compare current performance to previous baseline performance. It is a valuable tool to help management quantify the energy savings associated with conservation measures. It can also help to identify predictive maintenance opportunities of energy consuming equipment that often go undetected for long periods of time.

The Figure 10 below illustrates the cumulative sum trend for the natural gas consumption in this facility. The slope of the graph will be level if the facility is operating in the same manner as the baseline A downward trend indicates that energy consumption is improving compared to baseline (due to new equipment, procedures, preventative maintenance etc.). An upward trend indicates an increase in usage.

Reviewing the trend shown in Figure 10 below, a change can be seen in the slope after point 25 (circled in red). This indicates a change in the typical consumption pattern which could be due to a variety of factors including an increase in the number of theatre productions causing the heating system to run longer or higher temperature setpoints. The pattern should not be due to weather related issues, as this has already been accounted for through the regression analysis.



Month	Date dd-mmm-yy	Actual Natural Gas m3	Heat DD 12C HDD	Baseline Predicted m3	Difference (Act - Base) m3	CUSUM m3
8	01-Aug-12	-	-	-27	27	27
9	04-Sep-12		-	-31	31	58
10	01-Oct-12	-	12	87	-87	-29
11	31-Oct-12	909	93	837	72	43
12	29-Nov-12	2,422	265	2,438	-16	27
13	31-Dec-12	3,483	363	3,349	134	161
14	30-Jan-13	4,336	456	4,217	119	280
15	01-Mar-13	4,505	520	4,810	-306	-25
16	28-Mar-13	3,275	357	3,300	-24	-50
17	30-Apr-13	2,057	213	1,952	105	56
18	03-Jun-13	300	39	329	-28	27
19	28-Jun-13	22	-	-23	45	73
20	31-Jul-13	34	12	81	-48	25
21	30-Aug-13	53	12	84	-31	-5
22	30-Sep-13	168	7	37	132	127
23	30-Oct-13	822	94	845	-23	104
24	28-Nov-13	2,616	280	2,578	38	142
25	31-Dec-13	4,707	540	4,993	-286	-144

Figure 10: Cumulative Sum analysis for Natural Gas Consumption

Water:

The historical water consumption data is graphed in Figure 12 below. This data was collected from London Hydro utility bills from January 2012 onward. Water consumption throughout the facility is quite low since a significant reduction in consumption in the last half of 2012. The auditors were made aware of the installation of low flow urinals in the main public washrooms which may explain the drop in consumption.

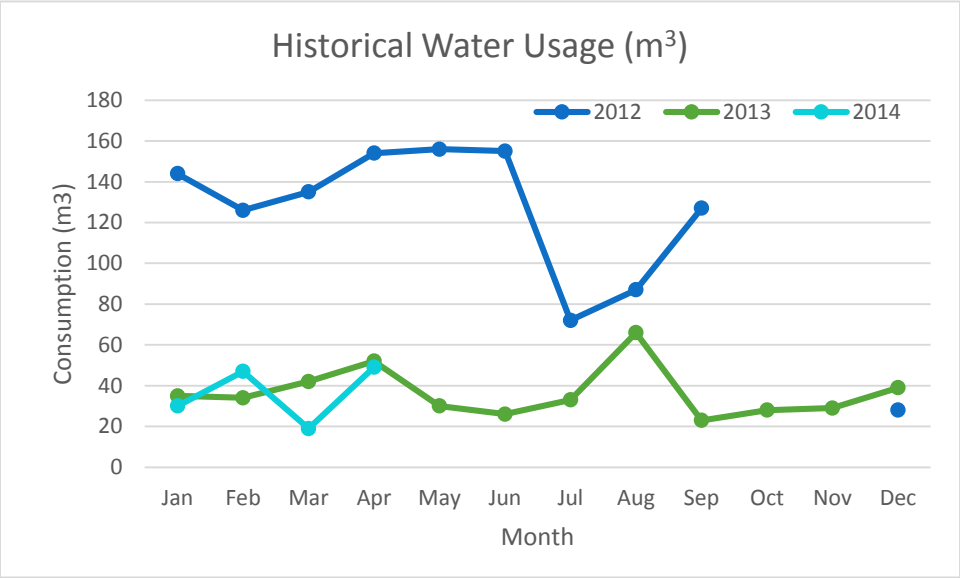


Figure 11: Historical Water Consumption

4. Energy Conservation Measures

4.1. Heating Ventilation and Air Conditioning

4.1.1. Install Insulation on Supply Air Ducting in Fly Loft

The supply air ducting located in the theatre attic (fly loft) delivers conditioned air to the theatre seating area through diffusers in the ceiling. While portions of the ducting in the fly loft are insulated, much of the main trunk line is uninsulated, causing heat loss to the attic space and reducing space temperature control. In addition, it was noted that tape was hanging loose around gaps in the ducting in several places, and insulation was beginning to become loose. Heat transfer to and from the attic space will therefore be occurring by conduction through the duct surfaces and infiltration through joints that are unsealed.

Figure 12: Supply air ducting located in the Attic (Fly loft) of the main theatre.

Given a modest savings of 5% of furnace use and 3% of cooling use, this results in a cost savings of $334 per year. At an approximate cost of $1,250 to repair/replace the insulation, this results in a simple payback period of 3.7 years.

4.1.2. Install Ceiling Fan in Main Theatre

In the main theatre space, conditioned air is introduced at the ceiling and returned at the floor level through the HVAC system return air ducts, creating cyclical air flow. However, temperature stratification occurs naturally in rooms with high ceilings as hot air rises and cool drops to the floor. This is called stack effect and it causes heat to accumulate at the ceiling. The heat not only accumulates at the ceiling in the theatre, but also passes through the openings at the back and front the ceiling to the attic space (fly loft). In the winter, this means that the furnace is working harder than it needs to because the heated air is not remaining at floor level where the patrons are seated.

It is recommended that one large high volume low speed (HVLS) ceiling fan be installed and run continuously during operating hours in the winter heating months. This will help to de-stratify the air, creating a warmer temperature at floor level resulting in lower heating demand heat from the heating system. According to Union Gas estimates, there is approximately 0.5 m^3/ft^2 of floor area served along with a modest increase in electricity usage. This will therefore create approximately $1,200 in energy savings and given a cost of $6,885, this project will result in a simple payback period of 5.8 years.

Incentives:

Up to $1900 per unit is available in incentives from the Union Gas Space Heating Program for fans with a minimum blade diameter of 20'. An example is shown in the attached link: https://www.uniongas.com/business/save-money-and-energy/space-heating-programs#DestratificationFans . This incentive would reduce the payback period from 5.8 to 4.2 years.

4.1.3. Ventilation of Hot Air in Main Theatre Attic.

The audit team reviewed methods of removing excess heat from the main theatre attic (fly loft) space in the summer and the potential of using the excess heat in the winter. All options, including roof ventilation or distribution fans etc. are not recommended for various reasons. They all have poor rate of returns and have technical barriers (interference with the current HVAC system air balance for example).

The best way of reducing the heat in the attic in the Summer and Winter is to reduce the migration of heat to the space through better roof insulation (planned to be done shortly) and through sealing and insulating the ducting (see section 4.1.1).

4.1.4. Insulation of Outdoor Cooling Coils

The insulation around the chiller's condensing water supply and return lines is missing around some elbows, and in other areas, is in need of repair. The lines are located outside the building at the back near the main Trane chiller. Heat transfer is significant between the chilled water line and the hot summer air if the lines are not insulated, causing the compressor to work harder.

The replacement of line insulation is inexpensive, requiring approximately $50 in materials and 1-2 hours install time. The estimated savings is approximately $47 annually, giving a payback period of 2.8 years.

Figure 13: Cooling coil water lines feeding in and out of Trane Chiller.

4.2. Controls

4.2.1. Program Temperature Setbacks in Theatre

Installation of programmable thermostats to implement programed automatic temperature setbacks during unoccupied periods typically reduces HVAC usage from 5-15%, depending on the application and site-specific usage. We recommend that programmable thermostats be used in three areas: the theatre, box office, and Procunier room. We have assumed in our costing, that the existing thermostats would all need to be replaced.

Given that staff already perform some manual setback through adjusting the existing electric thermostats, we estimate the savings at the low end of the typical range, totaling $458 per year. At $250 per installed thermostat, this results in a simple payback period of 1.6 years. Note that these programs are modifiable at any time and should be regularly checked to ensure that the schedule follows actual facility occupancy.

4.3. Building Envelope

4.3.1. Building Air Infiltration Reduction

Outdoor air infiltration poses several problems, both energy-related and otherwise. Excessive infiltration makes HVAC control very difficult, delivering unconditioned air 24/7 alongside the conditioned air delivered by the air systems. Sealing gaps to reduce air infiltration not only saves energy but also helps to improve overall space comfort at a relatively low cost. The following opportunities to improve air sealing were identified by the auditor:

- Apply weather stripping or caulking around the edges of all windows and perimeter doors where necessary
- Replace weather stripping around the fire hatches in the roof
- Seal and insulate areas around exhaust fans

While savings are difficult to determine without space air pressure tests, we estimate that approximately 3-5% reduction in building heat loss can be achieved through improved air sealing. A full review of all outer walls, doors and windows is recommended to address air infiltration issues with additional, caulking and

weather stripping. We estimate approximately $500 in material costs and savings of $260, resulting in a 1.9 year payback.

Figure 14: Exhaust fan installed in Theatre basement window.

4.3.2. High Efficiency Windows

The fenestration in general manager's office behind the east conference room is an original single paned window, see Figure 15 below. Cracks are evident in the glass in the top left corner and the caulking is quite old and needs replacing. Staff mentioned that the room can be quite cold in the winter and therefore the thermostat that controls heat to this office along with the box office and conference room is set higher in the winter to provide heat to this space.

Significant heat transfer occurs through the surface of single paned windows and infiltration is also a concern if there are holes or cracks in the glass surface or caulking. Energy savings should be significant if this window was replaced with a new window which is triple gazed, argon filled with a low emissivity coating and a warm edge spacer. It would not only make the room more pleasant in the heating and cooling season, but would allow the reduction in space heating / cooling for the whole box office area as the thermostat set point is increased in order to ensure this back room is warm.

We estimate the cost of replacing the window is $1,304. A quote is attached in Appendix A. It is recommended that the new window be triple gazed, argon filled with a low emissivity coating and a warm edge spacer. The cost is based on a quote from a local commercial supplier (FibreTec) and is of Class 5 accuracy (+/- 50%).

Figure 15: General Manager's office window.

The savings are estimated as $110 annually and as such, the savings do not justify the replacement of the existing window. We suggest that the window be inspected to ensure the outer pane caulking is truly sealed and in good repair. While immediate replacement is not justified by energy savings alone, it should be noted that the additional cost of upgrading to high efficiency over standard windows is easily covered by the additional savings.

4.4. Lighting

4.4.1. Retrofit T12 bulbs with T8 fixtures with electronic ballasts

Several spaces currently still use T12 lamps and it is recommended that they be upgraded to T8 lamps with electronic ballasts. Magnetic ballasts are less efficient than electric ballasts and if high efficiency 28W T8 bulbs are chosen, less electricity will be consumed when they are replaced. A primary concern is that T12 bulbs and ballasts are no longer being manufactured and therefore bulbs and ballasts will be more difficult to source in the marketplace. Please see the described financial incentives at the end of this section, provided by the OPA saveONenergy program.

T12 fixtures were found in the following locations:

- basement of the Box Office: computer room and prop storage (8 fixtures – 2 x 4')
- the fly loft above the main theatre (7 fixtures – 1 x 4' bulbs)
- the third floor wardrobe room (5 fixtures – 2 x 4' bulbs)
- stage working lights (4 fixtures – 2 x 4' bulbs)
- technical booth and men's wash room (2 fixtures – 1 x 4' bulbs; 2 fixtures – 2 x 4' bulbs)

The cost of retrofitting T12 magnetic ballasts to accommodate T8 bulbs (electric ballast) is approximately $50/fixture. The total cost of retrofitting the rooms listed above would be approximately $1,400 if the fixtures were not changed. The overall electrical savings for this retrofit is fairly small at approximately $172/yr because some of the lights seldom used (fly loft and box office basement) however it should be completed due to the phase out of T12 bulbs and ballasts.

Incentives:
Incentives are available from the OPA saveONenergy program which will furnish $17/fixture to change from T12 to T8s. The incentive for this project would therefore be $476 reducing the overall cost from $1,400 to $924 and reducing the simple payback to 5.4 years. Please note that an application will be required to be submitted to London Hydro, and approved, before work is initiated, in order to be eligible for the incentive.

4.4.2. Higher Efficiency T8 Opportunities

The majority of the building lighting has been retrofitted and upgraded to fluorescent T8 fixtures with magnetic ballasts and LED Par and MR16 spotlights. Your current 4' T8 light fixtures use 32 watts of power for a single bulb fixture. A recommended upgrade is to an energy efficient type of T8 bulb called "Premium T8" which uses 28W of power and is longer lasting, up to 36,000 hours compared to 20,000 hours for standard T8 bulbs. At $1 per bulb and $5 per fixture for installation cost, the simple payback period for this project is 2.2 years. However, since both bulbs can be used interchangeably, it is suggested that the current T8 bulbs be replaced with Premium T8 bulbs when they burn out throughout the facility.

Incentives:
The Premium 4' T8 bulbs area slightly more expensive (an extra $1.00/bulb), however the current incentive from the saveONenergy program of $1/bulb makes up for the difference. The overall life cycle cost is about $2.40 less per lamp each year compared to the regular 32W 4' T8s (over 10% savings) due to the energy savings and the increased life expectancy. This translates to an overall electricity savings of approximately $92/year based on the lighting count. Using an estimated installation cost of $5/fixture, this results in an incentivized simple payback period of 1.1 years. Please contact London Hydro to have this incentive preapproved and to obtain the list of approved T8 bulbs.

4.4.3. Occupancy Sensors

Occupancy sensors that control lighting have been installed in several spaces (washrooms in the change room area etc.) but many are not working properly. The technology has improved significantly recently, not only the accuracy of the sensors, but the reliability of the units themselves. It is recommended that the existing defective sensors be replaced, and additional sensors be installed in all other washrooms, change rooms, offices and meeting areas. This would end up being approximately 9 replaced/installed sensors.

The cost of the sensors range in price, from approximately $25 to $120 each depending on the technology type: -passive infrared technology (PIR), ultrasonic technology (US) or a combination of the two. PIR sensors are the cheapest and work well in small rooms without any obstructions like single offices and single washrooms. US sensors are more expensive but use sound waves that can reach around barriers and therefore are better for large meeting rooms and washrooms with stalls. We have assumed an installed cost of $60/each for our estimate.

The total savings for the 9 sensors is approximately $210 annually resulting in a project payback of 2.6 years.

It is recommended that the time delay be set at 15 minutes to reduce the likelihood of deactivating the lighting while it may be needed and to reduce the number of times the lamps are turned off and on (which can reduce the bulb life).

Incentives:
The OPA saveONenergy program offers up to $40/sensor if the occupancy sensor is controlling a load of over 300W. Only four of the recommended rooms meet this criteria and therefore $160 would be available, reducing the payback period to 1.8 years. This program is run through London Hydro and will need to be preapproved before work is begun.

4.4.4. Replace all Incandescent Lights

LED technology has advanced significantly through the past 5 years and now represents the best replacement for all remaining incandescent lighting throughout the building. This measure includes the following recommendations for each lighting type:

- Standard Incandescent: Replace bulb with medium-base LED equivalent
- MR16 Halogen: Replace bulb with MR16 LED equivalent
- Candelabra/Chandelier Bulbs: Replace bulb with LED equivalent

When dealing with dimmable light fixtures, note that many new LED lamps are dimmable, although this may necessitate replacing the dimmer switch as well. We estimate that converting the remaining incandescent lighting costs $2,764 and can generate $1,376 in savings, resulting in a 2 year payback period. Once accounting for $830 in incentives available through retail outlets, this payback period is reduced to 1.4 years.

4.4.5. Stage Working Lights

The main lighting fixture used for setting up the stage uses a 750W halogen lamp; not only are more energy efficient options available, but they also have a significantly longer lifetime. We recommend replacing this fixture with a four-lamp T5HO fixture, which will meet or exceed existing light levels while using nearly 70% less energy. At an estimated installed cost $250 and annual savings of $106, this replacement has a simple payback period of 2.4 years. Unfortunately, no specific incentive is available for this project.

4.4.6. Overnight Shutdown of Concession Stand Lights

Currently, lights in the concession stand area are left on 24hrs a day. It is recommended that the lights be switched off during unoccupied hours, which cuts runtime by at least 50%. This measure carries no cost and has potential to save $63 annually.

4.4.7. Replace Incandescent Exit Signs

Several emergency exit signs need to be retrofitted with LED lights. The auditors found 5 signs (two in the fly loft attic space, 3 in the basement of the Procunier room) that require updating. The savings will equate to approximately 23 W per sign which corresponds to a total savings of 1,007 kWh and $131 per year each. The cost to retrofit an existing sign is estimated at $55, which results in a simple payback period of 2.3 years. Please note that the saveONenergy Prescriptive Lighting program provides an incentive of $8 per retrofit kit, which lowers the payback to 1.9 years.

4.5. Domestic Water Use

4.5.1. Low Flow Toilets

A frequent target for water efficiency lies in toilets, which can use up to 18 liters per flush, or three times the current standard. We have identified 11 high-flow toilets where water-efficient toilets can generate significant savings. Using the existing water consumption as a benchmark, we estimate that there is approximately $759 in savings available but at a cost of $5,500, which equates to a relatively long simple payback period of 7.2 years.

While the relatively long payback period may not justify immediate replacement, individual toilets which are used more often may present a more attractive case for replacement. We have used the conservative estimate of 10 flushes per day for our estimate.

Flushes/Day	Water Saved/Year (m3)	Cost Savings	Simple Payback Period
10	36	$69	7.2
15	54	$103	4.8
20	72	$138	3.6
25	90	$172	2.9
30	108	$206	2.4

Table 5: Cost Savings from Low Flow Toilets Based on Use

4.5.2. Aerators for Sinks

Faucets often represent the fastest and easiest way to reduce water consumption as well as domestic hot water usage. We recommend all faucet aerators be replaced with low-flow aerators, which reduce water flow by 50% over a standard aerator and over 80% as compared to a missing aerator. At a low cost of $5 each and an estimated total savings of $203 and a simple payback period of approximately 4 months.

5. Points for Consideration

The following are opportunities which require further investigation, or do not have significant paybacks but are worthwhile energy conservation measures to consider. Often the cost of technology drops with time therefore these items may become affordable in years to come. Other projects may be worthwhile to consider once the asset is being replaced at end of life.

5.1. Overnight Shut Down of Computers and Computer Power Management

An average desktop computer uses approximately 50 W of power when idle. There approximately 8-10 computers (including the servers) in use in the offices at the Palace Theatre and although most computers may get shut down at night and on vacations, some may be left on. This results in a cost of approximately

$28/computer annually. Although initially this sounds insignificant, it can add up quickly over a number of employees.

A suggested course of action could be to utilize an automatic shutdown option available within Microsoft office, or alternately to engage the IT department to develop an automated system for nighttime shutdown. There should not be a capital cost associated with this option and with an assumed 5 computers shut down by this option, $140/year can be saved in electrical consumption. Please note, the adopted approach should accommodate employees who may be working outside of normal operating hours.

In addition to automatic shutdown of all computers, each should be checked for proper power management settings. Power management is built into Microsoft Windows and can be accessed panel. Monitors should turn off after 5 to 10 minutes of inactivity and the system should go into standby mode through the operating system control after 10 to 15 minutes of inactivity.

6. Next Steps

A number of energy conservation opportunities have been identified at Palace Theatre which will not only lower the cost of operating the building but may provide a better conditioned working environment for staff and visitors. According to Ontario's 2013 Long Term Energy Plan, the cost of electricity will continue to rise over the next few years. It will therefore become increasingly important to address energy efficiency opportunities as they are identified to capture cost savings.

It is a requirement that the Palace Theatre apply for pre-approval for incentive funding (through the utilities) for all projects before work is carried out. Information regarding the OPA saveONenergy Incentive Funding can be found at the following three locations.

OPA saveONenergy website:
https://saveonenergy.ca/Business/Program-Overviews.aspx

London Hydro:
https://www.londonhydro.com/site/#!/energy_conservation/content?page=landing

Union Gas:
https://www.uniongas.com/business/save-money-and-energy

Blue Sky Energy Engineering and Consulting would be pleased to help fill in the applications for incentives requested by the Theatre as necessary.

End of Report.

APPENDIX A:

Equipment Specification Sheets

FIBERTEC Window & Door

CUSTOMER QUOTATION

Quote # :	3494
Project Name:	MARK EDWARDS June 9, 2014
Quote Date:	
Sales Rep:	

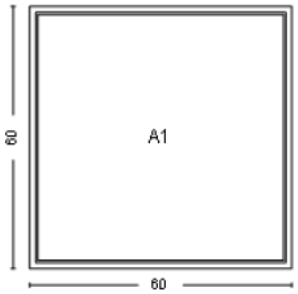
Billing Information:
MARK EDWARDS
BLUE SKY ENERGY
LONDON ONTARIO
905 855 9209

Phone: 1+888-232-4956
Fax: 1+905-660-6581

The Choice of the informed

Shipping Information:
MARK EDWARDS
BLUE SKY ENERGY
LONDON ONTARIO
905 855 9209

Line	Width [in]	Height [in]	Location	Options	Qty	Total
1-1	Frame Size: 60 x 60		None Assigned	Exterior Color? : White Interior Color? : White Strap Anchors?: 16 A1: 4 mm(1 9/16")TRI.2XSC.SS.ARG.CL.Ann. A1: 300 Series DirectSet Rectangle - 60 x 60 - Fix RO Size: 60.75 x 60.75	1	$711.29



Order Notes:

Thank you for the opportunity to quote your project.
Please note: This quote is valid for 30 Days.
All windows are viewed from outside.
Products included in this quote are Fibertec standard product line.

	Customer Price
SubTotal :	$711.29
H.S.T. :	$92.47
G.S.T. :	$0.00
Freight :	$0.00
Installation :	$0.00
Total :	$803.76

PRICE QUOTED FOB FIBERTEC