Exhibition Place

Back Pressure Steam Turbine

GreenSmart Energy Performance Report

2014 - 2016

A GreenSmart Energy Initiative

GreenSmart

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INTRODUCTION

Exhibition Place, as part of the 2014 – 2016 Strategic Plan has set a goal to reduce the impact of our operations and our business on all aspects of the environment. To meet this goal, we recognize the critical importance of improving the efficiency of existing buildings and reducing our energy consumption.

Three of the main steps towards reducing energy consumption are as follows;

- Firstly, ensure we have systems in place to improve efficiency of our energy use.
- Secondly, effectively track energy use to understand existing conditions and trends in order to forecast for the future to improve efficiencies.
- Thirdly, produce clean energy using solar, wind, geothermal and waste steam to reduce our greenhouse gas emissions.

This report covers the energy use and generation for the Back Pressure Steam Turbine for calendar years 2014, 2015 and 2016.

The Back Pressure Steam Turbine was added to the Mid Arch boilers in 2013. There are three steam boilers located in Mid Arch providing heating for the Coliseum Complex of the Enercare Centre, including the Ricoh Coliseum. The Back Pressure Steam Turbine Generator is connected to the steam boilers and acts as a back pressure reduction valve. It reduces steam to the required pressure as well as producing electricity at the same time.

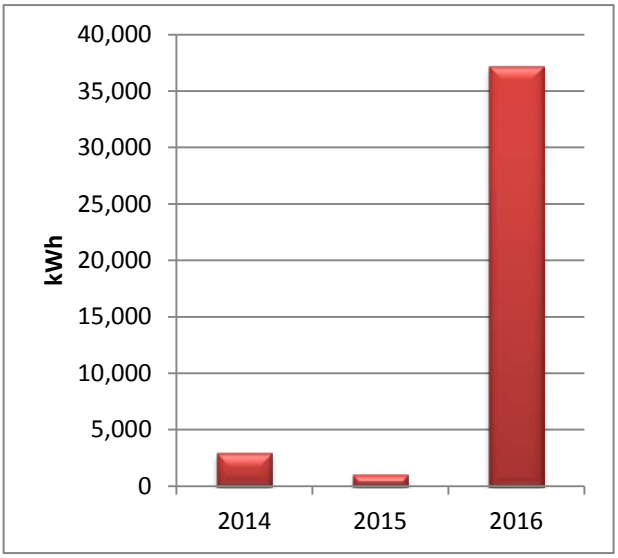
Steam pressure produced by the boilers is approximately 150 pounds per square inch (psi). This steam is directed through the Back Pressure Steam Turbine blades, reducing the pressure of the steam before it is distributed to service the low pressure steam heating system for the Coliseum Complex. As the steam moves through the Back Pressure Steam Turbine Generator its pressure will be reduced to 27 psi, and the by-product of electricity is produced by this process. The maximum rate at which the Back Pressure Steam Turbine can generate electricity is 275 kilowatt. This produced electricity can then be used by building operations or be transmitted back to the power grid of Exhibition Place.

This project is part of the Exhibition Place GreenSmart Energy Initiatives for the purpose of increasing equipment efficiencies and promoting sustainable development.

TOTAL ELECTRICAL GENERATION

Figure 1 compares the total electricity generation of Back Pressure Steam Turbine over the reporting period 2014, 2015 and 2016.

Figure 1 – Total Electrical Generation



Years	% Increase
2016 vs. 2014	1,189%
2016 vs. 2015	3,514%
2015 vs. 2014	-64%

FACTORS CONTRIBUTING TO INCREASE:

- Weather temperatures play an important role in the utilization of Mid Arch steam boilers. The colder the outdoor weather is, the more often steam boilers will run, and the more electricity will be generated through Back Pressure Steam Turbine. Although weather temperature in the winter months of 2016 (January, February, March) was warmer by 7°C and 5°C respectively compared to 2015 and 2014 as shown in Figure 3, electrical generation increased by 3,514% and 1,189% respectively compared to 2015 and 2014.
- This dramatic increase in production resulted from Exhibition Place optimizing the operation parameters of the turbine engine to operate with partial steam load, rather than at the full steam loads of all three boilers as it was initially designed to do.

MONTHLY ELECTRICAL GENERATION

Figure 2 compares the monthly electricity generation of Back Pressure Steam Turbine over the reporting period 2014, 2015 and 2016.

Figure 2 – Monthly Electrical Generation

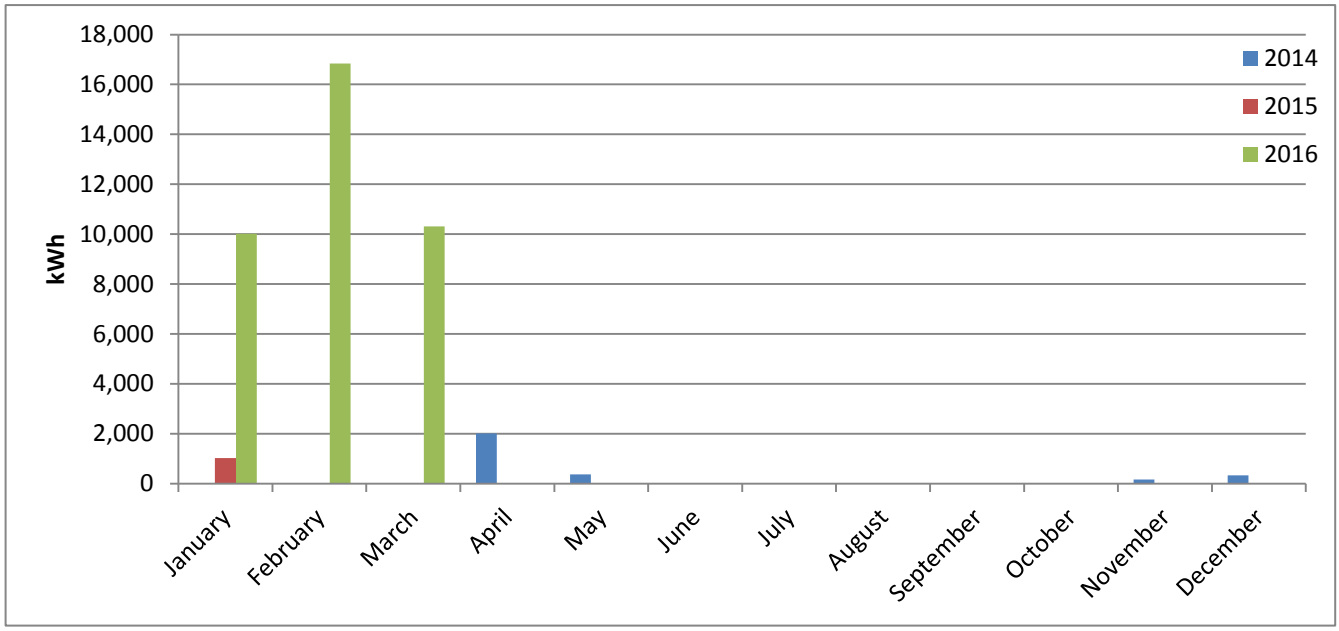


Figure 3 below shows the comparison of the average temperature for 2014, 2015 and 2016

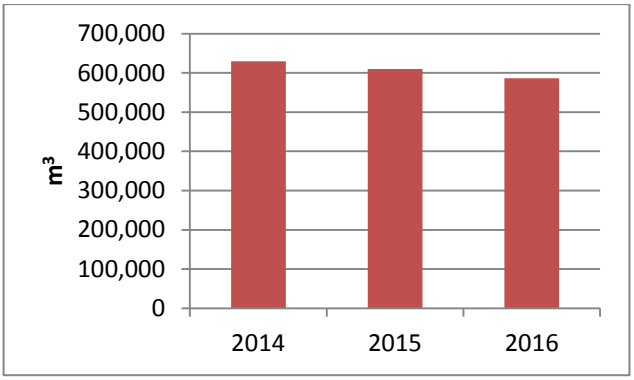
Figure 3 – Average Temperature for 2014, 2015 and 2016

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2014	-6	-6	-3	7	15	20	21	21	17	12	3	1
2015	-8	-13	-2	8	16	18	22	21	20	10	7	4
2016	-2	-1	3	5	14	19	22	24	20	13	8	0

NATURAL GAS CONSUMPTION

Figure 4 compares the total gas consumption of Mid Arch steam boilers over the reporting period. It is important to note that electrical generation is a by-product of steam production of the Mid Arch steam boilers. Therefore, natural gas consumption of the Mid Arch steam boiler does not represent the amount of natural gas required for electrical generation, but only represent the natural gas required to heat the facilities, with or without the Back Pressure Steam Turbine.

Figure 4 – Comparison of Mid Arch Gas Consumption



Years	% Increase
2016 vs. 2015	-7%
2016 vs. 2014	-4%
2015 vs. 2014	-3%

Figure 5 compares the monthly gas consumption of the Mid Arch meter over the reporting period 2014 – 2016 by Heating Degree Day (HDD).

A heating degree day (HDD) is a way to measure how cold it has been over a 24 hour period. It is determined by calculating the mean daily temperature for the day and subtracting it from a base temperature. Degree days are a good way to keep track of how much demand there has been for energy needed to heat buildings. The colder it is outside, the more degree days (HDD) and the more energy required to heat buildings

Figure 5 – Mid Arch Monthly Gas Consumption and HDD Comparison

Month	2014 (m^3)	2014 HDD	2015 (m^3)	2015 HDD	2016 (m^3)	2016 HDD
Jan	114,907	649	123,303	792	119,991	670
Feb	114,996	677	147,428	857	122,963	588
Mar	124,984	619	122,116	616	121,927	476
Apr	70,257	312	80,562	314	75,037	395
May	20,511	117	525	89	11,882	143
Jun	0	7	729	34	733	24
Jul	0	2	671	4	533	0
Aug	0	4	120	4	567	0
Sep	0	56	188	31	497	26
Oct	2,228	203	1,776	250	2,269	195
Nov	75,211	440	44,490	345	21,415	338
Dec	106,754	514	88,391	430	108,217	607
Total	**629,848**	**3,600**	**610,299**	**3,766**	**586,032**	**3,464**

- Mid Arch gas consumption decreased by 4% in 2016 compared to 2015. This was mainly due to the warmer winter in 2016.
- The Mid Arch gas meter shows the gas consumption of the three boilers located in Mid Arch and also the gas usage of the boiler that heats the corporate offices of the Royal Agricultural Winter Fair.
- The natural gas consumption is heavily dependent on weather and event activity. The warmer it is outside, the less energy is required to heat buildings. Again, as noted in Figure 3, the weather temperature in the winter months of 2016 (January, February, March) was warmer by an average of 7°C compared to 2015.

GREENHOUSE GASES

The City of Toronto has established aggressive targets to reduce Greenhouse Gas (GHG) emissions as set out in Figure 6 below. The primary greenhouse gases are carbon dioxide (CO2), sulphur oxides (SOx), nitrous oxide (NOx), water vapor, methane and ozone. As an agency of the City of Toronto, Exhibition Place both tracks its GHG emissions and aims to reduce them to help meet the City target.

Figure 6 –The City of Toronto's Emission Reduction Targets

	Air Quality Contaminants (2004 Baseline)	Greenhouse Gases (1990 Baseline)
2012	20%	6%
2020	--	30%
2050	--	80%

The City of Toronto has developed a greenhouse gas and air quality inventory program that has the primary purpose of tracking the progress of the City Community and the City Government (the latter as a subset of the City Community) towards achieving its adopted greenhouse gas and air quality emission reduction targets outlined above. The targets set by the City are absolute targets rather than relative targets, meaning they are independent of population growth or decline, economic growth or decline, or weather variability (e.g., hot summers that lead to more electricity consumption for air conditioning, and cold winters that lead to more natural gas consumption for space heating). The targets apply equally to the City Community and the City Government alike, but progress toward achieving the targets is cumulative. If a sector within the City Community overachieves it may be offset by a sector that underachieves, and vice versa. Equally, if a Division or agency of City Government overachieves it will offset those that do not.

Greenhouse gas emissions mitigated in CO2, NOx and SOx from electricity generation are shown in Figure 7. Greenhouse gas emissions from gas use by the Mid Arch steam boilers are shown in Figure 8.

Figure 7 – Green House Gas Emissions Mitigated through Electrical Generation

Year	Electricity		
	CO2	NOx	SOx
	Ton	Ton	Ton
2014	0.7	0.0010	0.0002
2015	0.3	0.0004	0.0001
2016	9.1	0.0129	0.0023

Figure 8 – Green House Gas Emissions from Natural Gas Use

Year	Gas		
	CO2	NOx	SOx
	Ton	Ton	Ton
2014	1,264	0.9587	0.0075
2015	1,225	0.9290	0.0072
2016	1,176	0.8920	0.0070

HYDRO SAVINGS

The total electrical generation of the turbine is shown in Figure 1. The total hydro savings for the electrical generation is shown in Figure 9.

Figure 9 – Hydro Savings

Year	Total Generation	Average Rate per kWh	Total Hydro Savings
	[kWh]	$	$
2014	2,884	0.1106	319
2015	1,028	0.1181	121
2016	37,166	0.1396	5,188

GAS EXPENSES

The Natural Gas Consumption is tracked by Mid Arch gas meter. The Mid Arch gas meter shows the gas consumption of the three boilers located in Mid Arch and also the gas usage of the boiler used to heat the corporate offices for the RAWF. Again, the addition of the turbine does not add to the volume of natural gas used.

Total gas consumption is shown in Figure 4 and the cost of that consumption is shown in Figure 10.

Figure 10 – Gas Cost

Year	M3	Average Rate/M3	$
2014	629,848	0.273	171,949
2015	610,299	0.330	201,399
2016	586,032	0.331	193,977

FUTURE DIRECTIONS

Increasing the efficiency of existing electrical and HVAC (Heating, ventilation and air conditioning) systems is a key step towards Exhibition Place's energy reduction goal. Generating electrical energy as a by-product of steam heating system helps us to reduce our environmental impact. The following projects are targeted for 2017 to help us meet our goal.

- Continuously optimize Back Pressure Steam Turbine operations to reduce maintenance, schedule and cost.

- Connect the steam plant at the Coliseum Complex and the heating plant at the Enercare Centre.

- With Hotel X heating demand, Exhibition Place plans to double the production of the Back Pressure Steam Turbine in 2017 - 2018.