Exhibition Place

# Back Pressure Steam Turbine

# GreenSmart Energy Performance Report

# 2016 - 2018

A GreenSmart Energy Initiative

GreenSmart

# TABLE OF CONTENTS

# INTRODUCTION

Exhibition Place, as part of the 2017 – 2019 Strategic Plan, has set a goal to reduce the environmental impact of operations and businesses.  . 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 2016, 2017 and 2018.

The Back Pressure Steam Turbine was added to the Mid Arch boilers in 2013. There are three steam boilers located in Mid Arch, they provide 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 required pressure as well as producing electricity.

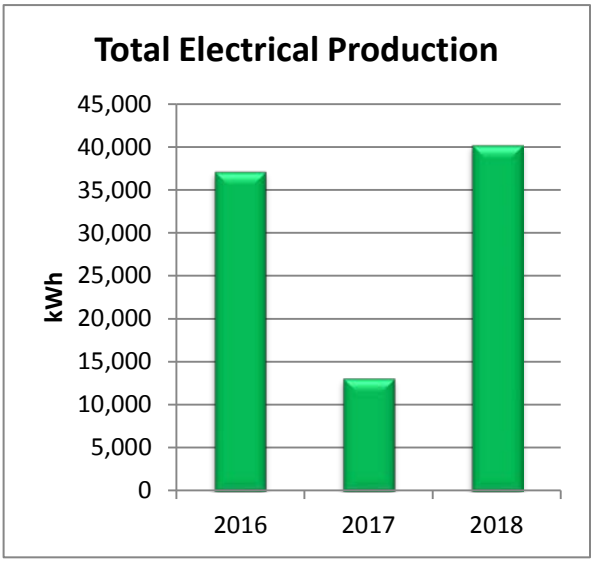
Steam pressure produced by the boilers is approximately 150 pounds per square inch (psi). This steam is directed through the Back Pressure Steam Turbine blades, reducing the pressure of the steam before it is distributed to service the low pressure steam heating system for the Coliseum Complex. As the 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 kilowatts. 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 program 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 2016, 2017 and 2018.

### Figure 1 – Total Electrical Generation




| Years | % Increase |
|---|---|
| 2018 vs. 2017 | 206% |
| 2018 vs. 2016 | 8% |
| 2017 vs. 2016 | -65% |

**FACTORS CONTRIBUTING TO INCREASE:**

- Weather temperatures play an important role in the utilization of the Mid Arch steam boilers. The colder the outdoor weather is, the more often the steam boilers will run, and the more electricity will be generated through the Back Pressure Steam Turbine. Weather temperature in the winter months of 2018 (January, February, March) was cooler by 1.6°C and 1.4°C respectively compared to 2017 and 2016 as shown in Figure 3, electrical generation increased by 206% and 8% respectively compared to 2017 and 2016.
- A Heat exchanger was installed at the east loading dock to allow heat from the Mid Arch steam boiler plant to transfer to the main hot water system in the Enercare Centre, effectively connecting the two systems. This project allows for the Steam boilers to be operated even in warmer months to help reduce the load of the Enercare Boiler plant by providing heat to the District Energy System.

## MONTHLY ELECTRICAL GENERATION

Figure 2 compares the monthly electricity generation of Back Pressure Steam Turbine over the reporting period 2016, 2017 and 2018. The Back Pressure Steam Turbine was not used in November because of specific show requirements of the event held in that month.

**Figure 2 – Monthly Electrical Generation**

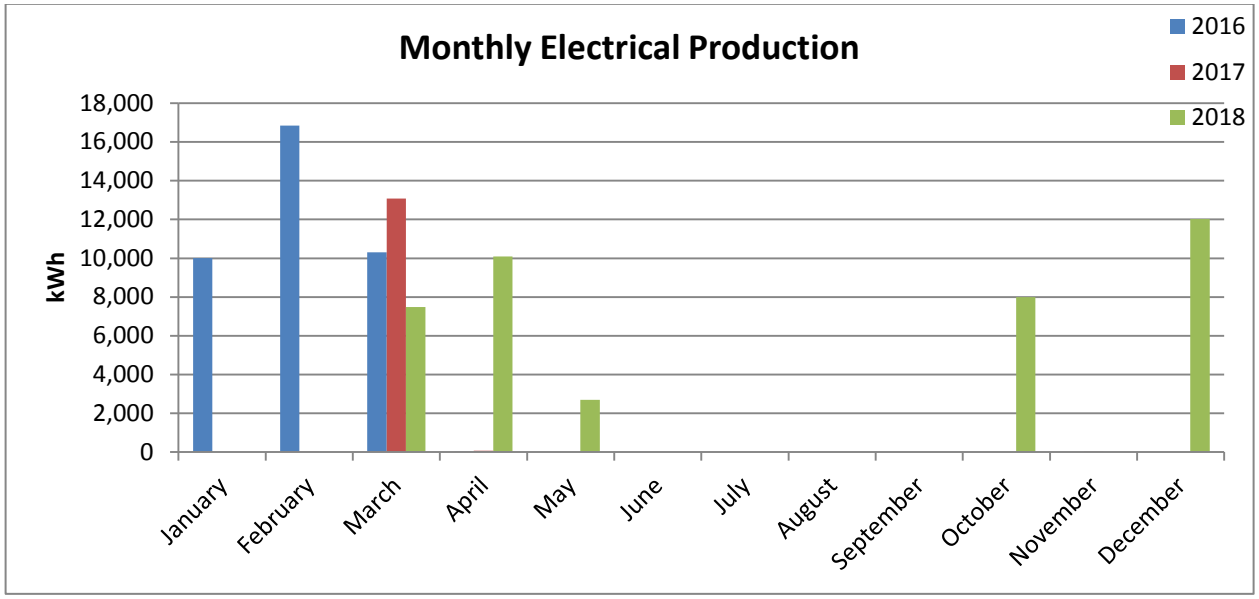



Figure 3 below shows the comparison of the average temperature for 2016, 2017 and 2018

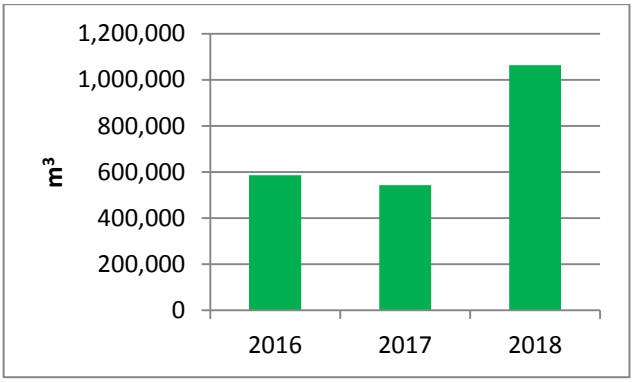
**Figure 3 – Average Temperature for 2016, 2017 and 2018**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | -2 | -1 | 4 | 6 | 16 | 20 | 21 | 24 | 20 | 13 | 8 | -1 |
| 2017 | -1 | -1 | 0 | 10 | 12 | 19 | 22 | 21 | 19 | 14 | 5 | -4 |
| 2018 | -4 | -1 | 1 | 5 | 17 | 20 | 23 | 24 | 19 | 10 | 2 | 1 |

## 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 Mid Arch steam boilers. Therefore, natural gas consumption of 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 |
|---|---|
| 2018 vs. 2017 | 96% |
| 2018 vs. 2016 | 81% |
| 2017 vs. 2016 | -7% |

Figure 5 compares the monthly gas consumption of the Mid Arch meter over the reporting period 2016 – 2018 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 | 2016 (m^3) | 2016 HDD | 2017 (m^3) | 2017 HDD | 2018 (m^3) | 2018 HDD |
|---|---|---|---|---|---|---|
| Jan | 119,991 | 588 | 105,041 | 575 | 176,577 | 694 |
| Feb | 122,963 | 558 | 108,606 | 476 | 162,737 | 507 |
| Mar | 121,927 | 450 | 117,122 | 538 | 142,313 | 424 |
| Apr | 75,037 | 295 | 28,854 | 245 | 124,563 | 393 |
| May | 118,82 | 120 | 678 | 158 | 88,479 | 71 |
| Jun | 733 | 21 | 905 | 20 | 67,204 | 13 |
| Jul | 533 | 0 | 251 | 0 | 36,287 | 0 |
| Aug | 567 | 0 | 465 | 6 | 2,377 | 0 |
| Sep | 497 | 18 | 435 | 39 | 1,488 | 39 |
| Oct | 2,269 | 175 | 1,355 | 123 | 54,197 | 266 |
| Nov | 21,415 | 299 | 43,853 | 372 | 66,690 | 455 |
| Dec | 108,217 | 552 | 135,623 | 679 | 140,027 | 498 |
| Total | **586,032** | **3,075** | **543,189** | **3,231** | **1,062,939** | **3,358** |

- Mid Arch gas consumption increased by 96% in 2018 compared to 2017. This is in part caused by the cooler winter in 2018 and also in part due to changes in our operation of the steam plant. With the newly completed heat exchanger project at door 20, the steam plant can be run to help reduce the load of the main Enercare Centre boilers while simultaneously generating electricity through the Back Pressure Steam Turbine. Operating the steam plant in this way also has an added benefit of reducing maintenance costs as frequent operation of the steam turbine helps in preserving the components of the turbine.

- The Mid Arch gas meter reflects 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 events that require the use of natural gas. 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 2018 (January, February, March) was Cooler by an average of 1.6°C compared to 2017.

## 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 |
| 2016 | 9.1 | 0.0129 | 0.0023 |
| 2017 | 3.2 | 0.0046 | 0.0008 |
| 2018 | 9.8 | 0.0140 | 0.0025 |

**Figure 8 – Green House Gas Emissions from Natural Gas Use**

| Year | Gas | | |
|---|---|---|---|
| | CO2 | NOx | SOx |
| | Ton | Ton | Ton |
| 2016 | 1,176 | 0.8920 | 0.0070 |
| 2017 | 1,090 | 0.8268 | 0.0064 |
| 2018 | 2,133 | 1.6180 | 0.0126 |

## HYDRO SAVINGS

The total electrical generation 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] | $ | $ |
| 2016 | 37,166 | 0.1417 | 5,266 |
| 2017 | 13,166 | 0.1293 | 1,702 |
| 2018 | 40,282 | 0.1285 | 5,176 |

## GAS EXPENSES

The Natural Gas Consumption is tracked by the 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.

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 | $ |
|---|---|---|---|
| 2016 | 586,032 | 0.243 | 142,464 |
| 2017 | 543,189 | 0.259 | 140,795 |
| 2018 | 1,062,939 | 0.231 | 245,964 |

## REDUCTION INITIATIVES STATUS UPDATE

Listed below is a status update on reduction initiatives undertaken as identified in the 2014 – 2016 Beanfield Centre GreenSmart Energy Performance Report.

| No | DESCRIPTION | STATUS UPDATE |
|---|---|---|
| 1 | Continuously optimize Back Pressure Steam Turbine operations to reduce maintenance, schedule and cost. | During periods of minimal load; steam is sent to the DES through a heat exchanger in the east loading dock of the ECC. By operating in this manner we can keep the steam turbine active (which prevents corrosion of components) while simultaneously reducing the load of the main hot water boiler plant in the ECC. |
| 2 | Connect the steam plant at the Coliseum Complex and the heating plant at the Enercare Centre. | A heat exchanger was installed at the east loading dock in Fall of 2017. This project effectively connects the two systems and allows us to run both plants more efficiently while also providing a method of providing sufficient heat to the DES if the ECC main hot water plant were to fail. |
| 3 | With Hotel X heating demand, Exhibition Place plans to double the production of the Back Pressure Steam Turbine in 2017 - 2018. | Repairs to the unit in 2017 negatively impacted our ability to increase electrical production for the 2017 calendar year. However, production recorded in 2018 is the highest since the unit was commissioned. |

## 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 also helps us to reduce our environmental impact. The following projects are targeted for 2019 to help us meet this goal.

- Continuously optimize Back Pressure Steam Turbine operations to reduce maintenance, schedule and cost.
- Study the feasibility of installing a new addition to the connection between the steam plant at the Coliseum Complex and the heating plant at the Enercare Centre.
- Exhibition Place plans to double Back Pressure Steam Turbine production in 2019 vs. 2018.
- Add additional meters in the steam plant to more precisely track steam use and distribution.