Exhibition Place

Solar Photovoltaic (PV)

GreenSmart Energy Performance Report

2016 - 2018

A GreenSmart Energy Initiative

GreenSmart

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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 electrical production of solar photovoltaic (PV) for calendar years 2016, 2017 and 2018.

Solar PV converts sunlight into electrical energy through solar cells. There are four solar PV projects installed at Exhibition Place, located on the rooftop of Horse Palace East, Horse Palace West, East Annex, and Better Living Centre.

Horse Palace East solar PV was installed in the summer of 2006, and was initially part of the Renewable Energy Standard Offer Program (RESOP). When first installed the 100 kilowatt Horse Palace East PV plant was the largest urban PV array in Canada. This project was supported by the Federation of Canadian Municipalities (FCM), Toronto Atmospheric Fund (TAF), and City of Toronto Better Buildings Partnership (BBP).

Horse Palace West PV and East Annex PV were launched in June 2012. Horse Palace East, Horse Palace West, and East Annex solar PV projects are all part of the Ontario Power Authority (OPA) “feed-in tariff” (FiT) program, in which Exhibition Place receives premium monthly payment from Toronto Hydro for producing renewable energy onsite.

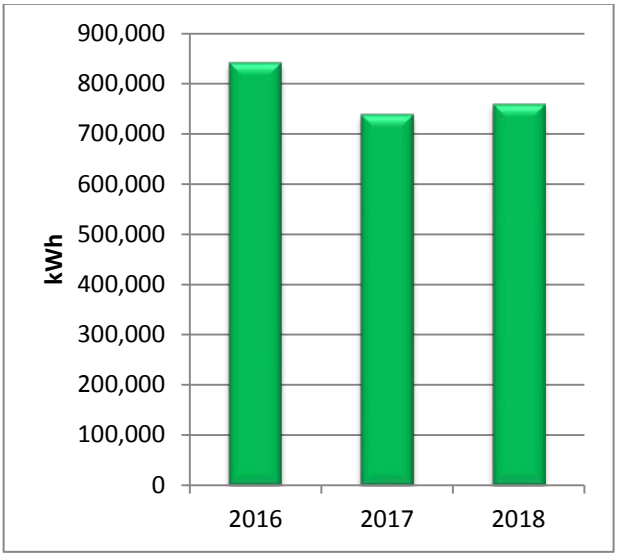
Better Living Centre PV was built and owned by Toronto Hydro Corporation and Exhibition Place leases the rooftop of Better Living Centre to Toronto Hydro to support this green initiative.

The solar PV projects demonstrate the leadership of Exhibition Place in advancing our understanding of PV generation in an urban context. Generating electrical energy using solar PV also contributes to reducing Greenhouse Gas (GHG) emissions.

TOTAL ELECTRICAL Production

Figure 1 compares the total electricity production of solar PV over the reporting period 2016, 2017 and 2018. The total electrical production includes solar PV generation for Horse Palace East and West, East Annex and Better Living Centre.

Figure 1 – Total Electrical Production



Years	% Increase
2018 vs. 2017	3%
2018 vs. 2016	-10%
2017 vs. 2016	-12%

Horse Palace East and West PV have a capacity of 100 kilowatt (kW) each, which means the maximum power generation of each solar PV plant is 100 kW. East Annex PV has a capacity of 150 kW and Better Living Centre is rated at 250 kW. Figure 2 on the next page shows yearly electrical production for each solar PV plant.

MONTHLY ELECTRICAL PRODUCTION

Figure 2 compares the monthly electricity production of Solar PV over the reporting period 2016, 2017 and 2018.

Figure 2 – Monthly Electrical Production

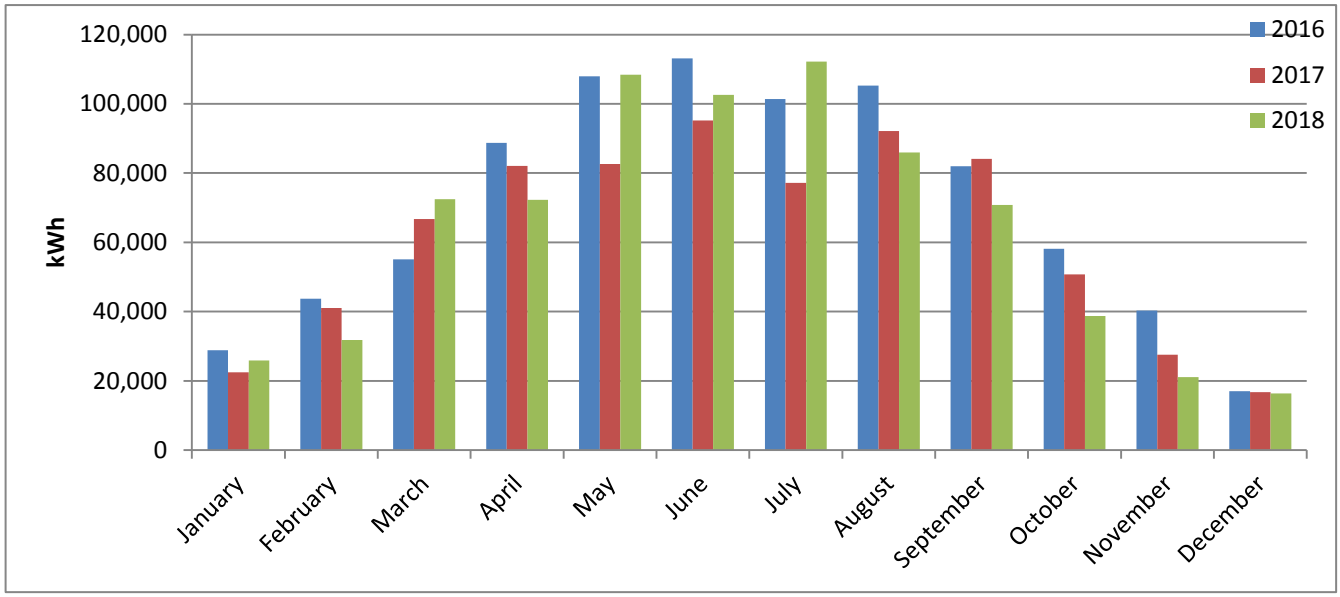


Figure 3 compares duration of daylight against total monthly electrical production for the reporting years 2016, 2017 and 2018. Duration of daylight is measured in hours from sunrise to sunset. In the winter months, snow cover prevents solar panels from receiving irradiance from the sun.

Figure 3 – Duration of Daylight vs. Monthly Electrical Production

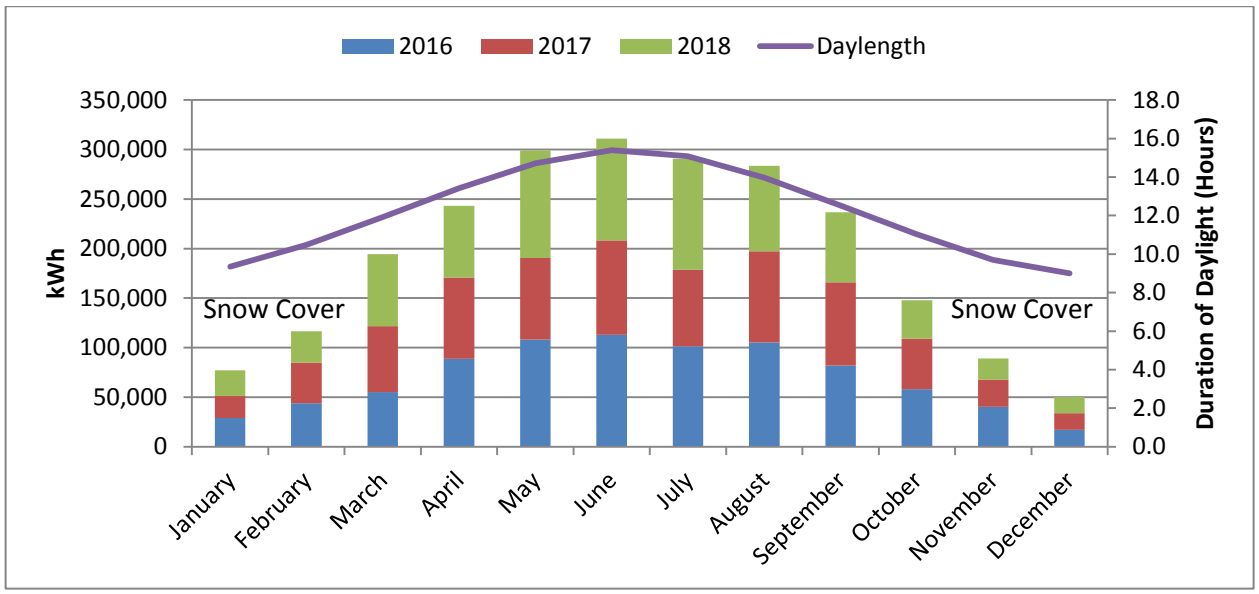


Figure 4 shows a comparison of monthly average cloud cover percentage for the reporting year 2016, 2017 and 2018. The lower the cloud cover percentage is, the higher the solar irradiance on solar panels will be.

Figure 4 – Cloud Cover Comparison 2016, 2017 and 2018

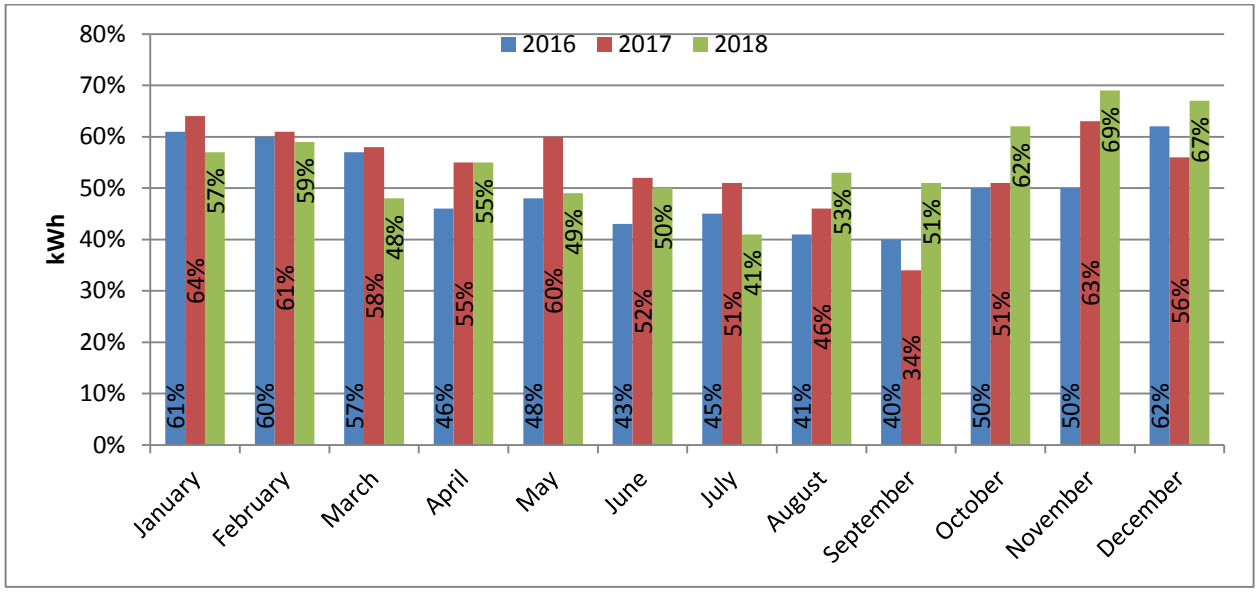


Figure 5 below shows the comparison of the average temperature for 2016, 2017 and 2018. It may be counter-intuitive, but solar panel efficiency decreases at high temperature (above 25 degree Celsius). Solar power generation is mainly affected by solar irradiance, which is a combined attribute of daylight duration and cloud cover percentage.

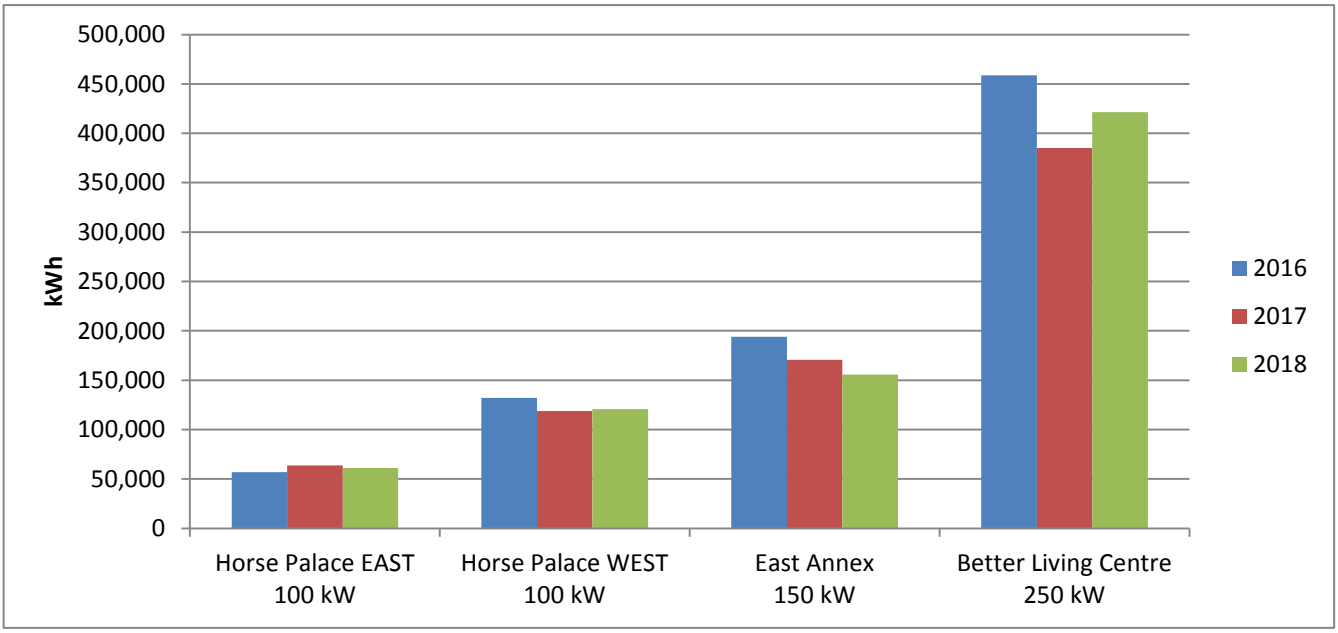
Figure 5 – Average Temperature for 2016, 2017 and 2018

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

ELECTRICAL PRODUCTION DISTRIBUTION

Figure 6 compares the electricity production distribution of Horse Palace East, Horse Palace West, East Annex and Better Living Centre solar PV for the reporting period.

Figure 6 – Electricity Production Distribution



Although Horse Palace East and Horse Palace West solar PV have the same capacity of 100 kW, the technology used for Horse Palace West is more advanced than the East solar PV, because Horse Palace East PV was installed in 2006 while West PV was launched in 2012. That is one of the reasons why Horse Palace East PV generated less electrical energy comparing to West PV.

Horse Palace East solar PV was a pilot project, in which two different solar panel manufacturers, Evergreen and Sharp, were selected. Horse Palace East solar panels are tilted at 0, 10 and 20 degrees to determine which generated the most electricity. One of the findings is that 0 degree solar panels are not efficient at generating electricity during winter because they cannot remove snow the same way other inclined panels do with the help of gravity.

There are two reasons why Better Living Centre Solar PV produced much more electricity than the other three plants. First, Better Living Centre has a much higher rated capacity of 250 kW. Second, Better Living Centre uses a different solar panel type from the other three plants. Better Living Centre solar PV utilizes tubular structure instead of flat solar panels. This innovation allows the PV plant to not only collect solar radiation from direct sunlight, but also to collect solar irradiance reflected from the white reflective roof surface below the solar tubes.

GREENHOUSE GASES

The City of Toronto has established aggressive targets to reduce Greenhouse Gas (GHG) emissions as set out in Figure 7 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 7 – 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. Similarly, 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 production is shown in Figures 8, 9, 10 and 11, and the total greenhouse gas emissions mitigated is shown in Figure 12.

Figure 8 – Horse Palace East PV Green House Gas Emissions *Mitigated*

Year	Horse Palace East PV Electrical Production		
	CO2	NOx	SOx
	Ton	Ton	Ton
2016	13.9	0.0198	0.0036
2017	15.6	0.0222	0.0040
2018	14.9	0.0213	0.0038

Figure 9 – Horse Palace West PV Green House Gas Emissions *Mitigated*

Year	Horse Palace West PV Electrical Production		
	CO2	NOx	SOx
	Ton	Ton	Ton
2016	32.2	0.0459	0.0083
2017	29.0	0.0414	0.0075
2018	29.4	0.0420	0.0076

Figure 10 – East Annex PV Green House Gas Emissions *Mitigated*

Year	East Annex PV Electrical Production		
	CO2	NOx	SOx
	Ton	Ton	Ton
2016	47.3	0.0675	0.0122
2017	41.7	0.0594	0.0108
2018	38.0	0.0542	0.0098

Figure 11 – Better Living Centre PV Green House Gas Emissions *Mitigated*

Year	Better Living Centre PV Electrical Production		
	CO2	NOx	SOx
	Ton	Ton	Ton
2016	111.9	0.1596	0.0289
2017	94.0	0.1340	0.0243
2018	102.8	0.1466	0.0265

Figure 12 – Total Green House Gas Emissions *Mitigated*

Year	CO2	NOx	SOx
	Ton	Ton	Ton
2016	205	0.2929	0.0530
2017	180	0.2570	0.0465
2018	185	0.2640	0.0478

HYDRO SAVINGS

The total electrical production is shown in Figure 6 and consists of Horse Palace East, Horse Palace West, East Annex, and Better Living Centre solar PV.

The total hydro savings for the production noted above is shown in Figure 13.

Figure 13 – Hydro Savings

Year	Total Savings	Average Rate per kWh	Total Hydro Savings
	[kWh]	$	$
2016	788,310	0.1396	117,479
2017	835,815	0.1293	95,531
2018	841,538	0.1285	97,506

In addition, as part of the feed-in tariff (FiT) program, Exhibition Place also receives monthly payments from Toronto Hydro for the electrical generation of Horse Palace East, Horse Palace West, and East Annex solar PV. The FiT program rate was set at $0.713 per kilowatt hour electricity produced; the benefit of this program is shown in Figure 14 below. Please note that Better Living Centre electrical production is not included in the FiT program, because it belongs to Toronto Hydro.

Figure 14 – FiT Program Benefit (Horse Palace East, Horse Palace West, and East Annex)

Year	Total Savings	Average FiT Rate per kWh	Total FiT Benefits
	[kWh]	$	$
2016	382,850	0.713	272,972
2017	353,585	0.713	252,106
2018	337,461	0.713	240,610

Figure 15 sums up hydro savings and FiT benefit to show the total savings from the solar PV programs.

Figure 15 – Total Savings (Hydro Savings and FiT Program Benefit)

Year	Total Savings
	$
2016	390,451
2017	347,637
2018	338,115

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	Source and replace the two damaged solar panels of Horse Palace East Solar PV plant.	Additional damage was sustained to this installation in August, 2018. Repairs are planned for 2019
2	Monitor PV Production Energy Monitoring Dashboard on a daily basis	PV Production has been added to the energy monitoring dashboard and is currently being monitored on a daily basis.
3	Track number of snow cover days to make sure solar panels function properly, and to detect alarms or faults on a timely basis.	Precipitation(including snowfall) is currently being tracked on a daily basis

FUTURE DIRECTIONS

Generating clean energy with renewable resources is a key step towards Exhibition Place's environmental impact reduction goal. The following projects are targeted for 2019 to help us meet this goal.

- Source and repair a damaged array belonging to the Horse Palace East Solar PV plant.
- Monitor PV production with Energy Monitoring Dashboard on a daily basis.
- Investigate different angles that the PV panels can be configured in order to optimize solar irradiance.
- Bring In consultant to investigate feasibility of installing additional PV projects on Exhibition Place roofs as they are renewed.