Toronto Fire Station #334
3.2 kW PV Installation

Final Report – January 2012

Technology

Monitoring

Best Practices

SolarCity
Partnership

PROJECT SNAPSHOT

Address:	339 Queen's Quay West, Toronto, ON
Building Type and Use:	Fire Station #334
Owner:	City of Toronto
Owner Contact:	Joel Arthurs
Phone #:	416-392-5177
Email:	jarthur@toronto.ca
System type:	Roof-mounted grid-tied photovoltaic system
Array Angle:	25 degrees from horizontal
Azimuth:	15 degrees West of South
String Configuration:	4 modules per string, 4 parallel strings
Module Manufacturer:	Sanyo
Module Model:	HIP-200BA3 200 watt
Number of Modules:	16
Inverter Manufacturer:	Fronius
Inverter Model:	IG 4500-LV (4.5 kW)
Number of Inverters:	1
System size (kW):	3.2 kW total
System size (sq. meters):	19
Installation date:	December 2006

PERFORMANCE

2010 Actual Performance*:	1,210 kWh/kW
RETScreen using on-site irradiance:	1,089 kWh/kW
RETScreen using 20 year historical average:	1,103 kWh/kW

FINANCIAL

Installed Cost (taxes included):	$62,007
External Funding:	0
Annual Income:	$3,106
Simple Payback:	19.7 years
Cost per kW:	$19,377

Photos provided by Lucio Mesquita

MONITORING

Monitoring equipment installed:	Yes
Overview of the monitoring plan:	Fronius Data Acquisition System. Monitored parameters include solar irradiance, cell and ambient temperature, wind speed, and energy output by the inverter.
Cost of M&V :	?
Who is analyzing the data?	City of Toronto Energy & Waste Management Office
Is there a dedicated staff person responsible for system operation management?	No

SUMMARY

The City of Toronto's 3.2 kW photovoltaic system at Fire Station #334 generated approximately 1,210 kWh/kW in 2010/2011, which was 11.1% higher than simulated yield derived from local irradiance. Designed to take advantage of Ontario's Feed-in Tariff (FIT) program which pays owners for the electricity produced by their system, the system was installed in 2006 for $62,007. Based on historical weather, the project will achieve a simple payback in 19.7 years. Had the site not required structural reinforcement, the financial case would have been more attractive.

FIT payments began in July 2010 and should provide a reliable revenue stream for the City of Toronto for the next 20 years.

BACKGROUND

In December 2006, the City of Toronto implemented a 3.2 kW photovoltaic pilot project at Toronto Fire Station #334. The PV system provides energy from a renewable source, which reduces both the financial and environmental costs of operating the fire station. The project demonstrates the City's commitment to renewable energy development and greenhouse gas reduction targets.

Special Site Considerations

The site required structural work to be able to support the PV system, which significantly added to the cost of the project.

PERFORMANCE ANALYSIS

RETScreen Model Parameters

RETScreen was used to predict expected yield. Table 1 shows the key parameters in the two RETScreen scenarios. The first uses a 16% loss factor derived from the California Energy Commission guidelines[1] and historic irradiance and temperature data from a Toronto weather station (RET20yr). The second also incorporates a 16% loss factor, but uses on-site irradiance and temperature data over the same one year period that actual production data were available (RETOnSite). Both scenarios assume 1% miscellaneous losses and inverter efficiency of 95.5% (as rated by the California Energy Commission).

1 California Energy Commission, 2001. A Guide to Photovoltaic (PV) System Design and Installation: Consultant Report. The 16% derate only includes loss factors such as STC tolerance, dirt and dust, mismatch and wiring that are relevant to the Toronto Parking Authority site.

Table 1. Key parameters in the different RETScreen scenarios.

RETScreen Input	RET20yr	RET1yrOnSite
Annual solar radiation (kWh/m^2 on a horizontal surface)	1,310	1,330
Annual average daily irradiance (kWh/m^2/d)	3.59	3.64
Annual average ambient temperature (C)	7.2	10.6
CEC weighted inverter efficiency	93.5%	93.5%
PV array losses	16%	16%
Miscellaneous power conditioning losses	1%	1%

Actual Performance vs. RETScreen Simulations

Annual energy yield from August 10, 2010 to August 9, 2011 was 3,873 kWh, or 1,210 per kW installed. Based on one year of data, production was within the expected range for PV systems in the GTA (which has typically been between 1000 and 1250 kWh/kW/yr).

Energy production over the 12 month period beginning in August 2010 and ending in July 2011 is shown in Figure 1. On an annual basis, the RET1yrOnSite model predicted output was 11.1% less than actual yield. The RET20yr scenario predicted output was higher at 8.8% less than actual yield.

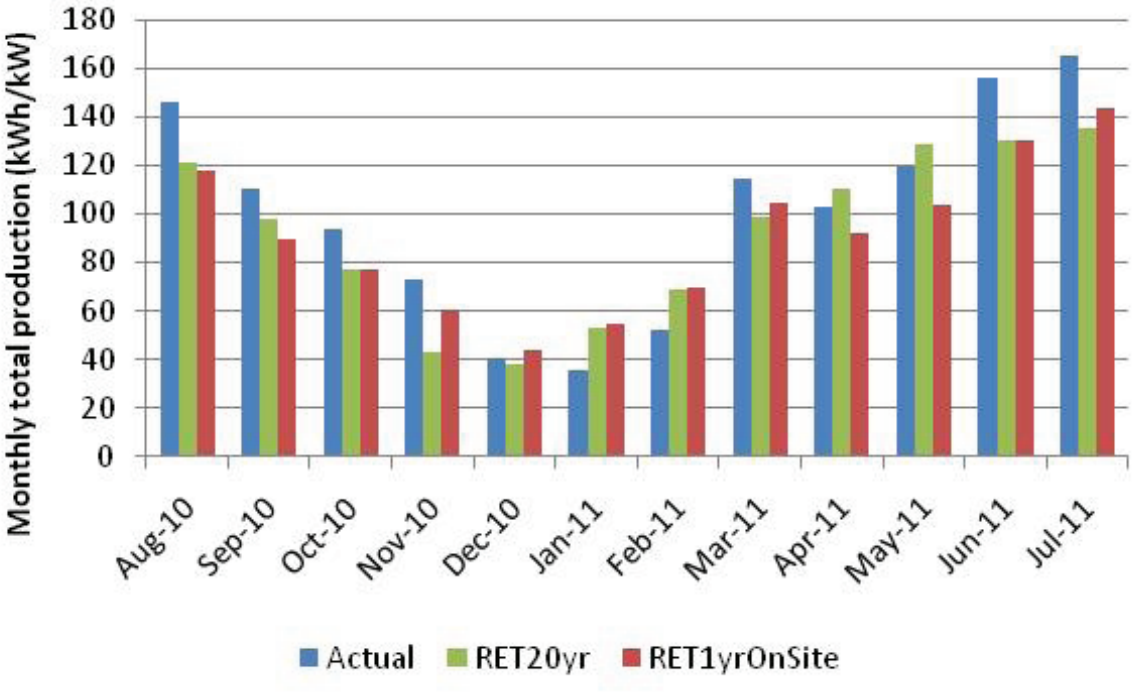
On a monthly basis, using the RET1yrOnsite model as a benchmark, energy yield fell below expectations during the winter (December through February) by an average of 22.4%. This trend has been observed at other sites in the GTA, and is likely due in part to the RETScreen program's failure to account for snow cover. For the remainder of the year (March through November), energy yield was an average of 17.8% above expectations.

BUSINESS CASE

The Feed-in Tariff contract pays a fixed price for energy produced by the City of Toronto's PV system for the next 20 years. To evaluate the business case, a RETScreen analysis using historical irradiance and ambient temperature data was used to simulate energy production and associated income for the next 20 years. The RET20yr model used in the business case was modified to include a derate factor of 6.5%, which was the derate factor that best fit the actual production data.

Table 2 presents the business case for The Toronto Fire Station #334 PV project. This analysis predicts an array output of 3,930 kWh per year, which would provide $3,152 of income per year at the current microFIT rate of $0.802/kWh. The simple payback for this scenario would be 19.7 years when the cost of structural work is included, and 12.8 years when it is not.

Figure 1. Actual and simulated energy production at Toronto Fire Station #334.



*Actual production in the month of Aug 2010 is actually comprised of data from Aug 10-31, 2010 and Aug 1-9, 2011 in order to be comparable to the RETScreen simulations, which provide monthly output only.

*Production was estimated from March 25 to 31, 2011.

Since the cost of structural work at Fire Station #334 was relatively high (35% of total construction costs) and probably unique to this particular site, a separate feasibility study that excludes structural work expenditures is presented below.

The project was financed through the City's capital budget.

Installed System Costs

The breakdown of installed system costs are shown in Table 3. The total cost of the system was $62,007, or $40,286 without structural work. This amounts to $19,377 per kW installed or $12,589 per kW installed without structural work. The City of Toronto was responsible for the entire cost of the project (no grants were received).

Table 2. Toronto Fire Station #334 PV Project: Business Case

	Total cost installed	Grants	Array output (kWh/yr)	Income from electricity sales	Simple payback (years)
Adjusted feasibility study (based on total cost)	$62,007	$0	3,930	$3,152	19.7
Adjusted feasibility study (based on total cost excluding structural work)	$40,286	$0	3,930	$3,152	12.8

Table 3. Toronto Fire Station #334 PV project: As-Built Cost Breakdown

Cost Items	Component Costs	Percent of Total Cost
Equipment	$20,558	33%
Electrical installation	$10,037	16%
Structural design	$3,500	6%
Structural work	$21,721	35%
Site visit & commissioning	$6,190	10%
Total Cost	**$62,007**	
Total Cost (excluding structural work)	**$40,286**	

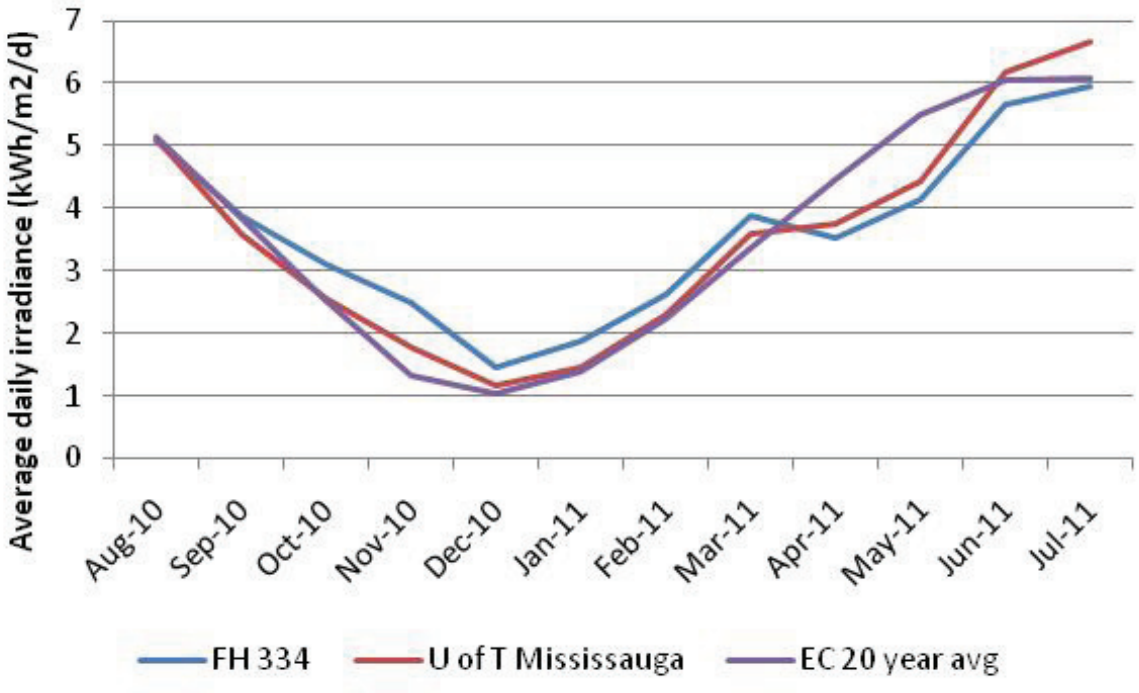
APPENDIX 1: MONTHLY IRRADIANCE DATA

Although a pyranometer was installed at Toronto Fire Station #334, data from this instrument were not used in the RET1yrOnSite model because irradiance was measured in the plane of the array (25 degrees) rather than at horizontal, which is required by the RETScreen program. Instead, irradiance data measured using a reliable pyranometer at the University of Toronto Mississauga Meteorological Station (UTMMS) were used in the RETScreen simulations. Data from these two pyranometers, as well as with Environment Canada's 20 year average for the City of Toronto are compared in Figure 4.

Irradiance measured in Toronto at a 25 degree angle (which is near optimal for the region) is expected to be greater than that measured in a horizontal plane. On an annual basis, irradiance measured at Toronto Fire Station #334 was 2.5% greater than that measured at UTMMS, and 1.6% greater than Environment Canada's 20 year average. On a monthly basis, irradiance at Fire Station #334 was stronger than the other two stations from September through March and weaker during the remainder of the year.

Overall, the irradiance curves from the three weather stations are similarly shaped, with the exception of April and May 2011. The dip in irradiance observed at Fire Station #334 and UTMMS in these months is likely a result of an increased amount of cloud cover and precipitation relative to Environment Canada's historical average. Total precipitation in April and May 2011 was 237.4 mm, while the long term average (1971 to 2000) in these months was 140.9 mm.[2]

Figure 4. Average daily irradiance in the Greater Toronto Area (2010-2011).



2 Canadian Climate Normals, 1971-2000. Environment Canada National Climate Data and Information Archive. Online. Available at: www.climate.weatheroffice.gc.ca.

About the SolarCity Partnership

The SolarCity Partnership is a joint initiative of the Toronto Atmospheric Fund, Toronto and Region Conservation Authority and the City of Toronto designed to promote best practices and careful monitoring of large solar installations. SolarCity Partnership is an information-sharing hub for both public and private organizations involved in deploying solar power. Our **SolarCityPartnership.ca** website provides case studies, research, and solar weather data to help with the effective use of zero emissions energy from the sun.

Toronto Atmospheric Fund

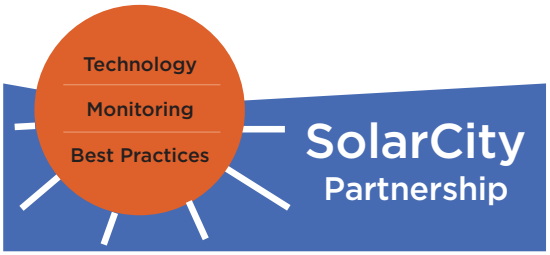
Toronto and Region Conservation for The Living City

Toronto

FCM | Green Municipal Fund / Fonds municipal vert

We want to hear from you!

If you have further best practices recommendations, insights into system design, deployment or maintenance or a project to profile, please get involved with the SolarCity Partnership! Contact us at:



info@solarcitypartnership.ca
416-661-6600 ext. 5337
www.solarcitypartnership.ca

This feasibility study was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.