Loyalty One
163 kW PV Installation

Final Report – January 2012

Technology

Monitoring

Best Practices

SolarCity
Partnership

PROJECT SNAPSHOT

Address:	6696 Financial Drive, Mississauga, ON
Building Type and Use:	Customer call centre for Loyalty One. Loyalty One is a North American company that administers various consumer loyalty, analytic, and marketing programs, including the popular Air Miles reward program.
Owner:	Loyalty One
Owner Contact:	Jeremiah Brenner
Phone #:	416-552-2077
Email:	jbrenner@loyalty.com
Carport Array Specifications	
System type:	Ground-mounted grid-tied solar photovoltaic system
Array Angle:	35 degrees from horizontal
Azimuth:	29 degrees East of South
Portion of Carport Array Under FIT Contract	
String Configuration:	Each inverter is connected to 3 strings of 8 modules per string.
Module Manufacturer:	Sanyo
Module Model:	HIP-205 NKHB1 (205 watt)
Number of Modules:	48
Inverter Manufacturer:	SMA
Inverter Model:	Sunny Boy 5000 US (5 kW)
Number of Inverters:	2
System Size (kW):	9.84
System Size (m^2):	60
Portion of Carport Array that is Net Metered	
String Configuration:	The inverter is connected to 4 strings of 8 modules per string.
Module Manufacturer:	Sanyo
Module Model:	HIP-205 NKHB1 (205 watt)
Number of Modules:	32
Inverter Manufacturer:	SMA
Inverter Model:	Sunny Boy 6000 US (6 kW)
Number of Inverters:	1
System Size (kW):	6.56
System Size (m^2):	40

Rooftop Array Specifications	
System type:	Roof-mounted grid-tied solar photovoltaic system
Array Angle:	0 degrees from horizontal
Azimuth:	0 degrees East of South
String Configuration:	SB 4000 US inverters: 3 inverters have 2 strings of 9 modules per string. 1 inverter has 2 strings of 10 modules per string.
	SB 6000 US inverters: 3 inverters have 3 strings of 10 modules per string.
	SB 7000 US inverters: 12 inverters have 4 strings of 9 modules per string. 3 inverters have 4 strings of 10 modules per string.
Module Manufacturer:	Sanyo
Module Model:	HIP-205 NKHB1 (205 watt)
Number of Modules:	716
Inverter Manufacturer:	SMA
Inverter Model:	4 x Sunny Boy 4000 US (4 kW)
	3 x Sunny Boy 6000 US (6 kW)
	15 x Sunny Boy 7000 US (7 kW)
Number of Inverters:	22
System Size (kW):	146.78
System Size (m^2):	900
Total System Specifications	
Total System Size (kW):	156.62 kW under FIT contract (163.18 kW total)*
Total System Size (m^2):	960
Installation Date:	System commissioned in November 2010.

*The net metered portion of the array was excluded from the analysis. All production data and simulation results pertain only to the portion of the array under FIT contract.

PERFORMANCE

	Carport (kWh/kW/yr)	Rooftop (kWh/kW/yr)	Total (kWh/kW/yr)
2010-2011 Actual Performance:	1,239	1,065	1,076
RETScreen using local irradiance:	1,116	1,016	1,022
RETScreen using 20 year historical average:	1,115	1,029	1,035

FINANCIAL

Installed Cost (taxes included):	$1,850,000[1]
External Funding:	Unknown.
Annual Income:	$121,523
Simple Payback (excluding external funding):	15.2
Cost per kW (excluding external funding):	$11,337

MONITORING

Monitoring equipment installed:	Yes.
Overview of the monitoring plan:	A Sunny WebBox is installed on-site, which logs energy production data collected from each inverter. These totals, along with solar radiation and temperature measurements, are accessible through the Sunny Portal website in hourly, daily, and monthly intervals.
Cost of M&V :	Unknown.
Who is analyzing the data?	Toronto and Region Conservation Authority's Sustainable Technologies Evaluation Program.
Is there a dedicated staff person responsible for system operation management?	Loyalty One has an Operation & Maintenance contract with RESCo Energy.

1 As reported by Derek Wong. 2010. Canada's Largest Solar Rooftop, Case Study Part Three. Carbon49: A Blog on Sustainability for Canadian Businesses. http://www.carbon49.com/2010/08/canada%E2%80%99s-largest-solar-rooftop-case-study-part-three/

SUMMARY

The Loyalty One 163 kW photovoltaic system located at 6696 Financial Drive in Mississauga, ON, was installed for a cost of 1.85 million dollars and commissioned in November 2010. Over a one year period beginning in September 2010 and ending in August 2011, total system production was 168,516 kWh, or 1,076 kWh per kW installed. Both the rooftop and carport arrays performed above expectations based on local irradiance and temperature data, by 4.9% and 11%, respectively. Based on historical weather, the system is projected to generate an annual revenue of $121,523 at the Feed-in Tariff rate of 71.3 cents per kilowatt-hour. The system will achieve simple payback in 15.2 years, which is within the observed range for similar PV systems in the GTA installed between 2006 and 2009.

BACKGROUND

Loyalty One is a North American company that administers various consumer loyalty, analytic, and marketing programs, including the popular Air Miles reward program. The organization operates a customer call centre located in Mississauga, which meets Leadership in Energy and Environmental Design (LEED) standards. In order to advance its commitment to corporate sustainability, Loyalty One contracted RESCo Energy to install a 163.18 kW photovoltaic system on site, which was the largest of its kind in Canada at the time of construction.

The Loyalty One call centre's PV system is divided into two main arrays. The first is a ground-mounted array consisting of sloped panels that form a carport in a portion of the parking lot. In addition to solar PV, this array incorporates a solar thermal installation that is used to heat the building's water supply. The second array is a horizontal panel system mounted on the roof of the building. These panels are anchored onto the roof's structural columns and suspended slightly above the roof's surface.

The Loyalty One arrays were installed at a cost of $1,850,000 and monitoring began in March 2010. This project was the first in Ontario to participate in the province's renowned Feed-In Tariff (FIT) program, through which solar energy is sold to the grid at a rate of 71.3 cents per kilowatt-hour. The majority of the array (156.62 kW) is under FIT contract, but a portion of the carport array (6.56 kW) is net metering. The scope of this report is limited to the PV system under FIT contract, since production data were not available from the net metered portion of the array.

The Loyalty One PV project has the potential to generate numerous environmental, economic, and social benefits. By offsetting the facility's need for power from conventional sources, greenhouse gas emissions will be reduced. In addition, the sale of electricity produced by the system will be a source of substantial long term revenue. This project serves as a model for other organizations looking to install large-scale PV systems, and will inform current best practices. Loyalty One has been widely recognized for its efforts, and was the winner of the Green Business Award in 2011's Green Toronto Awards.

Special Site Considerations

The rooftop PV system was not included in the design process for the Loyalty One call centre, and was added later during the construction phase. Since the roof of the building was not intended to bear the load of the solar array, the panels were installed directly above the building's structural columns for increased support. The optimal angle for solar arrays located in the Greater Toronto Area is approximately 35 degrees from horizontal. However, due to concerns about the increased roof loads of angled arrays, a horizontal panel inclination was chosen.

Since the horizontal rooftop array could not easily be seen, the ground mounted system was constructed to give increased visibility to the project. The system's inverter panel was also displayed prominently on a wall in the staff lounge, in order to further showcase the PV system and educate employees about solar energy generation. This setup is a departure from conventional installation practice, where inverters are typically located in an electrical room.

2 City of Toronto. 2009. Horse Palace Photovoltaic Pilot Project Findings Report. Available at: http://www.solarcitypartnership.ca/solarfiles/TAF_HorsePalace_web.pdf

PERFORMANCE ANALYSIS

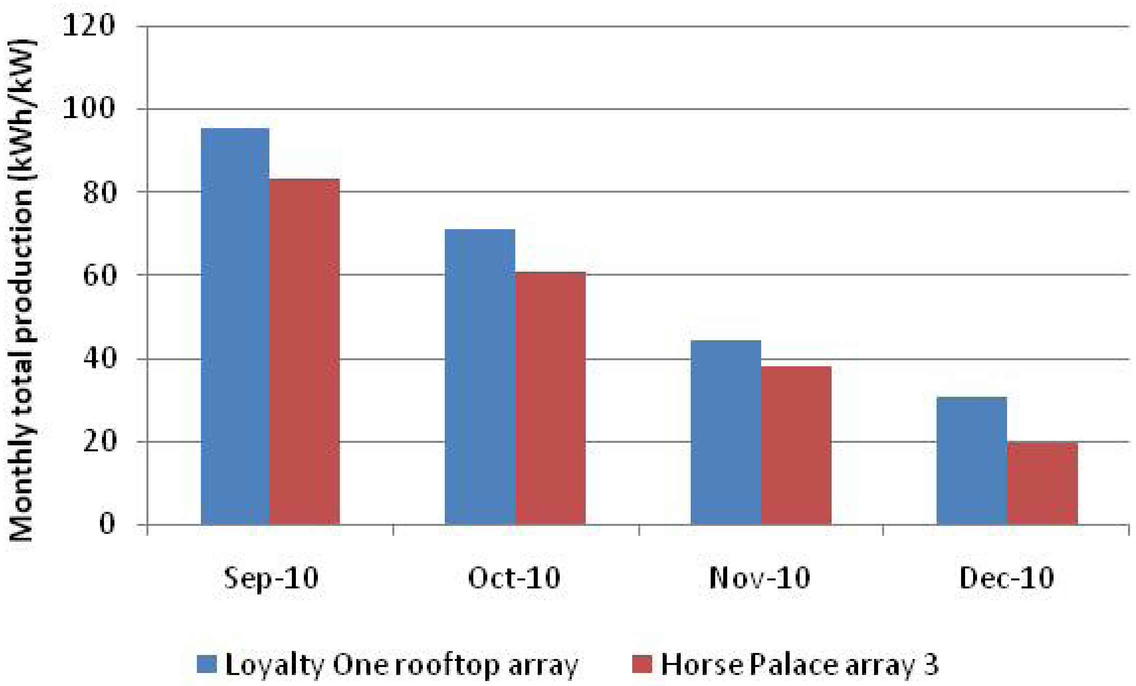
Energy Yield of Two Horizontal PV Systems in the GTA: Loyalty One Rooftop and Horse Palace Array 3

Results from the Horse Palace Photovoltaic Pilot Project provided evidence that horizontal panels are less efficient than their sloped counterparts, because they operate at higher temperatures and capture less solar radiation[2]. In order to gauge the productivity of the Loyalty One rooftop array, its yield was compared to the Horse Palace flat panel PV system at the Exhibition Place in Toronto over the same time period. The Horse Palace system consists of 40 Evergreen Solar 115 watt modules (EV-115) and an SMA 5200 Watt Grid Tie inverter with a rated efficiency of approximately 95% (similar to the Loyalty One SMA inverters).

The yield of the Loyalty One rooftop and Horse Palace PV systems is compared over a four month period in Figure 1 (one complete year of production data from each array over the same time period was not available). From September through December of 2010, total production of the Loyalty One rooftop array was 19.7% greater than that of the Horse Palace array.

The Sanyo HIP-205 NKHB1 panels utilized in the Loyalty One rooftop array have a module efficiency of 16%, while the Evergreen Solar EV-115 panels in the Horse Palace array have a module efficiency of 11%. These differing efficiencies could partly explain the discrepancy in energy yield of the two PV systems, but microclimatic conditions at each site may also play an important role.

Figure 1. Energy yield of two flat panel PV systems in the GTA.



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[3] and historic irradiance and temperature data from a Toronto weather station (RET20yr). The second also incorporates a 16% loss factor, but uses local irradiance and temperature data over the same one year period that actual production data were available (RET1yr). Both scenarios assume 1% miscellaneous losses and inverter efficiency of 95.5% (as rated by the California Energy Commission).

It should be noted that the on-site irradiance and ambient temperature data measured at Loyalty One were not used in the RET1yr model, because the pyranometer data were found to be considerably lower than could be explained by micro-climatic effects alone. Instead, reliable irradiance and temperature measurements taken at the University of Toronto Mississauga Meteorological Station (located approximately 12 km from the Loyalty One offices), were incorporated into the RET1yr model. Refer to Appendix 1 for a comparison of monthly irradiance at each site.

The RETScreen product database did not contain the Sanyo HIP-205 NKHB1 panels used in both the carport and rooftop PV systems. Therefore, the most similar model in the database, the Sanyo HIP-205 NKHA5, was used in the simulations. Since the capacity (205 watts) and module efficiency (16%) of each type of panel is identical, the simulation results for both were also expected to be similar.

Table 1. Key parameters in the different RETScreen scenarios.

RETScreen Input	RET20yr	RET1yr
Annual solar radiation (kWh/m^2 on a horizontal surface)	1,310	1,300
Annual average daily irradiance (kWh/m^2/d)	3.59	3.55
Annual average ambient temperature (C)	7.2	8.0
CEC weighted inverter efficiency	95.5%	95.5%
PV array losses	16%	16%
Miscellaneous power conditioning losses	1%	1%

3 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 Loyalty One site.

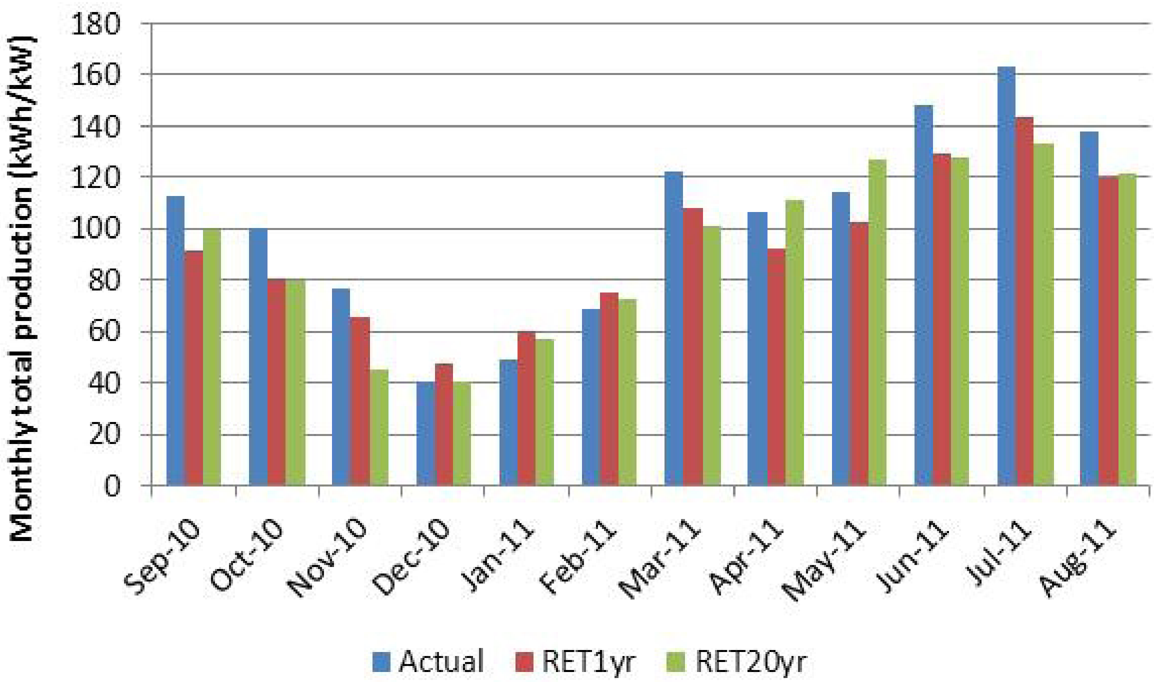
Actual Performance vs. RETScreen Simulations

Carport Array Simulation Results

Actual output of the carport array is compared to RETScreen estimated production in Figure 2. On an annual basis, the RET1yr data scenario best represents actual production of the carport array. Over the one year monitoring period, actual yield was 12,188 kWh, or 1,239 kWh per kW installed. This is 11% higher than simulated yield derived from local irradiance, and 11.1% higher than simulated yield derived from historic irradiance.

RETScreen simulation of numerous PV systems in the GTA suggests that energy yield typically falls below expectations in the winter and rises above expectations in the summer. The energy production of the carport array followed this pattern. Using the RET1yr model as a benchmark, actual yield was an average of 13.9% less than expectations during the winter (December 2010 through February 2011), and an average of 16.2% greater than expectations during the remainder of the year. The low winter yield relative to predicted values is likely due in part to the fact that RETScreen does not account for snow cover.

Figure 2. **Actual vs. RETScreen simulated performance of the Loyalty One carport array.**

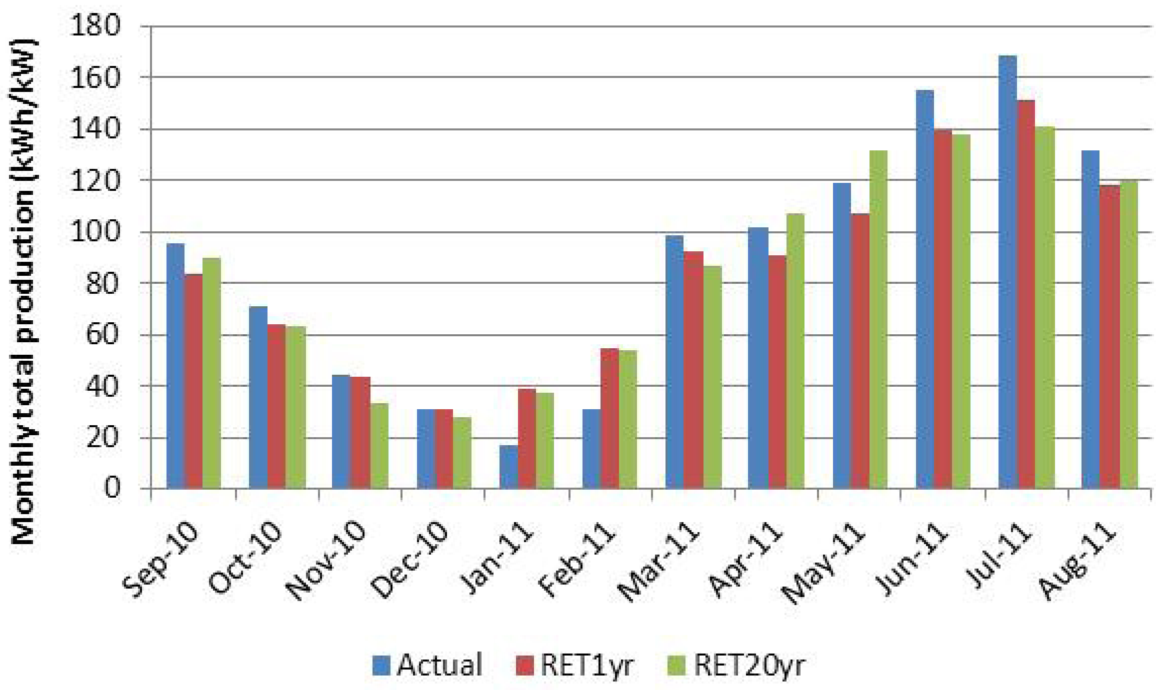


Rooftop Array Simulation Results

Actual output of the rooftop array is compared to RETScreen estimated production in Figure 3. On an annual basis, the RET20yr data scenario best represents actual production of the rooftop array. Over the same one year monitoring period, the rooftop array produced 156,328 kWh of energy, or 1,065 kWh per kW installed. This is 4.9% higher than simulated yield derived from local irradiance, and 3.5% higher than simulated yield derived from historic irradiance.

The rooftop array exhibited a seasonal variation in yield similar to that of the carport array. The RET1yr model is used as a benchmark for production because it based on local irradiance and temperature conditions. From December 2010 through February 2011, energy output was an average of 34.2% below expectations. This difference is larger than at the carport, and may have been caused in part by the differing angle of the two arrays. Flat panels are generally assumed to be more susceptible to accumulations of snow (as well as dirt, dust, and other debris). However, performance was an average of 10.2% greater than expectations during the remaining 9 months of the year, which suggests that the panels were well-maintained and functioning effectively.

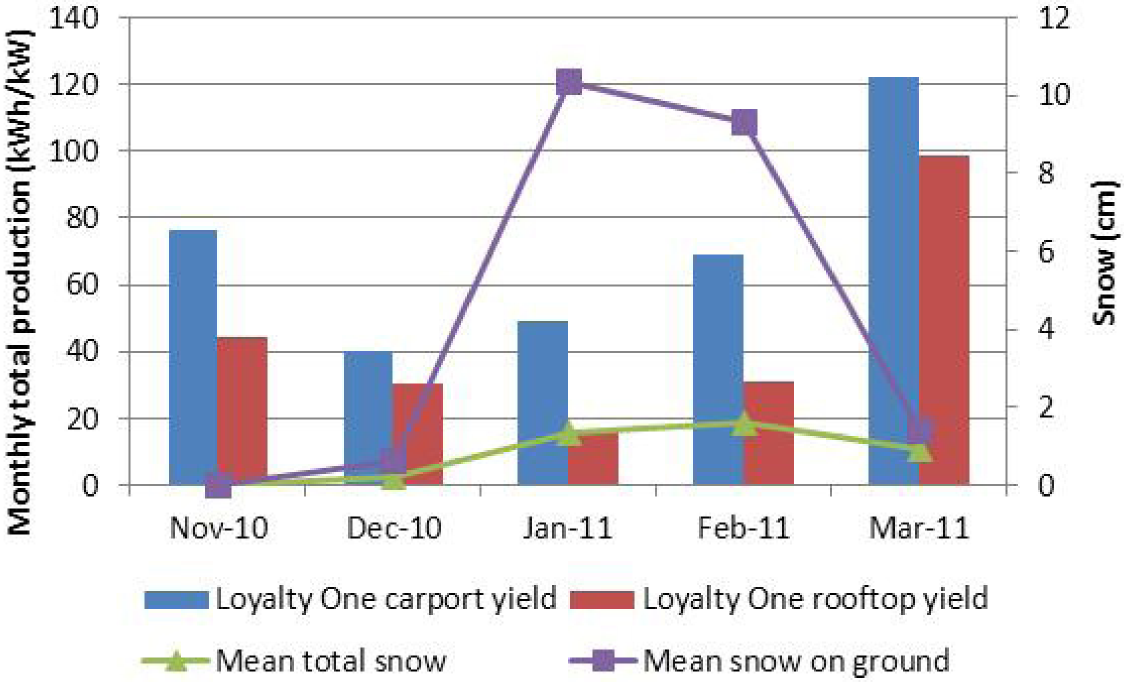
Figure 3. **Actual vs. RETScreen simulated performance of the Loyalty One rooftop array.**



Snow Cover Analysis

Snow cover data was obtained for the winter monitoring period in order to analyze how snow may affect the comparative production of the horizontal and angled arrays (Figure 4). When the daily and monthly data were analyzed, there was not a statistically significant relationship between either measurement of snow cover and energy production of the rooftop and carport arrays. From Figure 4, it appears that in general, output tended to decrease as snow cover increased. However, the primary cause of the low winter production was likely the decreased availability of solar radiation in the winter months. Refer to Appendix 2 for plots of daily interval data.

Figure 4. **Monthly average precipitation as snow and monthly average snow accumulation on the ground measured at Pearson International Airport compared to the energy yield of the Loyalty One rooftop and carport PV systems.**



BUSINESS CASE

The Feed-in Tariff contract pays a fixed price for energy produced by Loyalty One'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 7% for the carport array and 12% for the rooftop array. These were the derate factors that best fit the actual production of each array over the one year monitoring period.

Table 2 presents the business case for the Loyalty One PV Project. This business case includes two different scenarios for income generation at the projected annual output. The first scenario includes only the 156.62 kW under FIT contract, which accumulates income at a rate of 71.3 cents per kilowatt-hour. The second scenario includes an additional 6.56 kW of production capacity, which represents the portion of carport array that is currently net metering. The net metering rate was estimated to be 14 cents per kilowatt hour. Although no production data was collected for the net metered portion of the carport array, it was assumed to produce electricity at the same rate projected for the portion of carport array under FIT contract (1,234 kWh/kW/yr).

In scenario A, which includes only the portion of the array under FIT contract, the analysis predicted a total output of 170,439 kWh per year, which would provide $121,523 of annual income. This prediction was not substantially affected when the net metered portion of the array was included in the analysis (scenario B). Although projected output increased to 178, 537 kWh per year, annual income from electricity sales only increased to $122,657 due to the much lower rate structure of net metering. The simple payback under both scenarios was approximately 15 years. Assuming that the life of the system exceeds this time period, Loyalty One stands to gain significant revenues from the project.

Table 2. Loyalty One PV Project: Business Case

	Total cost installed	Array output (kWh/yr)	Annual income from electricity sales	Simple payback (years)
Adjusted feasibility study A (FIT contract only)	$1,850,000	170,439	$121,523	15.2
Adjusted feasibility study B (FIT contract + net metered array)	$1,850,000	178,537	$122,657	15.1

Feed-in Tariff Issues

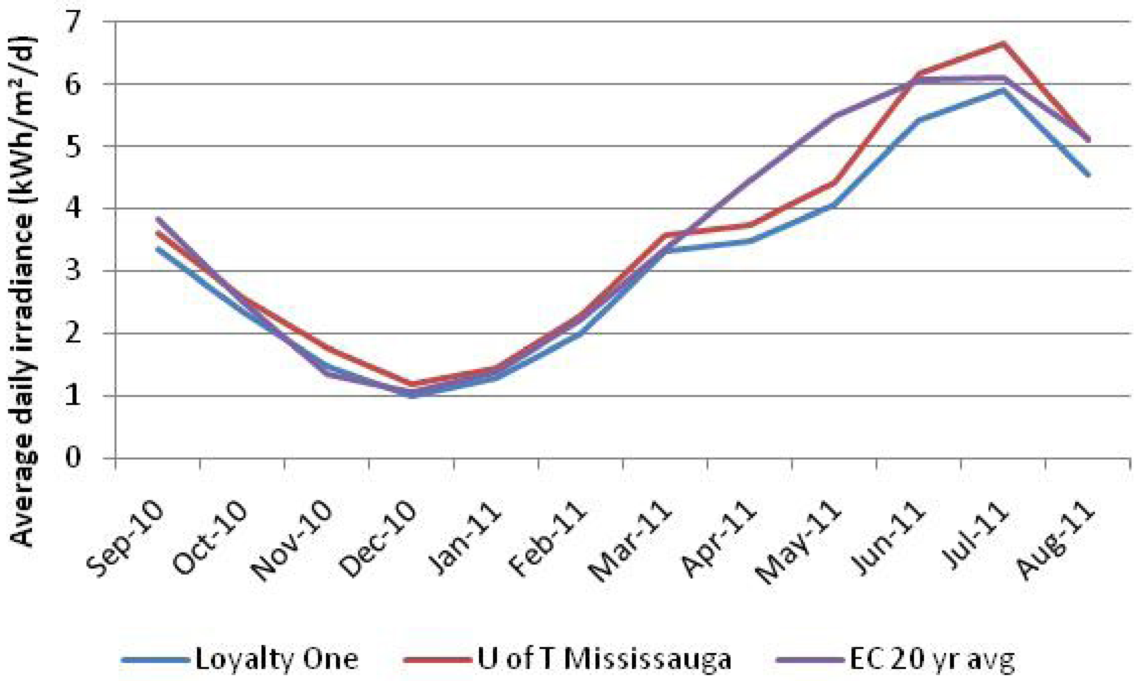
The PV system was conceived under the Ontario’s Renewable Energy Standard Offer Program (RESOP), which preceded the FIT program. Construction began as the FIT program was being developed, so the project transitioned from RESOP to FIT. The transition was ultimately successful, but not always straightforward.

APPENDIX 1: MONTHLY IRRADIANCE DATA

Figure A1 presents the pyranometer data from the University of Toronto Mississauga Meteorological Station (UTMMS) and the Loyalty One call centre from September 2010 through August 2011. Environment Canada's 20 year average for the City of Toronto is also included for comparison. On an annual basis, solar irradiance measured at Loyalty One was 10.2% below that measured at UTMMS and 11.1% below Environment Canada's 20 year average. This is an unreasonably large discrepancy; therefore, the Loyalty One irradiance data were not incorporated into the RET1yr model. Instead, irradiance measured at the UTMMS (located approximately 12 km from the Loyalty One call centre) was used in the RET1yr model.

On a monthly basis, 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 Loyalty One and UTMMS in these months was 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.[4]

Figure A1. Average daily irradiance in the Greater Toronto Area (2010-2011).



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

APPENDIX 2: DAILY SNOW COVER DATA

Figure A2. Daily average precipitation as snow and monthly average snow accumulation on the ground measured at Pearson International Airport compared to the energy yield of the Loyalty One rooftop and carport PV systems.

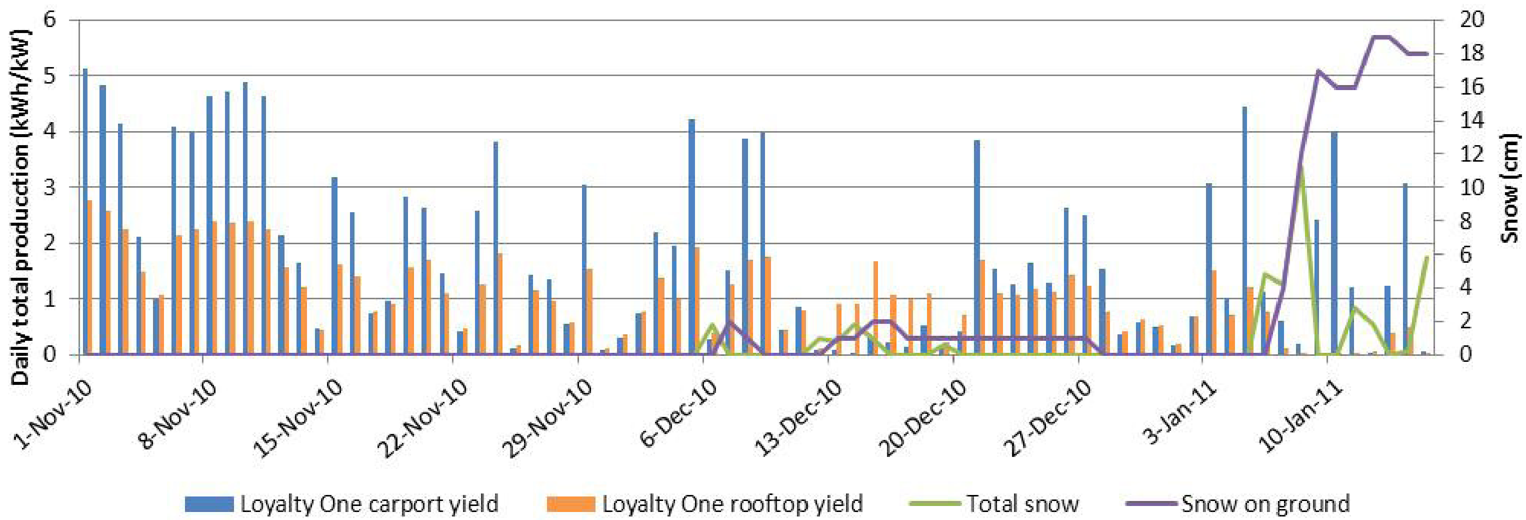
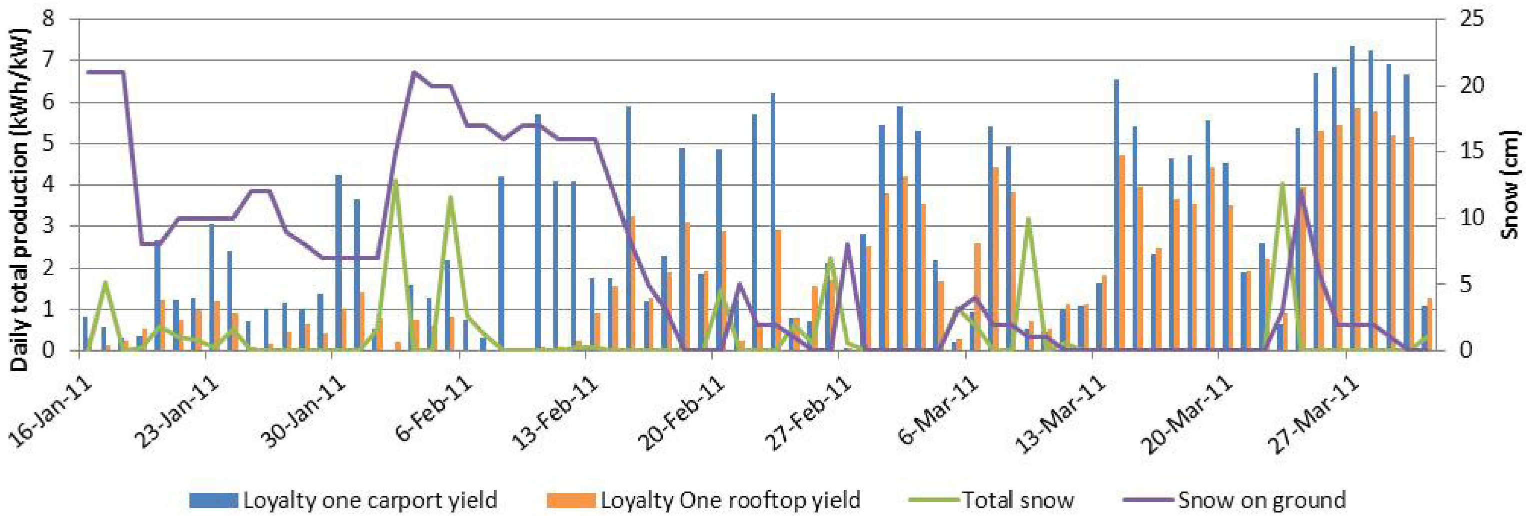


Figure A3. Daily average precipitation as snow and monthly average snow accumulation on the ground measured at Pearson International Airport compared to the energy yield of the Loyalty One rooftop and carport PV systems.



About the SolarCity Partnership

The SolarCity Partnership was developed to provide third party monitoring of large urban solar installations and develop best practice recommendations based on independent project evaluations. The 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 radiation data to help with the effective use of zero emissions energy from the sun.

Supporting Partners

The SolarCity Partnership was founded in 2008 by the Toronto Atmospheric Fund, the City of Toronto Energy and Waste Management Office, and the Toronto and Region Conservation Authority, with support from the Federation of Canadian Municipalities Green Municipal Fund. Phase 2 of the Partnership, co-ordinated by the Toronto and Region Conservation Authority, has expanded to include solar facility assessments across the Greater Toronto Area with funding support from the Region of Peel and York Region, and in-kind contributions from various site partners.

We want to hear from you!

If you have further best practice 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

289-268-3902

www.solarcitypartnership.ca