Reducing Operational Costs of Small/Medium-Sized Businesses in Puerto Rico through the Implementation of Photovoltaic Solar Energy Systems

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Abstract *— Photovoltaic (PV) Solar Systems have been identified as a renewable energy source that can help reducing operational costs of small/medium-sized businesses in Puerto Rico. Food preparation and food sales businesses are the most electricity consuming businesses and, as a consequence, an attractive candidate for exploring benefits of PV. Data analysis and evaluation demonstrated that PV systems producing more than 75% of the business' electricity needs provide acceptable return on investment and help reduce operational costs of the businesses evaluated.*

Key Terms *— Energy Costs and Demand, Operational Costs, Photovoltaic, Solar Energy*

INTRODUCTION

The purpose of this project is to propose the implementation of Photovoltaic (PV) solar systems in small/medium-sized businesses localized in Puerto Rico. This initiative has been identified as a cost saving opportunity for reducing operational costs of these types of businesses in the island.

Background

Puerto Rico electricity costs are relatively high in comparison to that of the United States and other countries in the world, which results in high operational costs for local small/medium-sized businesses. There have been various efforts from the governmental and private industrial sectors for solving the energetic cost problem in the island, but these initiatives remain in the initial stages as the vast majority of residents and small/medium-sized businesses continue paying high utilities bills due to the high dependence on fossil fuels for producing electricity in Puerto Rico.

Various renewable energy sources have been suggested as possible alternatives for producing electricity, such as wind energy, geothermal energy, ocean-thermal energy conversion (OTEC), biomass, and solar energy [1]. The latter is one of the most attractive alternatives for the island of Puerto Rico due to the relatively high solar irradiation received on this location, which can be estimated approximately as 5 to 6 kWh/m^2 per day [2]. As a result, Photovoltaic (PV) Solar panels systems have been identified as one of the renewable energy sources that is available in Puerto Rico and which can help in the solution of the energetic problem in the island.

PV Solar systems are mainly composed of the following components: PV panels/modules, charge controllers, batteries/capacitors, and power inverters. These systems basically convert sunlight radiation (solar energy) into direct current (DC) electricity, which is further transformed into useful alternating current (AC) electricity.

LITERATURE REVIEW

The effect of producing electricity from sunlight occurs because of the action of the PV cells (core of the system) comprising the PV panels/modules [1]. Bell Laboratories (New Jersey, USA) invented the Solar PV cells in 1954 [3, 4], and since then, several improvements to the PV solar systems have been developed. These improvements are focused on the manufacturing materials, manufacturing techniques, and additional components, such as the sun trackers [5], for improving the efficiency on the conversion of solar energy to electricity. PV panels output will depend on sunlight radiation, temperature, and load impedance [5]. Most of the PV cells are made from silicon (mono-crystalline or poly-crystalline), and other semiconductors thin-films [1, 3, 4]. Around 80% of the market was dominated by silicon-based PV cells in 2010 [3]. There are two (2) main configurations for the PV solar systems; these are grid-connected PV solar systems, which comprised approximately 85% of the installed systems as of 2010, and off-grid PV solar systems [1, 3]. In the United States, approximately 0.02% of total electricity was generated from solar PV systems in 2009 [6], which indicated that this renewable energy source has not been fully exploited yet and that there is opportunity for increasing the amount of electricity that can be produced through this alternative energy production method. There are some limitations that must be taken into account when analyzing the suitability for implementing these systems, which includes intermittency and high variability (such as solar irradiation and sunlight times) [6].

The main components of regular PV solar systems are the following [1, 4]:

- PV Solar Panels
  - ✓ Serial interconnection of PV cells
- Charge Controller
  - ✓ To protect batteries from overcharging
- Batteries
  - ✓ Charged by DC
- Power Inverter
  - ✓ To convert DC to AC
- Additional features (*e.g.* sun trackers [5])

Operational efficiency of the PV panels is reduced with time [7], as any other equipment, which may represent a negative impact on the expected financial returns. Jordan and Kurtz demonstrated in an historical data evaluation that the mean degradation rate is approximately 0.8% per year, which suggests reasonable performance of the PV solar systems after 25 years which is the common warranty period provided by the manufacturers [1, 7]. On the other hand, the cost of installed PV solar systems has declined approximately 62.5% in the last decades [3]. Also, it has been estimated that the annual solar power production will be approximately 31,000 MW by 2050 and module efficiency will be doubled by this year [1], which in addition to the electricity costs savings at the long term, makes the investment on these systems more attractive.

Methodology and Data Collection

Information regarding energy consumption estimates, revenues, operational costs, and other expenses for different small/medium-sized businesses in Puerto Rico was collected and analyzed for determining suitability in the implementation of PV solar systems and suggesting the best system for each type of business. Some of the small/medium-sized businesses that were analyzed on this project include supermarkets, restaurants, and retail sales stores that were expected to have relatively high electricity consumption [8]. The collected data was evaluated and analyzed with a focus on reducing operational costs of the selected businesses. After evaluation, the suitability of implementing PV Solar systems for each type of business was analyzed. Findings and recommendations of this analysis were summarized below so that newcomers and existing small/medium-sized businesses can take advantage of the economic benefits of the implementation of these PV solar systems.

Energy Consumption

Energy consumption data for various small/ medium-sized businesses was collected [8] and summarized in Table 1.

Table 1
Approximate Energy Consumption for various businesses [8]

Commercial Building	Electricity Consumption (BTU/ft^2)	Electricity Consumption (kWh/ft^2)
Food Service	260,000	76.2
Food Sales	200,000	58.6
Office	95,000	27.8
Service	85,000	24.9
Retail Store	80,000	23.4
Warehouse	45,000	13.2

Supermarkets, restaurants, and those businesses related to food sale or preparation were found to be the ones with the highest energy consumption. This fact can be attributed to the conditions (*e.g.* storage temperature) needed for preserving food on acceptable conditions for further sale or preparation. Table 2 shows a summary of the electricity consumption distribution for a traditional supermarket [9], and confirms that refrigeration for food preservation is the major contributor to the high energy consumption in supermarkets.

Table 2
Approximate Energy Consumption for various businesses [9]

Classification	Energy Usage (%)
Refrigeration	43
HVAC (including cooling & heating)	20
Plug Loads	17
Lightning	13
Cooking equipment	2
Other	5

Historical data for the actual average cost of electricity for commercial customers was collected from the Puerto Rico Electricity Power Authority (PREPA) data base. The historical data is summarized on Figure 1. This information is updated on a monthly basis, with a 1-month out of phase, and it is uploaded to the website of the Institute of Statistics of Puerto Rico, from which it can be easily retrieved. The average electricity cost in the last twelve (12) months for a commercial customer was approximately 26 cents per kWh ($US 0.26/kWh), as per data shown in Figure 1.

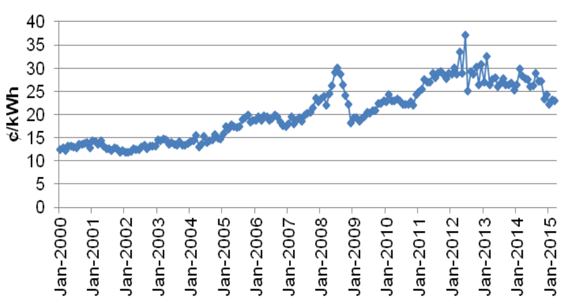

Figure 1
Average Electricity Cost for PREPA Commercial Customers

Local Businesses Revenues and Expenses

Revenue information for various small/medium-sized local businesses was collected from the Top 400 Locally Owned Companies list of the Caribbean Business magazine [10]. The data for the different companies that appears on the Top-400 list was classified per business type and then it was averaged. This information is summarized on Table 3. It is important to note that this information is an approximate for the average annual revenue of each business type and variations in actual revenue can occurs within the same business type and between businesses types.

Data related to the expenses for each of the business type that is shown on Table 3 was difficult to gather. On the other hand, expenses estimates for supermarkets and restaurants, which represented the highest energy consumption businesses in this study (see Table 1), were obtained.

For a supermarket, the cost of utilities was estimated as 3.0% to 3.5% of the total annual sales [11]. These percentages represent approximately $980,000 to $1,100,000 in utility costs for an average local supermarket, as per data on Table 3. Other expenses for supermarket include cost of goods sold (CGS), which was estimated to be approximately 72.5% to 78.1% of the total annual sales, and median payroll expense, which was estimated to be approximately 8.5% to 12.0% [12]. Based on these numbers, and taking into account that the CGS is not an operational cost, utility costs represent a significant portion of the operational costs for a local supermarket.

For a restaurant, the utility expense was estimated at 2.6% of sales [13], this represents approximately $720,000 in utility costs for an average local restaurant, as per data on Table 3.

Table 3
Local Small/Medium-Sized Businesses Average Revenue [10]

Business Type	Average Annual Revenue
Supermarket	$32,700,000
Restaurant	$27,680,000
Retail Store	$25,310,000
Office/Service	$53,310,000
Warehouse/Distributor	$271,650,000

The Food Marketing Institute (FMI) has estimated the median supermarket size as 46,500 square foot (ft^2) and the weekly sales as approximately \$11.85 per ft^2 [14]. The size of an average restaurant located in Puerto Rico can be estimated as approximately 2,500 to 3,500 ft^2 [15, 16].

PV Solar Systems

Various PV panels' models are currently available in the market for sale, such as Silicon mono-crystalline, Silicon poly-crystalline, Thin-films, among others [1, 3, 4, 6]. Table 4 shows a compilation of various PV panels' brands and types available in the market with their respective size, power output, efficiency, and cost [17].

Table 4
PV Panels Properties and Costs [17]

Brand (Type)*	Area (ft^2)	Power (W)	Efficiency (%)	Cost per Panel
Trina (Poly)	17.62	250	15.30	\$247.00
Hanwha (Poly)	17.78	245	14.80	\$250.90
Canadian Solar (Poly)	17.33	250	15.50	\$265.10
Suniva (Poly)	17.51	250	15.40	\$269.95
Solar World (Mono)	18.05	250	14.90	\$279.00
Ben Q (Poly)	17.34	265	16.40	\$279.95
Hyundai (Mono)	17.42	255	15.80	\$301.67
REC (Poly)	17.75	255	15.50	\$309.00
LG (Mono)	17.68	250	15.20	\$323.20

*Poly = poly-crystalline and M = mono-crystalline

In addition to the PV panels/modules, the PV solar systems are composed of other main components such as the charge controller, batteries set, inverter (central inverter or individual micro-inverters), racks, and additional features such as sun trackers [1, 4]. PV solar system packages are also available in the market and are sold ready to be installed [18]. Some of these PV solar system packages are summarized on Table 5. PV solar systems can be connected to the grid or either stand-alone as a grid-off system. For the latter, a batteries bank needs to be installed with the system which will store electricity for the time when there is no sunlight available. These batteries bank could be also bought from various suppliers.

Table 5
PV Solar Systems Properties and Costs [18]

System Name	Array Size (kW)	# of Panels	Monthly Output** (kWh)	System Cost
WS Off-grid 1	7.8	30	1,404	\$18,187
WS Off-grid 2	8.55	30	1,539	\$22,237
WS Off-grid 3	9.36	36	1,685	\$19,922
WS Off-grid 4	10.26	36	1,847	\$26,980
WS Off-grid 5	11.7	45	2,106	\$28,524
WS Off-grid 6	12.83	45	2,309	\$34,708
WS Off-grid 7	14.04	54	2,527	\$31,236
WS Off-grid 8	15.39	54	2,770	\$38,526

**Array size x 30 days x 6 hours sunlight per day

Batteries banks are also available in the market for the different PV solar systems capabilities [19]. The system power output will be the determinant factor for selecting the type of batteries bank and the ampere-hour capacity needed. A summary of the batteries banks that are available in the market is shown on Table 6.

Table 6
PV Batteries Banks Properties and Costs [19]

Batteries Options	Volt (VDC)	Ampere Hour	# of Batteries	Batteries Cost
Fullriver AGM Battery Bank	48	415	8	\$4,144
Fullriver AGM Battery Bank	48	830	16	\$8,404
Rolls Battery Bank	48	428	8	\$2,926
Rolls Battery Bank	48	856	16	\$5,800
Rolls Battery Bank	48	1,284	24	\$8,674
UPG AGM Battery Bank	48	200	8	\$1,697

UPG AGM Battery Bank	48	400	16	$3,438
Four Star Solar Battery Bank	48	415	8	$5,473
Four Star Solar Battery Bank	48	200	8	$2,433

Batteries bank capacity is determined by using P = IV

DATA ANALYSIS, EVALUATION AND RESULTS DISCUSSION

The data collected for both PV solar systems and batteries banks available in the market (refer to Tables 4 to 6) were averaged and normalized with respect to electricity consumption units (kWh) to facilitate the analysis among the different businesses. Tables 7 and 8 show a summary of the normalized data used in the analysis.

Table 7
PV Solar System Normalized Cost [18]

System Name	System Cost	Cost per kW Installed	Average Cost per kW
WS Off-grid 1	$18,187	$2,331.67	$2,445
WS Off-grid 2	$22,237	$2,600.82	
WS Off-grid 3	$19,922	$2,128.42	
WS Off-grid 4	$26,980	$2,629.63	
WS Off-grid 5	$28,524	$2,437.95	
WS Off-grid 6	$34,708	$2,705.22	
WS Off-grid 7	$31,236	$2,224.79	
WS Off-grid 8	$38,526	$2,503.31	

Table 8
PV Batteries Banks Normalized Cost [19]

Batteries Options	Batteries Cost	Capacity (kWh)	Cost per kWh	Average Cost per kWh
Fullriver AGM Battery Bank	$4,144	20	$208	$192
Fullriver AGM Battery Bank	$8,404	40	$211	
Rolls Battery Bank	$2,926	21	$142	
Rolls Battery Bank	$5,800	41	$141	
Rolls Battery Bank	$8,674	62	$141	
UPG AGM Battery Bank	$1,697	10	$177	
UPG AGM Battery Bank	$3,438	19	$179	
Four Star Solar Battery Bank	$5,473	20	$275	
Four Star Solar Battery Bank	$2,433	10	$253	

Batteries bank capacity (kWh) is equal to Amp-hour times Volt

An analysis of supermarkets with different sizes and with PV solar systems of different capacities was performed to evaluate the possible benefits of implementing these systems on food sales businesses. Figures 2 to 5 show the cash flows for each case analyzed along the approximate system useful life of 25 years. The supermarkets analyzed on this part of the study included the average footprint of 46,500 ft^2 [14] and two (2) additional boundaries of 30,000 and 60,000 ft^2. Various scenarios were evaluated in which four (4) different PV solar systems were installed on each of the three types of supermarkets described above. Three (3) Grid-Connected PV Solar systems accounting for 25%, 50%, and 75% of the total energy consumption and the fourth was an Off-grid PV Solar system. Each PV system was evaluated separately on each supermarket type. The cash flows for each year are the resultant of the savings in electricity that the supermarket is having because of the no electricity consumption from PREPA and the maintenance costs. An inflation of 2.0% was assumed for accounting for the money time value.

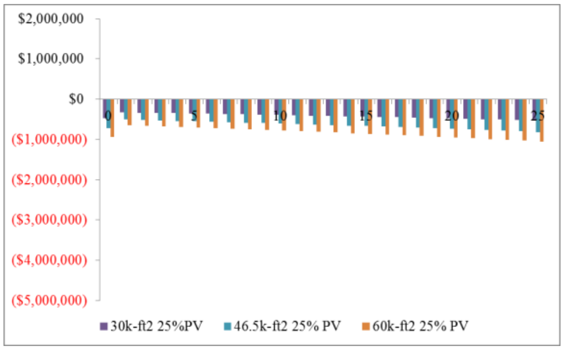

Figure 2
Cash Flow for Supermarkets producing 25% of the Total Electricity Consumption by a PV Grid-Connected System

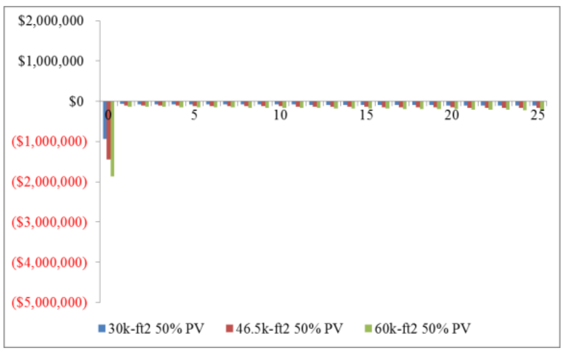

Figure 3
Cash Flow for Supermarkets producing 50% of the Total Electricity Consumption by a PV Grid-Connected System

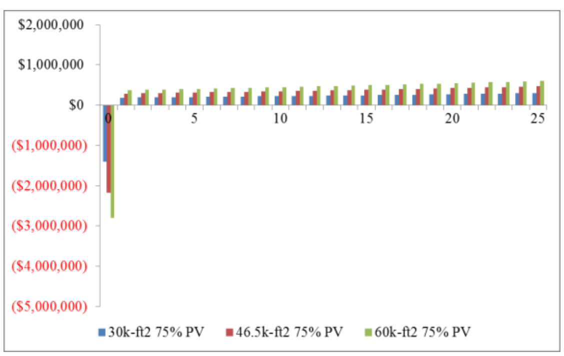

Figure 4
Cash Flow for Supermarkets producing 75% of the Electricity Consumption by a PV Grid-Connected System

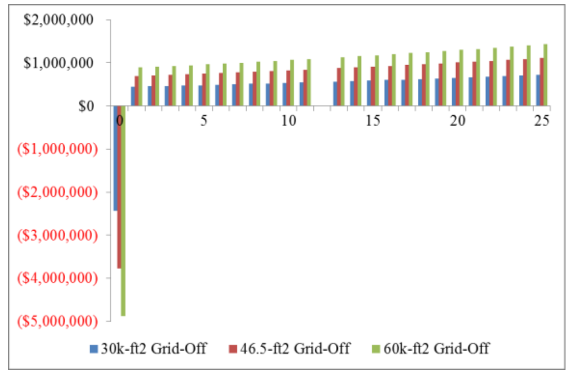

Figure 5
Cash Flow for Supermarkets producing 100% of the Electricity Consumption by a PV Grid-Off System

It is observed that the Grid-Off PV Solar system required the higher initial investment for the three (3) supermarkets evaluated, but at the same time it provided higher returns in the long term, as shown in Figure 5. Table 9 provided a summary of the Net Present Value (NPV) and Internal Rate of Return (IRR) for each case analyzed. The payback period for this investment was calculated to be between 6 to 7 years for the last two (2) systems, *i.e.* PV Grid-Connected system to produce 75% of electricity consumption and PV Grid-Off system, which seems to be attractive and beneficial.

The analysis for the Grid-Off system required including a batteries bank with enough capacity for the times when there is no sunlight. This analysis was based on having approximately 6 hours of sunlight per day, which is approximately the effective daily sunlight time in Puerto Rico, and on a daily operating time of 8 hours. The average useful life of a common batteries bank is approximately 10 to 15 years, if the proper maintenance is provided. This situation requires considering a replacement of the batteries bank at approximately half of the system life, *i.e.* between years 12 and 13, which resulted in a lowered return (cash flow) in that time. Despite this, the Off-Grid PV Solar System provided acceptable results that can be considered as a guide for a supermarket or other food sales business owner that wants to evaluate the possibility of implementing PV Solar systems on its business.

Table 9

NPV and IRR Results for the Investment on PV Solar Systems for Supermarkets

System Type	Supermarket Footprint (ft^2)	NPV (Million)	IRR
Grid-Connected 25% Electricity Consumption by PV	30,000	(-$8.281)	-
	46,500	(-$12.836)	-
	60,000	(-$16.563)	-
Grid-Connected 50% Electricity Consumption by PV	30,000	(-$2.556)	-
	46,500	(-$3.961)	-
	60,000	(-$5.111)	-
Grid-Connected 75% Electricity Consumption by PV	30,000	$ 3.170	14.8%
	46,500	$ 4.914	14.8%
	60,000	$ 6.340	14.8%
Grid-Off System	30,000	$7.906	19.5%
	46,500	$12.255	19.5%
	60,000	$15.813	19.5%

For the average supermarket footprint (46,500 ft^2) [14], with an average annual electricity consumption of 58.6 kWh/ft^2 [8], the initial investment on an Off-Grid PV system was estimated to be approximately $3.8 million and it is expected to have a return on the investment after the sixth year. This generalized case provided an acceptable NPV of approximately $12.3 million and an IRR of 19.5%.

When taking the whole panorama into account, *i.e.*, all electricity consumption related costs and not only the quantity that is replaced by the PV system, it is noticed that the first two (2) PV systems evaluated for supermarkets, which accounted for the 25% and 50% of the electricity consumption, will produce a final negative present worth as they did not provide enough savings that can absorb the impact of the remaining electricity costs (75% of the electricity consumption for the first system and 50% for the second system), as detailed on Figures 2 and 3 and in Table 9. In the case of the third (PV Grid-connected system to produce 75% of the electricity consumption) and fourth (PV Off-Grid) systems, the NPV obtained was positive, indicating that investing on those options is beneficial for the business. The latter option (PV Off-Grid System) is suggested as the most beneficial for supermarkets and food sales businesses as the initial investment will create value and provides a positive higher present worth.

When comparing the results obtained on this evaluation with the operational costs related to utility expenses for a supermarket, it is observed that definitively, it is beneficial to invest an equivalent amount of approximately four (4) times the annual utility expense (estimated as $980,000 to $1,100,000) [10, 11] in a PV Solar system that satisfy at least 75% of the electricity needs of the supermarket, which will significantly reduce the utility expense for the rest of the PV system useful life and which provides an acceptable return on investment.

The same data analysis and evaluation was performed for small/medium-sized restaurants as an example of food services businesses. Similarly, the PV Grid-Connected systems accounting for 25% and 50% of the electricity consumption of the restaurant provided negative present worth values. Thus, confirming the non-investment decision on these systems for food related businesses. Figures 6 and 7 shows the cash flows for the restaurants in where a PV Grid-Connected system supplies 75% of the electricity demand and a PV Grid-Off system equipped with a batteries bank are implemented, respectively. The NPV and IRR results are shown on Table 10.

For this evaluation, only two (2) restaurant types were selected based on the average range of size for a small/medium-sized restaurant in Puerto Rico, *i.e.* 2,500 to 3,500 ft^2 [15, 16], as shown on Figures 6 and 7.

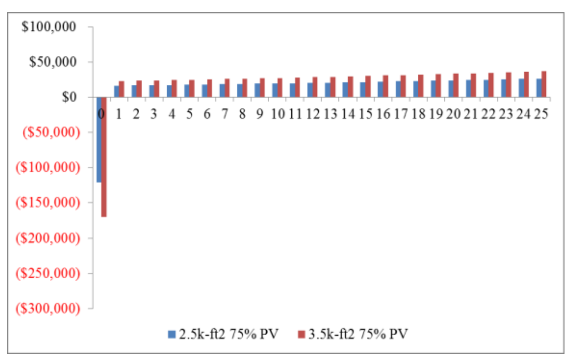

Figure 6
Cash Flow for Restaurants producing 75% of the Electricity Consumption by a PV Grid-Connected System

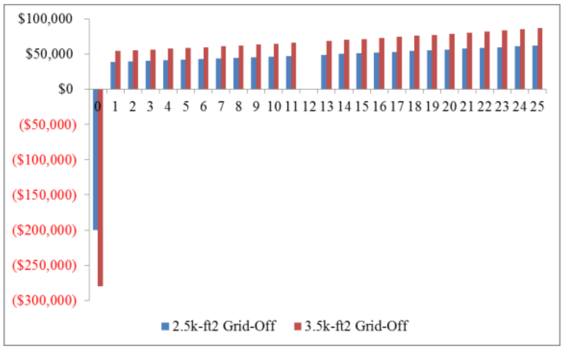

Figure 7
Cash Flow for Restaurants producing 100% of the Electricity Consumption by a PV Grid-Off System

Table 10
NPV and IRR Results for the Investment on PV Solar Systems for Restaurants

System Type	Restaurant Footprint (ft^2)	NPV (Million)	IRR
Grid-Connected 25% Electricity Consumption by PV	2,500	(-$0.717)	-
	3,500	(-$1.004)	-
Grid-Connected 50% Electricity Consumption by PV	2,500	(-$0.221)	-
	3,500	(-$0.310)	-
Grid-Connected 75% Electricity Consumption by PV	2,500	$0.274	14.8%
	3,500	$0.385	14.8%
Grid-Off System	2,500	$0.697	20.6%
	3,500	$0.975	20.6%

By analyzing the results obtained, it is observed that the operational costs related to utility expenses for a local small/medium-sized restaurant can be significantly decreased by implementing PV Solar Systems that account for at least 75% of the electricity consumption. An investment of approximately $120,000 to $170,000 in a PV solar system for a restaurant of 2,500 to 3,500 ft^2 will provide approximately 75% of the electricity consumption in the restaurant and the return on investment could be obtained after the seventh year. After that moment, the electricity to be consumed has been already paid and will remain in that state until completing the useful life of the PV system, which is estimated at approximately 25 years. Also, a stand-alone Grid-Off PV solar system equipped with the correct batteries bank is an excellent alternative for investment, as it will produce acceptable return on investment in a timely manner.

A similar evaluation for the average range of size for retail stores in Puerto Rico was performed, and similar results were obtained. Implementing a Grid-Connected PV Solar system that provides approximately 75% of the electricity consumption or a Grid-Off PV Solar system equipped with a batteries bank will produce acceptable return on investment and will help reducing operational costs related to utilities expenses. Figures 8 and 9 show the cash flows for the implementation of PV Solar systems on average size retail stores of 2,000 and 2,500 ft^2, respectively.

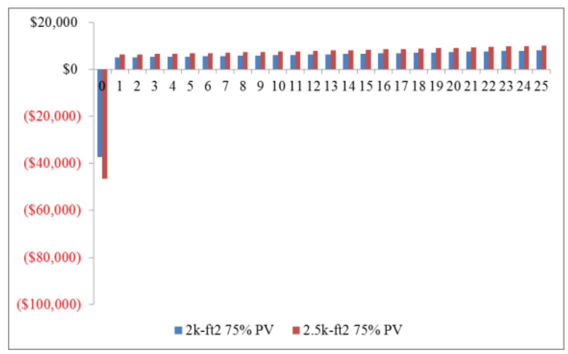

Figure 8
Cash Flow for Retail Stores producing 75% of the Electricity Consumption by a PV Grid-Connected System

Table 11 summarizes the NPV and IRR results for this evaluation. It is observed that the Grid-Off system provided the highest present worth value and IRR results, indicating that it is the best option for investment as it will provide higher benefits and an acceptable return on investment.

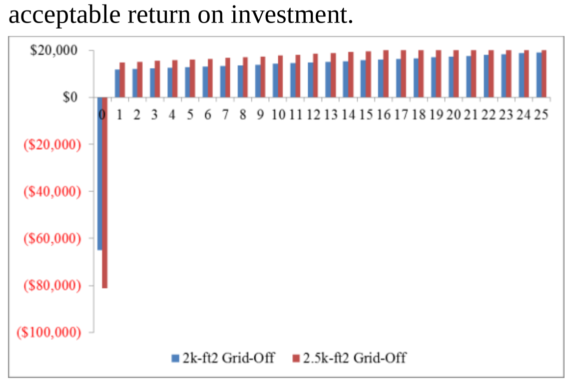

Figure 9
Cash Flow for Retail Stores producing 100% of the Electricity Consumption by a PV Grid-Off System

Table 11
NPV and IRR Results for the Investment on PV Solar Systems for Restaurants

System Type	Retail Store Footprint (ft^2)	NPV (Million)	IRR
Grid-Connected 25% Electricity Consumption by PV	2,000	(-$0.221)	-
	2,500	(-$0.276)	-
Grid-Connected 50% Electricity Consumption by PV	2,000	(-$0.068)	-
	2,500	(-$0.085)	-
Grid-Connected 75% Electricity Consumption by PV	2,000	$0.085	14.8%
	2,500	$0.106	14.8%
Grid-Off System	2,000	$0.222	20.0%
	2,500	$0.278	20.0%

Conclusions

Food service, food sales, and retail stores businesses were evaluated with a focus on reducing operational costs, specifically utility expenses, by implementing PV Solar systems. Those businesses related to food preparation and/or food sale were found to be the highest electricity consuming and, as a consequence, were identified as a good candidate for evaluating possible benefits of implementing these renewable energy systems on small/medium-sized businesses in Puerto Rico.

The information and methodology used is intended to help in the evaluation of the suitability for implementing PV systems in small/medium-sized businesses that are similar and comparable to those presented herein. The information presented was averaged and normalized for simplification and generalization purposes.

It was found that Grid-Connected PV solar systems that provide at least 75% of the electricity needs of the businesses evaluated were able to give acceptable return on investment while helping reducing small/medium-sized businesses operational costs. Even better, Grid-Off PV solar systems that are equipped with the correct batteries bank and that receive adequate maintenance could improve the return on investment while also help reducing operational costs, specifically utilities expenses.

It is recommended to use this study as a guideline for deciding whether or not is suitable to implement PV Solar systems for a small/medium-sized business and to follow this methodology by using specific data to the business desired.

References

[1] Gevorkian, P. "Solar Power Technology", *Sustainable Energy Systems in Architectural Design*, Ch. 1 and 4, 2006, pp. 1-37 and 91-153.

[2] NREL, "San Juan, PR Solar radiation WBAN No. 11641". Retrieved from: http://rredc.nrel.gov/solar/pubs/redbook/PDFs/PR.PDF

[3] Timilsina, G.R. *et al.*, "A Review of Solar Energy: Markets, Economy and Policies", *The World Bank: Policy Research Working Paper*, 5845, Oct. 2011. Retrieved from: https://openknowledge.worldbank.org/bitstream/handle/10986/3612/WPS5845.pdf?sequence=1

[4] NREL, "Solar Photovoltaic Technology Basics", *Learning About Renewable Energy*, Retrieved from: http://www.nrel.gov/learning/re_photovoltaics.html

[5] Kumaresh V. *et al.*, "Literature Review on Solar MPPT Systems", *Advance in Electronic and Electric Engineering*, Vol. 4, No. 3, 2014, pp. 285-296.

[6] Brown, P. *et al.*, "U.S. Renewable Electricity Generation: Resources and Challenges", *Congressional Research Service*, R41954, 7-5700, Aug. 2011, pp. 1-52.

[7] Jordan, D. C. *et al*, "Photovoltaic Degradation Rates – An Analytical Review", *Progress in Photovoltaics: Research and Applications*, Vol. 21, No. 1, 2013, pp. 12-29.

[8] Sustainable Food Services, "Energy Conservation", *SustainableFoodService.com*, 2013. Retrieved from: http://www.sustainablefoodservice.com/cat/energy-efficiency.htm

[9] Energy Star, "Facility Type: Supermarkets and Grocery Stores", *Energy Star Building Upgrade Manual*, Ch 11. Retrieved from: http://www.energystar.gov/buildings/tools-and-resources/energy-star-building-upgrade-manual-chapter-11-supermarkets-and-grocery-stores

[10] Caribbean Business, “Top 400 Locally Owned Companies”, T*he Caribbean Business Book of Lists*, 2014, pp. 47-65. Retrieved from: http://www.caribbeanbusinesspr.com/bol2014/index.html

[11] CDFI Fund, “Underwriting Supermarkets and Grocery Stores”, *Financing Healthy Food Options: Implementation Handbook*, Sep. 2011. Retrieved from: http://www.cdfifund.gov/what_we_do/resources/Underwriting%20supermarkets_for%20Fund_102411.pdf

[12] King, R.P., Leibtag, E.S., Behl, A.S. “Supermarket Characteristics and Operating Costs in Low-Income Areas”, *Agricultural Economic Report No. 839*, Dec. 2004. Retrieved from: http://www.ers.usda.gov/media/911472/aer839.pdf

[13] Laube, J. “Introduction: How to Evaluate Your Restaurant’s Profitability”, *Restaurant Numbers*. Retrieved from: http://www.restaurantowner.com/RN_1.pdf

[14] Food Marketing Institute, “Supermarket Facts”, *FMI: The Voice of Food Retail*, 2015. Retrieved from: http://www.fmi.org/research-resources/supermarket-facts

[15] Urban Edge Properties, “Outlets at Montehiedra, PR”. Retrieved from: http://uedge.com/property_home/?propid=OutletsatMontehiedra_PR

[16] Urban Edge Properties, “Las Catalinas Mall, PR”. Retrieved from: http://uedge.com/property_home/?propid=LasCatalinasMall_PR&state_name=PR&sp_zip_code=&sp_miles=&proprtyName=LasCatalinasMall&tabType=property

[17] Solar Town, “Solar Module Comparison”. Retrieved from: http://www.solartown.com/learning/solar-panels/solar-module-comparison

[18] Wholesale Solar, “Off-grid Solar Power Systems Complete Systems”. Retrieved from: http://www.wholesalesolar.com/off-grid-packages

[19] Wholesale Solar, “Battery Bank Options”. Retrieved from: http://www.wholesalesolar.com/solarpowersystems/large-home-4-off-grid-solar-power-system.html