

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

Jean A. Caminero-Rodriguez, EIT
 Master in Engineering Management Graduate Program
 Prof. Héctor J. Cruzado, PhD, PE
 Civil and Environmental Engineering Department



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.

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/m² per day [2]. As a result, 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.

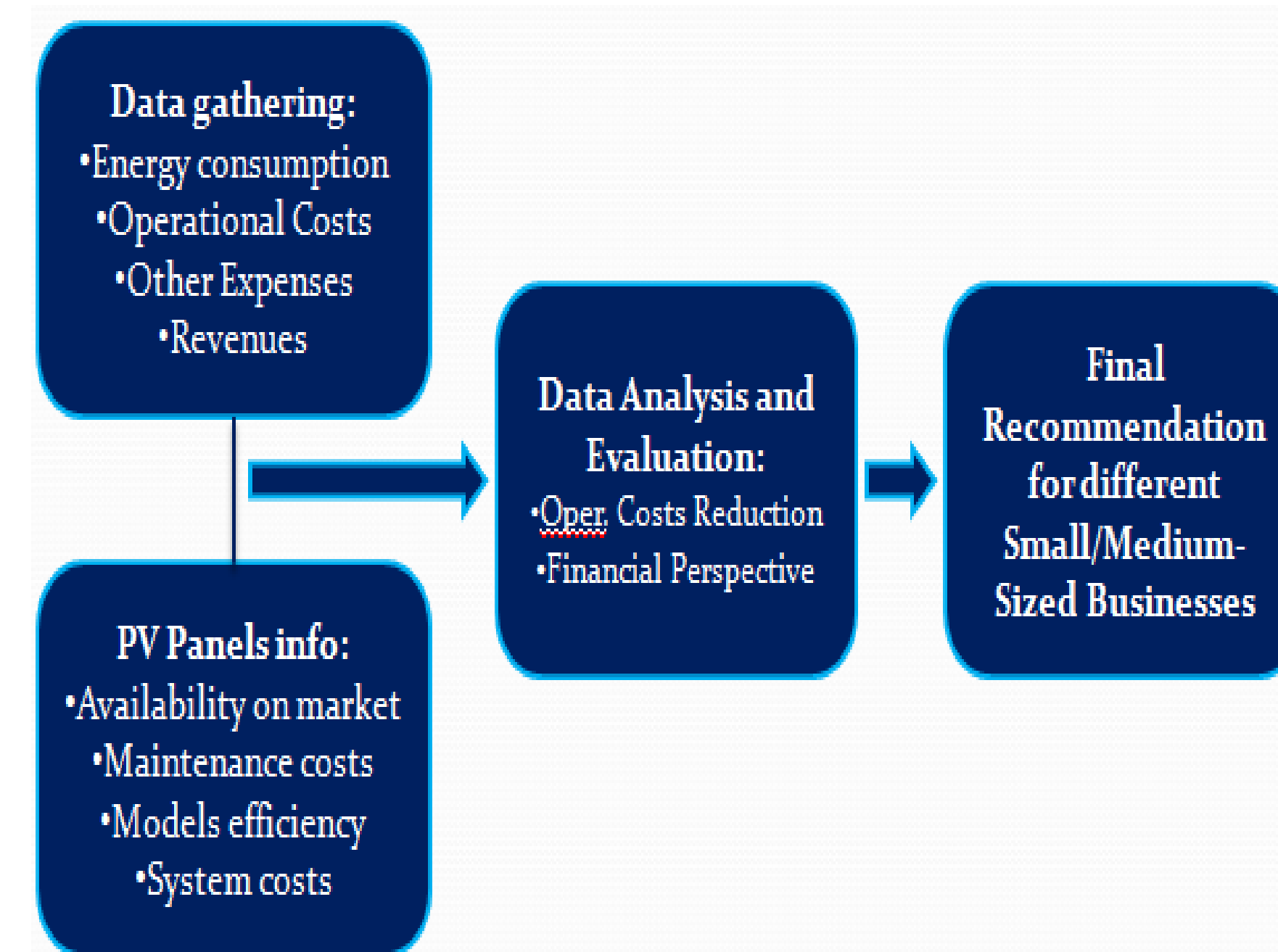
Literature Review

- The effect of producing electricity from sunlight occurs because of the action of the PV cells (system's core) comprising the PV panels [1]
- Bell Laboratories (NJ, USA) invented the Solar PV cells in 1954 [3, 4], and since then, several improvements focused on the manufacturing of the PV solar systems have been developed for improving the efficiency on the conversion of solar energy to electricity
- Output depends on sunlight radiation, temperature, & load impedance [1]
- 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 is dominated by Silicon-based PV cells [3]
- There are two (2) main configurations for the PV solar systems [1,3]:
 - ✓ Grid-connected PV solar systems
 - ✓ Off-grid PV solar systems
- Cost of installed PV solar systems has declined approximately 62.5% [3]
- It has been estimated that the annual solar power production will be approximately 31,000 MW & module efficiency will be doubled by 2050 [1]

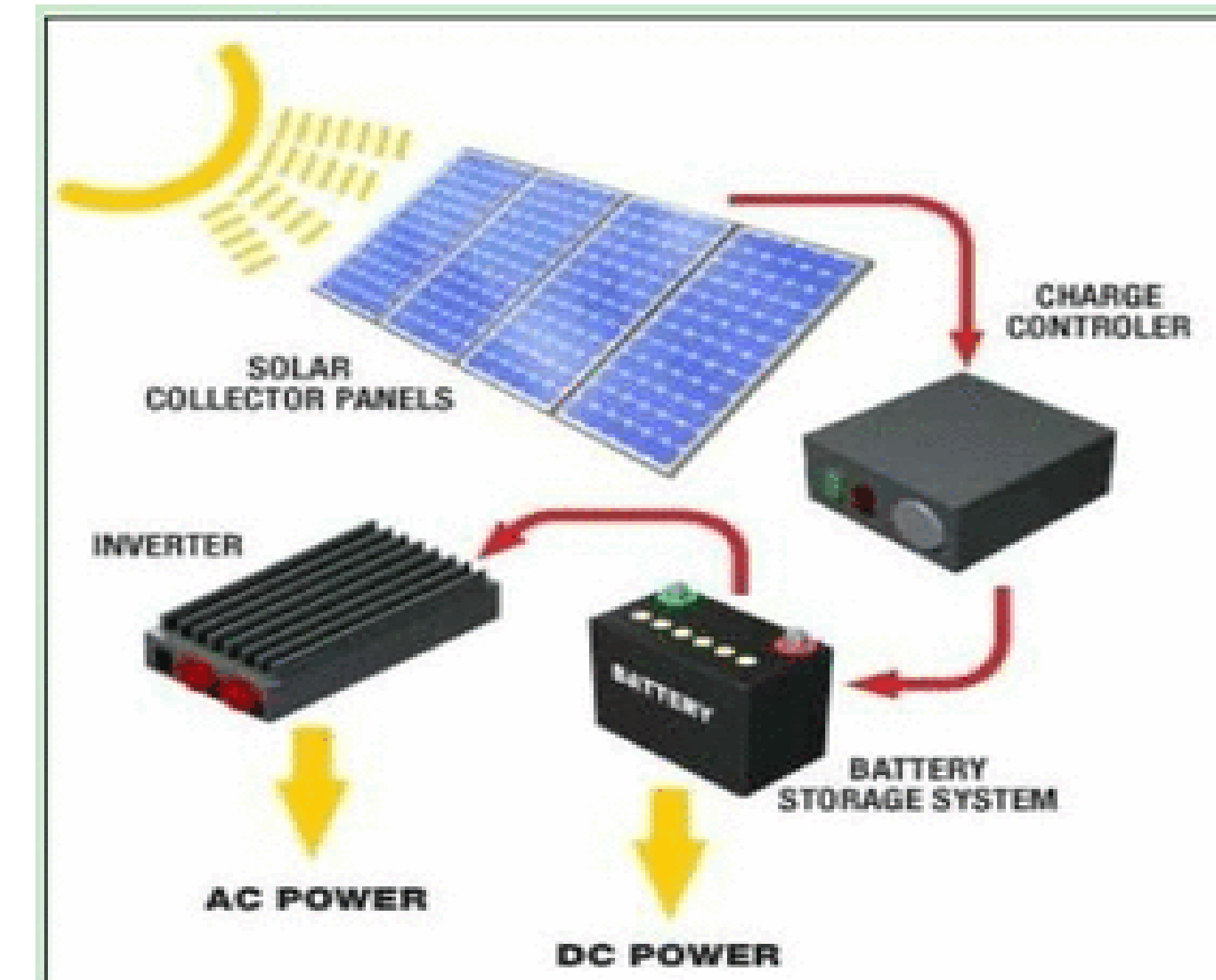
Main Objective

The purpose of this project is to propose the implementation of the most suitable PV Solar System for small/medium-sized businesses localized in Puerto Rico (PR) based on their needs. This initiative has been identified as a cost saving opportunity for reducing operational costs of these types of businesses in PR.

Methodology



PV Solar System



Retrieved from: <http://drsolarsolution.weebly.com/inverter/category/solar-inverters-in-bangalore>

Data Evaluation

Table 1: Energy Consumption by business[5]

Commercial Building	Electricity Consumption (kWh/ft ²)
Food Service	76.2
Food Sales	58.6
Office	27.8
Service	24.9
Retail Store	23.4
Warehouse	13.2

Table 2: PV Solar Systems Properties and Costs [6]

System	# Panels	Monthly Output (kWh)	System Cost	Average Cost per kW
WS Off-grid 1	30	1,404	\$18,187	\$2,445
WS Off-grid 2	30	1,539	\$22,237	
WS Off-grid 3	36	1,685	\$19,922	
WS Off-grid 4	36	1,847	\$26,980	
WS Off-grid 5	45	2,106	\$28,524	
WS Off-grid 6	45	2,309	\$34,708	
WS Off-grid 7	54	2,527	\$31,236	
WS Off-grid 8	54	2,770	\$38,526	

Results

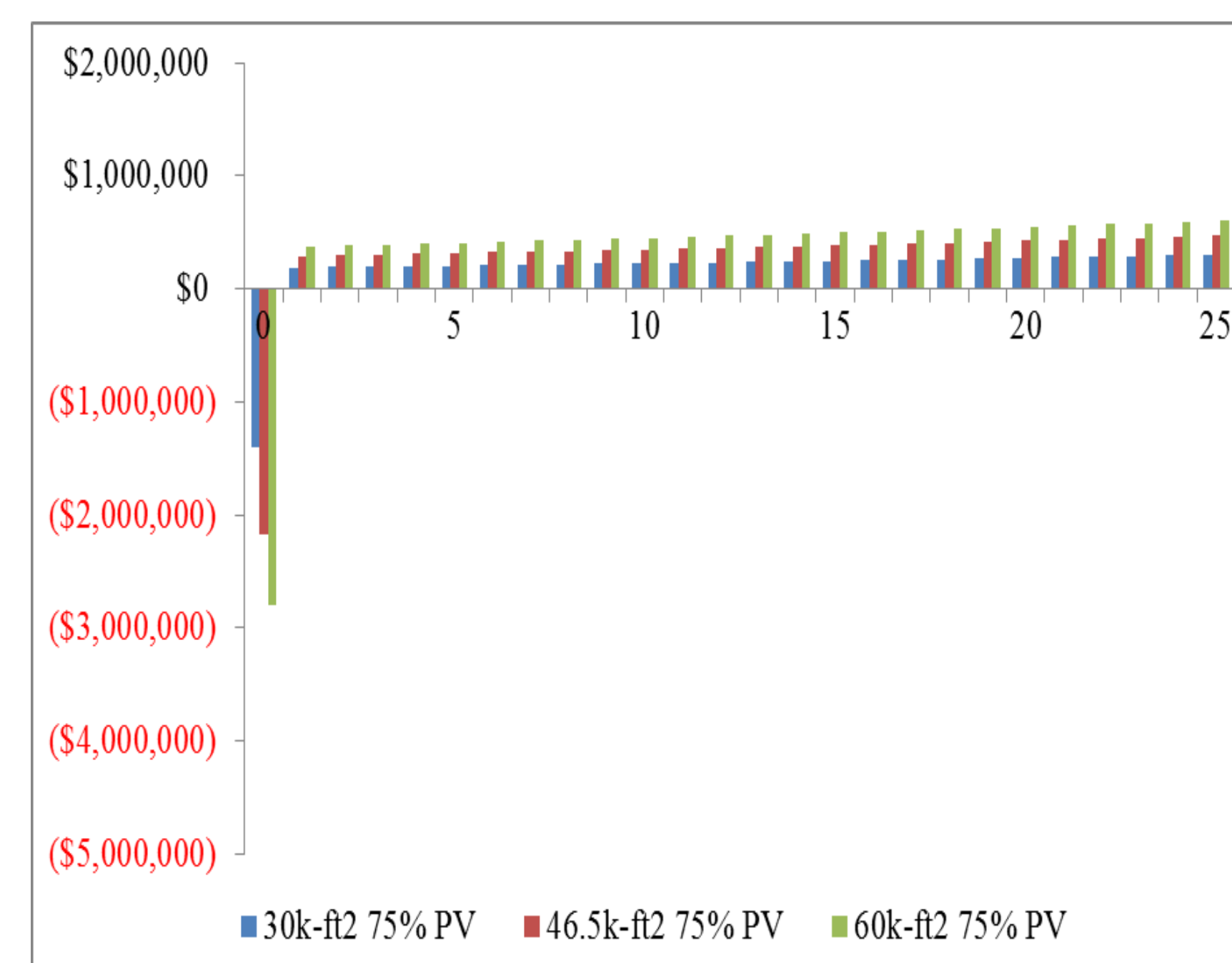


Figure 1: Cash flow for Supermarket producing 75% of Electricity Consumption by a PV Grid-Connected System

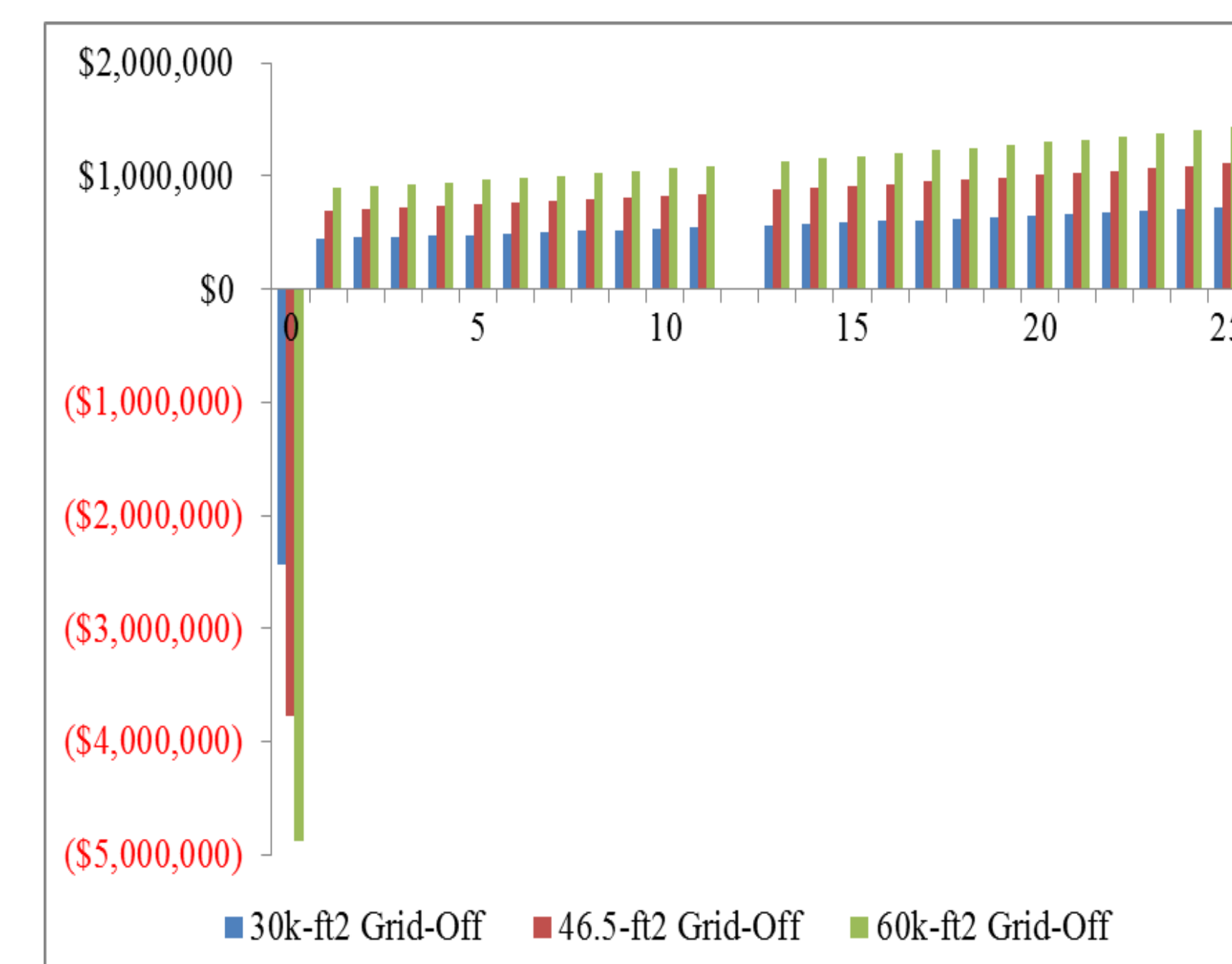


Figure 2: Cash flow for Supermarket producing 100% of Electricity Consumption by a PV Grid-Off System

Results Summary

Table 3: Summary of NPV and IRR results for the businesses and PV systems evaluated

System Type	Business Footprint (ft ²)	NPV (Million)	IRR
Grid-Connected 75% Electricity Consumption by PV for Supermarket	30,000	\$ 3.170	14.8%
	46,500	\$ 4.914	14.8%
	60,000	\$ 6.340	14.8%
Grid-Connected 75% Electricity Consumption by PV for Restaurant	2,500	\$0.274	14.8%
	3,500	\$0.385	14.8%
Grid-Connected 75% Electricity Consumption by PV for Retail Store	2,000	\$0.085	14.8%
	2,500	\$0.106	14.8%
Grid-Off System for Supermarket	30,000	\$7.906	19.5%
	46,500	\$12.255	19.5%
Grid-Off System for Restaurant	60,000	\$15.813	19.5%
	2,500	\$0.697	20.6%
Grid-Off System for Retail Store	3,500	\$0.975	20.6%
	2,000	\$0.222	20.0%
	2,500	\$0.278	20.0%

Conclusions

Various businesses were evaluated with a focus on reducing operational costs by implementing PV Solar systems. Those businesses related to food preparation and/or food sale were found to be the highest electricity consuming and identified as a good candidate for evaluating possible benefits of implementing these renewable energy systems. The 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 business' electricity needs were able to provide acceptable return on investment while helping reducing operational costs. Even better, Grid-Off PV solar systems equipped with the correct batteries bank and that receive adequate maintenance could improve the return on investment while also help reducing operational costs. 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

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