Received: 14 APR 2026 | Accepted: 17 JUN 2026 | Published Online: OCT 2026
UCLM Journal of Business, Accounting and Management Vol. 1 Issue 1 (October 2026)
DOI: target: target: https://doi.org/10.5281/zenodo.23468414

On-Grid Solar Photovoltaic (PV) System Adoption: Its Impact on the Performance of Small and Medium Enterprises in Mandaue City, Cebu

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ABSTRACT

This study examined factors influencing the adoption of on-grid solar photovoltaic (PV) systems and the perceived impact of such adoption on the performance of small and medium enterprises (SMEs) in Mandaue City, Cebu. A descriptive-correlational research design was used with a researcher-made questionnaire administered to 15 SME business owners using on-grid solar PV systems. Data were analyzed using simple percentage, weighted mean, and chi-square tests. Among the adoption factors, cost savings obtained the highest aggregate mean (M = 3.65, Strongly Agree), followed by reliability of energy supply (M = 3.56), quick return on investment (M = 3.49), environmental footprint (M = 3.37), and affordability of upfront costs (M = 3.08). The overall perceived impact of solar PV adoption on business performance was also high (M = 3.52, Strongly Agree), with profitability obtaining M = 3.63, business image and reputation M = 3.48, and environmental sustainability M = 3.45. Chi-square analysis identified statistically significant relationships between reliability of energy supply and profitability, environmental footprint and environmental sustainability, and quick return on investment and profitability. Other tested relationships were reported as not statistically significant. The findings provide localized evidence on how solar-adopting SMEs in Mandaue City perceive the economic, environmental, and reputational implications of on-grid PV systems, while the small sample limits generalizability.

Keywords: *On-grid solar photovoltaic, solar PV adoption, small and medium enterprises, business performance, Mandaue City*

INTRODUCTION

Renewable energy has gained attention as businesses respond to energy costs, environmental concerns, and sustainability objectives. Solar photovoltaic (PV) technology converts sunlight directly into electricity and can provide an alternative source of power for businesses. The International Energy Agency (IEA, 2024), as cited in the source thesis, projects continued rapid expansion of solar PV capacity through 2030.

On-grid or grid-tied solar PV systems are connected to the public electricity grid. They allow businesses to use electricity generated from solar panels and, where applicable, send excess generation to the grid through net-metering arrangements. The source study situates on-grid systems as particularly relevant to urban SMEs because the systems do not require battery storage and can be integrated with an existing utility connection.

In the Philippines, renewable-energy development is supported by Republic Act No. 9513, or the Renewable Energy Act of 2008, while net metering provides a mechanism for eligible electricity users to receive credits for electricity delivered to the grid. The study identifies these policy mechanisms as part of the context in which businesses consider solar PV adoption.

Prior studies cited in the thesis report financial, operational, and environmental motivations for solar adoption. Fapetu et al. (2023) reported electricity-cost reductions and operational improvements among Nigerian SMEs using solar systems. Hsbollah et al. (2023) examined solar PV adoption and

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corporate image and business sustainability among Malaysian SMEs. Farias-Rocha et al. (2019) examined the financial feasibility of on-grid residential PV systems in the Philippines, while Addun et al. (2022) assessed the technical performance of a grid-tied solar PV installation in the Philippine setting.

Despite this literature, the source thesis identifies a gap in localized empirical evidence concerning how on-grid solar PV adoption relates to business performance among SMEs in Mandaue City. The study therefore focuses on businesses that have already adopted on-grid PV systems and examines the factors associated with adoption and their perceived effects on profitability, environmental sustainability, and business image and reputation.

Theoretical Background

The study is anchored primarily on the Technology–Organization–Environment (TOE) framework of Tornatzky and Fleischer (1990). The framework considers technological characteristics, organizational conditions, and the external environment as contexts influencing technology adoption. In the present study, technological considerations include reliability, cost-saving potential, and environmental benefits; organizational considerations include business characteristics and resources; and environmental considerations include policies, competition, and other external pressures.

The study also draws on Rogers's (1962) Diffusion of Innovations theory, which explains adoption through characteristics such as relative advantage, compatibility, complexity, trialability, and observability. Davis's (1989) Technology Acceptance Model contributes the concepts of perceived usefulness and perceived ease of use. Ajzen's (1991) Theory of Planned Behavior further considers attitude, subjective norms, and perceived behavioral control as determinants of behavioral intention. Together, these perspectives were used in the source study to frame the motivations and perceived performance effects associated with solar PV adoption.

Research Objectives and Hypothesis

The study examined the profile of participating businesses; assessed factors influencing on-grid solar PV adoption in terms of cost savings, affordability of upfront costs, reliability of energy supply, environmental footprint, and quick return on investment; assessed perceived effects on profitability, environmental sustainability, and business image and reputation; and tested the relationship between adoption factors and perceived performance impacts.

The null hypothesis stated that there is no significant relationship between the factors influencing SMEs to adopt an on-grid solar PV system and the perceived impact of the system on business performance.

METHODOLOGY

Research Design

A descriptive-correlational research design was employed. The descriptive component summarized business profiles, adoption factors, and perceived performance impacts, while the correlational component examined relationships between adoption factors and performance dimensions. The research flow in the source thesis connects the business profile, adoption factors, and perceived impacts to data gathering, processing, analysis, interpretation, and recommendations.

Research Setting and Respondents

The study was conducted in Mandaue City, Cebu. The source describes Mandaue as a highly urbanized commercial and industrial area with manufacturing, merchandising, and service establishments. The respondents were 15 business owners of SMEs located in Mandaue City that had adopted on-grid solar PV systems. Convenience sampling was used.

Enterprise Category	Frequency	Percentage
Small enterprises	6	40.00%
Medium enterprises	9	60.00%

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Total	15	100.00%

Research Instrument

A researcher-made questionnaire was used. It contained three sections: (1) business profile, including nature and form of business, years of operation, years of solar PV use, and enterprise category; (2) factors influencing adoption; and (3) perceived impact of on-grid solar PV adoption on profitability, environmental sustainability, and business image and reputation. Sections 2 and 3 used a four-point Likert scale: 4 = Strongly Agree, 3 = Agree, 2 = Disagree, and 1 = Strongly Disagree.

Pilot Testing and Data Collection

The source thesis reports a dry run involving 15 business owners in Lapu-Lapu City who had adopted on-grid solar PV systems. The researchers also sought assistance from solar installers and manually identified potential businesses, including the use of Google Maps satellite imagery. Permission was obtained from relevant authorities and participating business personnel before administration of the questionnaire.

Statistical Treatment

Simple percentage was used to describe business profiles. Weighted mean was used to summarize the adoption factors and perceived business-performance impacts. Chi-square tests were used to examine the relationship between each adoption factor and each performance dimension.

Ethical Considerations

The source study describes voluntary participation, informed consent, confidentiality and privacy, integrity and accuracy of reporting, transparency, and secure management and disposal of research data as ethical safeguards.

RESULTS

Business Profile

Among the 15 participating SMEs, 53.30% were in merchandising, 40.00% in services, and 6.70% in manufacturing. Corporations constituted 80.00% of the sample and sole proprietorships 20.00%. Regarding years of operation, 33.30% had operated for more than 10 years, 26.70% for 1–3 years, 26.70% for 7–10 years, and 13.30% for 4–6 years. For solar PV usage, 46.70% had used the system for 1–3 years, 20.00% for 4–6 years, and 33.30% for 7–10 years; none reported more than 10 years of use.

Variable	Category	Frequency	Percentage
Nature	Service	6	40.00%
Nature	Merchandising	8	53.30%
Nature	Manufacturing	1	6.70%
Form	Sole proprietorship	3	20.00%
Form	Partnership	0	0.00%
Form	Corporation	12	80.00%
Form	Cooperative	0	0.00%
Years in operation	1–3 years	4	26.70%
Years in operation	4–6 years	2	13.30%
Years in operation	7–10 years	4	26.70%
Years in operation	More than 10 years	5	33.30%
Solar usage	1–3 years	7	46.70%
Solar usage	4–6 years	3	20.00%
Solar usage	7–10 years	5	33.30%
Solar usage	More than 10 years	0	0.00%
Enterprise category	Small	6	40.00%
Enterprise category	Medium	9	60.00%

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Factors Influencing On-Grid Solar PV Adoption

Adoption Factor	Mean	Interpretation
Cost savings	3.65	Strongly Agree
Affordability of upfront costs	3.08	Agree
Reliability of energy supply	3.56	Strongly Agree
Environmental footprint	3.37	Strongly Agree
Quick return on investment	3.49	Strongly Agree
Overall aggregate mean	3.43	Strongly Agree

Cost savings obtained the highest aggregate mean (M = 3.65). The two highest individual indicators in this category were reducing monthly electricity bills and the potential to save on electricity expenses (both M = 3.73). Affordability of upfront costs had the lowest category mean (M = 3.08), although it remained within the Agree interpretation. Reliability of energy supply had M = 3.56, with reducing the effect of electricity-rate fluctuations obtaining M = 3.80. Environmental footprint had M = 3.37, while quick return on investment had M = 3.49, with the expectation of a quick return receiving M = 3.73.

These patterns are broadly consistent with the sources cited in the thesis. Fapetu et al. (2023) associated solar adoption with electricity-cost reduction among SMEs, while Hsbollah et al. (2023) reported economic and sustainability considerations. Farias-Rocha et al. (2019) discussed the financial feasibility of on-grid PV, and Addun et al. (2022) examined technical performance in a Philippine grid-tied installation.

Perceived Impact on Business Performance

Performance Dimension	Mean	Interpretation
Profitability	3.63	Strongly Agree
Environmental sustainability	3.45	Strongly Agree
Business image and reputation	3.48	Strongly Agree
Overall aggregate mean	3.52	Strongly Agree

Profitability received the highest aggregate mean (M = 3.63). The highest-rated profitability indicator (M = 3.87) stated that adoption had reduced operational costs, leading to improved profitability. Environmental sustainability obtained M = 3.45, with items concerning environmental responsibility receiving M = 3.53. Business image and reputation obtained M = 3.48; the highest-rated indicator (M = 3.67) concerned customers and partners viewing the business as more forward-thinking and environmentally aware because of solar use.

The findings are consistent with the direction of evidence cited in the thesis from Fapetu et al. (2023) and Hsbollah et al. (2023), which reported financial, sustainability, and corporate-image outcomes associated with solar adoption. However, the present study measures perceived impact rather than independently verified financial or environmental performance.

Relationship Between Adoption Factors and Perceived Performance

Adoption Factor	Performance Dimension	Chi-Square	Critical Value	Source Result
Cost savings	Profitability	35.655	43.773	Not significant
Cost savings	Environmental sustainability	18.214	36.415	Not significant
Cost savings	Business image and reputation	39.161	43.773	Not significant

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Affordability of upfront costs	Profitability	40.667	49.802	Not significant
Affordability of upfront costs	Environmental sustainability	38.125	41.337	Not significant
Affordability of upfront costs	Business image and reputation	41.625	49.802	Not significant
Reliability of energy supply	Profitability	47.222	37.652	Significant
Reliability of energy supply	Environmental sustainability	28.000	31.410	Not significant
Reliability of energy supply	Business image and reputation	27.650	37.652	Not significant
Environmental footprint	Profitability	30.333	31.410	Not significant
Environmental footprint	Environmental sustainability	26.375	26.296	Significant
Environmental footprint	Business image and reputation	29.475*	31.410	Not significant
Quick return on investment	Profitability	37.000	37.652	Significant
Quick return on investment	Environmental sustainability	20.500	31.410	Not significant
Quick return on investment	Business image and reputation	32.250	37.652	Not significant

Based on the reported chi-square comparisons, three relationships were identified by the source study as significant: reliability of energy supply with profitability; environmental footprint with environmental sustainability; and quick return on investment with profitability. The remaining tested relationships were reported as not significant.

Because the study uses a small sample of 15 businesses, these inferential results should be interpreted cautiously. In addition, the source table labels one column 'Chi-Square p-Value' while presenting values alongside a separate critical-value column; the values reported in the thesis function as chi-square statistics in the comparison with critical values. The manuscript therefore preserves the reported test structure rather than relabeling the statistics as p-values.

DISCUSSION

The results show that the participating SMEs strongly endorsed several reasons for adopting on-grid solar PV systems, particularly cost savings and energy-supply reliability. This pattern is consistent with the literature reviewed in the thesis, which identifies electricity-cost pressures and energy reliability as important considerations in SME solar adoption (Fapetu et al., 2023; Hsbollah et al., 2023). The relatively lower mean for upfront-cost affordability indicates that initial investment remains a distinct consideration even among businesses that have already adopted the technology.

The perceived business-performance results were also strongly positive across profitability, environmental sustainability, and business image and reputation. Profitability received the highest mean, reflecting respondents' strong agreement with statements concerning lower operational costs and electricity expenses. Environmental and reputational dimensions were also rated strongly, indicating that respondents associated solar PV with environmental responsibility and a more sustainability-oriented business identity.

The chi-square findings indicate that the adoption factors were not uniformly related to all performance dimensions. Reliability of energy supply was significantly associated with profitability,

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while environmental footprint was significantly associated with environmental sustainability. Quick return on investment was also significantly associated with profitability. In contrast, cost savings and affordability of upfront costs did not show significant relationships with the tested performance dimensions in the source analysis. Thus, the study's results distinguish between factors that respondents considered important in deciding to adopt solar and factors that were statistically associated with particular perceived outcomes.

These findings should not be interpreted as evidence that solar PV caused the reported performance outcomes. The descriptive-correlational design, convenience sampling, small sample size, and use of perceived measures limit causal inference. The results are best understood as evidence of reported perceptions and associations within the participating SMEs.

CONCLUSION

Among the 15 participating SMEs using on-grid solar PV systems in Mandaue City, cost savings was the highest-rated adoption factor, while affordability of upfront costs received the lowest category mean but remained positively rated. Respondents also reported strong perceived impacts on profitability, environmental sustainability, and business image and reputation. The source analysis identified significant relationships between reliability of energy supply and profitability, environmental footprint and environmental sustainability, and quick return on investment and profitability.

Overall, the study provides localized evidence that participating SMEs associate on-grid solar PV adoption with economic, environmental, and reputational benefits. However, because the evidence is based on a small convenience sample and perceived outcomes, the findings should not be generalized to all SMEs in Mandaue City or interpreted as a causal estimate of solar PV's financial effect.

RECOMMENDATIONS

1. SMEs may examine financing mechanisms such as installment arrangements, loans, or leasing options to address the initial capital requirement associated with solar PV installation.
2. SMEs may conduct regular monitoring of solar PV performance, including energy generation, electricity consumption, utility bills, operating costs, and system reliability, to document changes over time.
3. Business owners may retain records of pre-adoption and post-adoption energy expenses and operational indicators to support more objective evaluation of return on investment.
4. Solar providers and installers may present transparent information on system costs, expected generation, maintenance requirements, payback periods, and net-metering arrangements to help businesses evaluate adoption decisions.
5. Future researchers should use larger and more geographically diverse samples and consider longitudinal designs to examine whether perceived benefits are sustained over longer periods.
6. Future studies may combine survey responses with objective financial and energy data to distinguish perceived effects from measured changes in profitability, electricity costs, and environmental performance.

Author Contributions

Author 1: Conceptualization, Methodology, **Author 2:** Data curation, Writing-Original draft preparation; **Author 3**: Investigation, Validation, **Author 4**: Visualization, Writing- Reviewing; **Author 5:** Supervision, Editing; **Author 6:** Investigation, Validation; **Author 7:** Writing- Reviewing, Supervision.

Funding

This research received no external funding.

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Generative AI Statement

The authors used ChatGPT (Open AI) solely as a language-support tool to improve the clarity, coherence, and grammatical accuracy of the manuscript. All AI-assisted outputs were critically reviewed, revised, and validated by the authors to ensure the accuracy, integrity, and originality of the content. The authors accept full responsibility for the final version of the manuscript and its published content.

Ethical Considerations

Prior to the data gathering, ethical approval was obtained from the University of Cebu Academic Research Ethics Committee (UCAREC). The approved protocol ensured adherence to the principles of respect for persons, beneficence, justice, voluntary participation, informed consent, confidentiality, and anonymity, and compliance with the Data Privacy Act throughout the research process.

Declaration of Competing Interest

The authors declare that they have no competing financial, professional, or personal interests that could have influenced the conduct, findings, or publication of this study.

Data Availability

Data will be made available by the corresponding author on request.

Acknowledgments

The authors sincerely acknowledge the University of Cebu Lapu-Lapu and Mandaue (UCLM) for its unwavering support in completing this research. The guidance and institutional resources provided by the University Research Center greatly contributed to the successful conduct of the study. Finally, the authors express their sincere appreciation to the peer reviewers and editors for their constructive comments and recommendations, which significantly improved the quality and scholarly merit of this manuscript.

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