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PROCEEDING FOR
INTERNATIONAL COLLOQUIUM ON
NEXTGEN CONSTRUCTION
2025

Future-Ready Construction and Facility Management:
Driving Research and Innovation for a Smart Built Environment

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INTERNATIONAL COLLOQUIUM ON
NEXTGEN CONSTRUCTION
2025

Organiser:
Universitas Pamulang (UNPAM)

Co-organiser:
Department of Built Environment Studies and Technology,
Faculty of Built Environment,
UiTM Perak Branch

Faculty of Built Environment, UiTM Sarawak Branch

Colloquium Date:
6 May 2025

Unit Penerbitan UiTM Perak, 2025

Perpustakaan Negara Malaysia Cataloging in Publication Data

No e- ISBN: 978-967-2776-60-4

Cover Design : Nur'Ain Ismail
Typesetting : Nur'Ain Ismail

Proceeding for International Colloquium on NextGen Construction 2025
Future-Ready Construction and Facility Management:
Driving Research and Innovation for a Smart Built Environment
e-ISBN : 978-967-2776-60-4

PARAMETERS FOR ECONOMIC VIABILITY OF RESIDENTIAL ON-GRID SOLAR PHOTOVOLTAIC (PV) SYSTEM – A LITERATURE REVIEW

Ruqaiyah Ashari[1], Asmalia Che Ahmad[1], and Izatul Farritta Mohd Kamar[1]

[1] Department of Built Environment Studies and Technology, Faculty of Built Environment, Universiti Teknologi MARA, Perak Branch, Malaysia

*Corresponding Author: ruqaiyahashari@gmail.com

Abstract
The increasing demand for sustainable energy solutions has led to the adoption of solar photovoltaic (PV) systems, especially in residential buildings. Therefore, concern regarding the economic viability of such systems is one of the critical obstacles in extensive adoption. Due to this issue, an investigation on parameters of the economic viability of solar photovoltaic adoption is necessary. The objective of this paper is to identify the parameters influencing the economic viability of solar photovoltaic (PV) on-grid system. A literature review has been conducted to achieve this objective. The outcome indicates that the evaluation of the economic viability of on-grid solar PV systems is conducted by analyzing key financial indicators, including payback period (PB), net present value (NPV), internal rate of return (IRR), and levelized cost of energy (LCOE).

Keywords: Solar PV, Residential Houses, Economic Viability, Renewable Energy, Facility Management

1. INTRODUCTION

The 12th Malaysia Plan (2021–2025) includes measures to accelerate the integration of renewable energy sources into the national grid. In Malaysia, the adoption of solar PV systems in residential houses has been growing due to the government incentives and rising energy costs. Various policies, such as Malaysia's Net Energy Metering (NEM) scheme and renewable energy tariffs, aim to promote the use of solar PV. However, the economic feasibility of these systems varies depending on factors such as installation costs, payback periods, and financial returns. Limited studies have comprehensively analyzed these economic parameters in the context of residential applications, creating a research gap that needs to be addressed.

The objective of this research is to identify the parameters influencing the economic viability of solar photovoltaic (PV) on-grid systems for residential buildings. A literature review was conducted to achieve this objective. This study will provide valuable insights into the economic viability for the financial sustainability of solar PV systems in residential buildings and contribute to the implementation of renewable energy policies and strategies.

2. LITERATURE REVIEW

The electrical grid is a system that connects electricity producers to users through power stations, high-voltage transmission lines, and distribution networks (Vehe et al., 2021). It acts like a large energy storage system, allowing solar PV energy to be added or taken as needed (Vehe et al., 2021). According to Kumar & Moses (2018), an on-

e-ISBN : 978-967-2776-60-4

grid solar PV system generates electricity using solar panels and supplies it to the power grid. If the system produces more energy than needed, the extra power is sent to the electric company. On-grid systems do not need batteries for storage, unlike off-grid systems, which require large storage, or hybrid systems, which have storage based on energy needs (Kumar & Moses, 2018).

The increasing energy demand, environmental concerns, and depletion of fossil fuel reserves have led to the exploration of renewable energy sources, particularly solar energy. Solar photovoltaic (PV) systems have emerged as a viable solution for residential energy consumption. This literature review focus on the evaluation parameters to analyze the economic viability of solar energy usage in residential buildings, considering factors such as installation costs, payback period, net present value (NPV), internal rate of return (IRR), and levelized cost of energy (LCOE).

The total cost of a residential solar PV system consists of capital costs (equipment, installation, and labor), operation and maintenance costs, and government incentives (Chowdhury et al., 2022). The declining price of PV modules has significantly reduced the initial investment required for solar energy adoption (IRENA, 2021). However, variations in system costs depend on geographic location, solar irradiance, and financial policies (Sivaram et al., 2020).

The payback period of a solar PV system is the time required to recover the initial investment through electricity savings. Studies indicate that residential solar PV systems typically have a payback period ranging from 5 to 15 years, depending on local energy prices and incentives (Rahman et al., 2023). Additionally, financial tools such as net metering and feed-in tariffs improve the financial attractiveness of solar investments (Sarkar & Singh, 2020).

Net Present Value (NPV) and Internal Rate of Return (IRR) NPV and IRR are key financial indicators used to assess the profitability of solar PV investments. A positive NPV indicates economic feasibility, while a high IRR suggests an attractive return on investment. Research shows that residential PV systems can achieve an IRR of 10%–20%, making them competitive with traditional investment options (Zhou et al., 2021). Government subsidies and tax credits further enhance the economic viability of solar energy (Al-Waeli et al., 2021).

Levelized Cost of Energy (LCOE) LCOE represents the average cost per unit of electricity generated over the system's lifetime. Lower LCOE values indicate cost-competitiveness with conventional electricity sources. A study by Lazard (2022) found that the LCOE for residential solar PV has declined significantly, reaching levels comparable to grid electricity in many regions. However, variations exist due to installation costs and energy production efficiency (Wang et al., 2022).

Overall, the economic viability of residential solar PV systems is influenced by multiple parameters, including initial costs, financial incentives, payback period (PB), NPV, IRR, and LCOE.

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3. METHODOLOGY

According to Wondimagegn Mengist, et al,. (2021) literature review is a process that allowed to collect relevant evidence on the given topic that fits the pre-specified eligibility criteria and to have an answer for the formulated research The questions. The primary objectives of this paper is to identify the parameters influencing the economic viability of solar photovoltaic (PV) on-grid system for residential building Within this purpose, a review of relevant literature was performed. Within this purpose, a review of relevant literature was performed. In the first stage, the researcher selects establish publishers such as Google Scholar and Scopus. Then, from the publication databases, the initial search was done using the "economic viability" and “solar on-grid system” as the keywords. Hence, the literature content is manually identified by researchers the economic viability for solar on-grid system. In conclusion, these literature findings were discussed to demonstrate the parameters that indicates the cost-effectiveness of residential solar PV systems.

Table 1: The result of economic parameters for economic viability of PV solar.

Author / Parameters	Najib et al (2019)	Zeraatpishe het. Al (2018)	Muhibullah et al (2021)	Husain et al (2021)	Ahshan et al (2020)	S. Ud-Din Khan et al. (2022)	Abdullahi Abdulkadir Ahmed et al (2023)	Zhiyi Ren et al (2023)	Eliser Tarigan (2023)
Payback Period (PB)	√	√	√	√	√	√	√	√	
Net Present Value (NPV)	√	√	√	√	√			√	
Internal Rate of Return (IRR)	√	√			√			√	
Levelized Cost of Energy (LCOE)	√			√		√	√		
Profitability Index (P1)		√			√				
Unit cost of electricity (UCE)									√

e-ISBN : 978-967-2776-60-4

In many studies, Payback Period (PB) and Net Present Value (NPV) are frequently selected as the primary parameters to assess economic viability. This is because:

a) Payback Period (PB) is a straightforward and easy-to-understand indicator. It shows how long it takes for the initial investment to be recovered through energy savings. Investors and homeowners often prefer this parameter because it gives a clear picture of when they can start benefiting financially from the system
b) Net Present Value (NPV), on the other hand, represents the total value of cash flows over time, taking into account the time value of money. A positive NPV means the investment is profitable. NPV provides a more comprehensive evaluation as it includes all expected costs and benefits throughout the system's lifespan.

Both parameters are widely used due to their practicality and ability to support informed decision-making, especially in comparing different systems. Hence, combining PB and NPV offers a balanced effective way to determine whether a solar PV investment is economically viable.

5. CONCLUSION

Several essential attributes have been derived from the list of economic parameters for economic viability for solar PV systems (Table 1). The essential attributes that are most practices in economic viability are payback period (PB), Levelized Cost of Energy (LCOE), Net Present Value (NPV) and Internal Rate Return (IRR). Hence the essential attributes of economic viability are conceptualized into a conceptual diagram as shown in Figure 1.

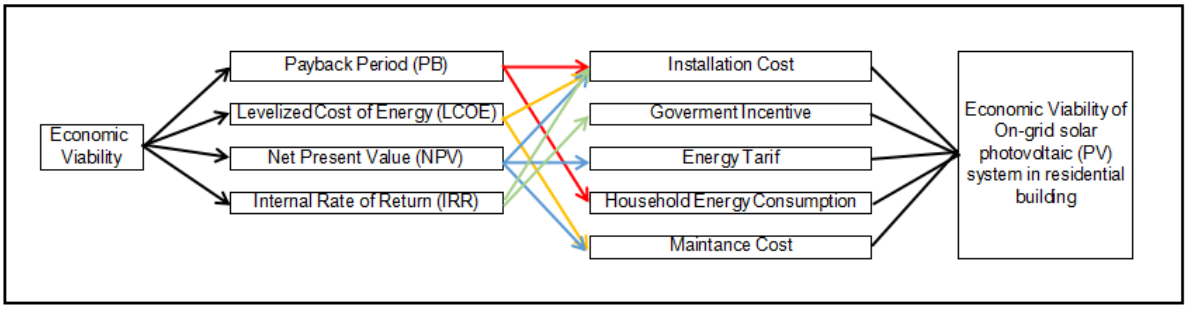

Figure 1: Conceptual Framework of economic viability on-grid solar photovoltaic (PV) system in residential building.

Based on the diagram, the economic viability of an on-grid solar photovoltaic (PV) system for residential buildings is influenced by multiple parameters. Economic viability is assessed through parameters such as the payback period, levelized cost of energy, net present value (NPV), and internal rate of return (IRR). These metrics are directly impacted by factors including installation costs, government incentives, energy tariffs, household energy consumption, and maintenance costs. For instance, higher installation costs and maintenance expenses may extend the payback period, while government incentives and favorable energy tariffs can improve economic feasibility.

e-ISBN : 978-967-2776-60-4

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