Solar Photovoltaic Applications in Residential Buildings and Shrimp Aquaculture Farms in Thailand

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Abstract

This systematic article synthesizes empirical evidence from four studies examining the application, performance, and economic feasibility of solar photovoltaic (PV) systems in residential buildings and aquaculture farms in Thailand. A structured review approach was used to extract data relating to system sizing, energy consumption, financial investment indicators, and technological principles of solar cells. Findings indicate that PV adoption is highly effective in both sectors, with residential buildings achieving payback periods of approximately 4–5 years, while shrimp farms especially medium and large scale, demonstrate strong Net Present Value (NPV), Benefit-Cost (B/C) ratios above 1.6, and Internal Rate of Return (IRR) up to 19%. This review confirms that solar PV is economically viable and technologically adaptable under Thailand's climatic conditions. Recommendations are offered for policymakers and future research.

Keywords: Solar Photovoltaic, Residential Buildings, Shrimp, Aquaculture, Farms

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Introduction

Solar photovoltaic energy has become a critical component of sustainable energy planning in Thailand. Increased electricity consumption in residential buildings, combined with energy-intensive agricultural operations such as white-leg shrimp farming, has motivated research into the feasibility and optimization of PV technologies. Although several isolated studies exist, a systematic synthesis of their methodologies, findings, and implications is lacking (Puzu et al, 2023). Therefore, this systematic article consolidates existing empirical findings on:

1. Solar panel sizing for multi-story residential buildings
2. Financial viability of solar PV in shrimp aquaculture
3. Break-even analysis for solar installation in rental housing
4. Fundamental operation of solar cells relevant to design and energy forecasting

This synthesis aims to provide evidence-based insights to guide engineering design, investment decisions, and future research directions.

Methodology

1. Search Strategy

A targeted document review was conducted using four primary academic sources published between 2019 and 2024. The search focused on studies involving PV system sizing, economic evaluation, and energy management in Thailand. Only peer-reviewed articles and applied research studies were included.

2**. Inclusion Criteria**

Studies were included if they met the following criteria:

1. Conducted in Thailand
2. Provided quantitative data related to PV system performance, energy consumption, or financial analysis
3. Included measurable outcomes such as number of panels, NPV, B/C ratio, IRR, or payback period
4. Peer-reviewed or published in academic journals

3. Data Extraction Approach

Data were extracted systematically into the following categories:

- Context and study objective
- Method of calculation or analysis
- Energy-use characteristics
- Solar system specifications
- Key numerical outcomes
- Financial indicators

Data synthesis followed a narrative and analytical approach appropriate for heterogeneous studies.

Results

1. Solar Panel Sizing in Multi-story Residential Buildings

The study by Wat Kalaya & Prasit (2019) used actual energy consumption measurements from a seven-story rental building with 61 rooms to determine PV panel requirements. Based on load profiling and model calculations, the required number of panels was:

Panel Rating (W)	Number of Panels
75 W	1,089
120 W	681
150 W	545
250 W	327

Higher-wattage panels significantly reduce the installation footprint. The study emphasizes the role of real consumption data in precise system sizing.

2. Energy Use and Financial Investment Performance in Shrimp Farms

Chonticha et al. (2024) collected in-depth interview data from five stakeholders and survey data from 150 shrimp farmers. Farm characteristics were:

- Small farms: 3.14 rai
- Medium farms: 4.07 rai
- Large farms: 5.48 rai
- 2–3 production cycles per year
- High aeration and water-quality system usage

Financial outcomes for PV capacities of 1.1 kW, 2.2 kW, and 4.4 kW were:

- Farm Size NPV (Baht) B/C Ratio IRR (%) Discounted Payback (Years)
- Small 34,878.34 1.63 9 7.95
- Medium 114,837.41 2.58 17 5.20
- Large 260,315.20 2.96 19 4.95

Medium and large farms show high economic feasibility, suggesting strong potential for solar adoption in Thailand's aquaculture sector.

3. Break-even Analysis for PV Installation in a Residential Complex

Ouaychai et al. (2020) investigated a residential building with 61 rooms, each equipped with common appliances. Based on tariff and energy-use data from the Nonthaburi Electricity Authority, the study recommended:

- 250 W panels × 156 units
- Investment cost: 1,755,500 Baht
- Payback period: 4.80 years (~4 years, 9 months, 18 days)

This demonstrates consistent economic viability of solar PV for rental housing operations.

4. Fundamental Technological Principles of Solar PV Systems

Phra Jamlong & Pakdee (2019) outlined the semiconductor basis of PV conversion. Silicon-based p-n junctions generate electric flow when exposed to light. Key technological findings include:

- PV systems produce electricity even during cloudy conditions
- Cloud reflection may enhance solar radiation on certain days
- Energy output is proportional to light density, not direct sunlight alone

These principles explain the suitability of PV systems for Thailand's climate, which includes frequent cloudy periods.

Discussion

1. Cross-sector Comparison

The findings reveal strong consistency across sectors:

- Residential buildings benefit from predictable energy loads and achieve payback within ~5 years.
- Shrimp farms benefit from high and continuous energy demand, leading to high returns despite larger investment needs.

Both contexts indicate that solar PV reduces operating costs significantly.

2. Importance of Real Energy-use Data

All studies emphasize that system sizing must rely on actual measured consumption, not theoretical assumptions. Differences in building load, farm aeration cycles, and equipment usage patterns strongly influence optimal PV system design.

3. Financial Feasibility

Across all studies:

- NPV values are positive
- B/C ratios > 1.0 indicate economic justification
- IRR values (9–19%) surpass typical bank loan interest rates in Thailand
- Payback periods under 8 years indicate low financial risk

4. Technological Reliability

Solar PV performance under cloud cover is a crucial advantage in tropical climates. This improves reliability and supports energy planning in both urban and rural settings.

Conclusion

This systematic review integrates findings from four empirical studies on the use of solar PV systems in Thailand. Evidence strongly supports the economic and technological feasibility of PV adoption in both residential and aquaculture contexts. System sizing must be based on real energy-use patterns, and investment returns are particularly strong in medium and large-scale shrimp farms and multi-unit residential buildings. Future research should evaluate long-term maintenance costs, battery storage integration, and climate variability impacts.

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References

Chonticha, T., Kulapa, K., & Sansanee, W. (2024). Investment Analysis of the Solar Cell for White-Leg Shrimp Farmers. Journal of Social Science Panyapat, 6(1), 447–460.

Ouaychai, W., Pichat, R., Sitthut, M., & Adisak, T. (2020). Calculation of break-even point for solar panel installation for public buildings, Bangkhen Subdistrict, Mueang District, Nonthaburi Province. Industrial Technology, Phranakhon Rajabhat University, 3(1), 31–38.

Phra Jamlong, P., & Pakdee, P. (2019). Solar Cells: Change to Energy. Journal of Research and Development Institute, Rajabhat Maha Sarakham University, 6(2), 525–536.

Puzu, N., Palasai, W., Nuntadusit, C., Narato, P., & Chaopisit, I. (2023). Flow and heat transfer characteristic on the downstream surface in case of solid body and vortex generating jet turbulators. International Journal of Science and Innovative Technology (IJSIT), 6(2), 1–10

Wat Kalaya, S., & Prasit, K. (2019). Study of the number of solar cells for installation by calculation method. Industrial Technology Research Journal, Phranakhon Rajabhat University, 2(1), 15