Performance and Economic Analysis of a Large Residential PV System

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Abstract

This paper presents a real-world, long-term performance and economic evaluation of a 25 kW residential photovoltaic (PV) system installed in Florida in 2019 at a cost of $64,000 ($2.56/W). The system has been monitored for four years (October 6, 2020 – October 7, 2024) using detailed utility billing data and an Enphase monitoring system. The research objective is to provide homeowners with a practical decision-making tool for assessing PV economics, beyond vendor marketing claims. Contour analysis of installed costs ($/W) and loan interest rate illustrates key economic thresholds for viability. This validated case study highlights how financing terms and government incentives critically shape solar adoption outcomes. Findings demonstrate how empirical data can refine consumer decision tools and guide realistic policy frameworks.

Keywords: Solar economics; photovoltaic systems; residential PV; loan financing; ROI and IRR analysis

1. Introduction

The urgent need to mitigate climate change has accelerated the transition to renewable energy, with solar PV emerging as a leading residential solution. Federal and state incentives in the U.S. have fueled adoption, but in Florida, aggressive vendor marketing—often based on theoretical rather than empirical data—has led to consumer confusion and unrealistic expectations. This study bridges the gap between marketing claims and empirical performance by presenting a documented 25 kW case study under Florida utility conditions. The analysis considers equipment costs, inverter performance, utility policies, electricity rates, panel degradation, warranties, and government incentives. By leveraging four years of measured performance, this validated model quantifies payback period, ROI, and IRR to support informed homeowner investment decisions.

2. Methods and Approach

2.1 Pre-Solar Baseline

Between 2015 and 2018, average household electricity consumption was 3,299 kWh/month (39,588 kWh/year), costing $381.91/month or $4,582.92/year. The average rate was $0.1158/kWh.

2.2 System Installation

The PV system installed on March 18, 2019 consists of 75 LG 335 W panels (25 kW DC) and Enphase micro-inverters. Installed cost: $64,000 ($2.56/W). After applying the 30% Federal Investment Tax Credit (ITC, $19,529), net cost was $44,471, financed as follows:

- Loan Term: 15 years
- APR: 3.94%
- Payments: $329.41/month for the first 18 months, then $478.23/month (option to pay

ITC upfront to keep $329.41 fixed)
• Utility (SECO) published rates: $0.1106/kWh (<1,000 kWh/month) and $0.1306/kWh (>1,000 kWh/month); credit for exported power: $0.095/kWh
• Additional Costs: $66.67/month liability insurance (system >10 kW requirement)

Figure 1. Installed Solar System.

2.3 Data Collection

The four-year monitoring period covered October 6, 2020 – October 7, 2024, using two sources:
• Utility billing data with detailed line items (energy consumed, credits, adjustments, taxes, fees)
• Enphase monitoring system providing daily, monthly, and annual kWh data on system production, household demand, imports, and exports.

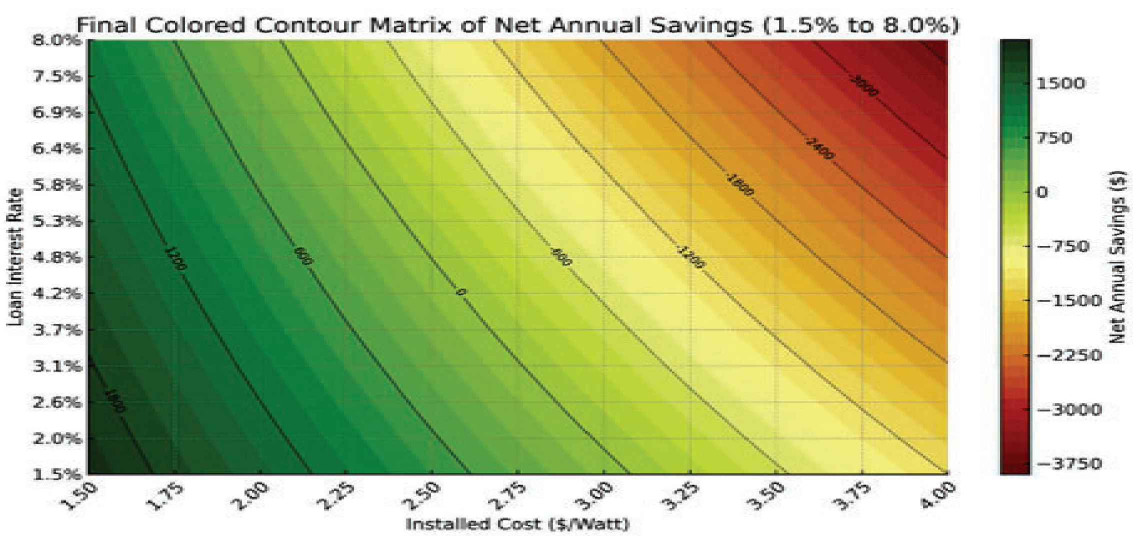

Figure 2: Contour Matrix of Net Annual Savings.

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2.4 Analytical Approach

At the time of vendor presentation, a homeowner typically knows two key facts: their historic electricity consumption (kWh/year) and corresponding costs, and the proposed PV system's expected output (kWh/year) with its installed cost ($/W) and incentives, which determine the loan amount. The vendor provides loan terms, and the applicable utility policy is applied.

Investment Outcome = (kWh × Utility Rate) − [Loan Payment + Residual Utility Cost (Imported kWh × Utility Rate)]

3. Results

At the installed cost of $2.56/W and an interest rate of 3.94%, the system produced near break-even annual savings, validating the importance of financing conditions. These break-even thresholds were calculated after removing the financial impact of undervalued exported energy, residual charges, and required liability insurance.

4. Discussion / Future Work

This study covered all economic parameters related to installing a residential solar system. For systems under 10 kW, where utilities genuinely apply equal rates for imports and exports, government incentives remain the decisive factor.

Lessons Learned: Real-world PV economics diverge significantly from vendor projections; financing terms critically determine outcomes. Broader Implications: Net savings are highly sensitive to $/W and loan interest rate, underscoring the role of financial institutions and policymakers. Limitations: The four-year period does not isolate solar-resource variation; while no significant degradation was observed, longer datasets are required for conclusive long-term performance trends. Future Work: Expand the dataset to include other system sizes, geographic regions, and community/shared solar models; incorporate panel degradation over longer periods.

5. Conclusions

This study provides real-world validation of PV economic models:

- Residential PV systems are financially viable under favorable installed cost and financing conditions.
- Contour analysis of $/W and loan interest rate offers a universal decision tool for homeowners.
- Results offer guidance for homeowners, policymakers, financiers, and vendors toward realistic solar adoption strategies.

Practical Note: If the original contractor goes out of business, future service may require upfront fees for warranty evaluation.

The author's long-term monitoring experience underscores the real financial consequences of PV adoption under current Florida utility and policy structures. This validated model offers a scalable template for community and regional PV economic assessments.

Table3: All Data is the Average of 4 Years monitoring and Tabulating all SECO Invoices and Enphase Records			
a	$0.0950	$/kwh	Wholesale credit per solar kwh exported to the grid
b	$0.1106	$/kwh	Retail charge $/kwh imported from the grid < 1000 kwh/month
c	$0.1306	$/kwh	Retail charge $/kwh imported from the grid >1000 kwh/month
T	40,575.00	kwh/y	Annual residence kwh consumption kwh/year
A	36,100.00	kwh/y	Total kwh/year produced by the solar system(Enphase)
B	18,482.53	kwh/y	Direct solar kwh/year to the residence (Enphase)
C	17,617.48	kwh/y	Solar kwh/year exported to the network (Enphase)
D	21,800.00	kwh/y	kwh/year imported by the residence before factoring solar contribution (Enphase)
D'	23,332.00	kwh/y	kwh/year imported by the residence before factoring solar contribution (SECO)
D(av)=(D+D')/2	22,460.25	kwh/y	Average kwh/year imported by the residence before factoring solar contribution
E	4,475.00	kwh/y	Net annual energy imported to fill the deficit kwh/mo. calculated (calculated)
E'	4,338.28	kwh/y	Net annual energy imported to fill the deficit kwh/mo. calculated (Enphase)
E(av)=(E+E')/2	4,406.64	kwh/y	Average annual energy imported to fill the deficit kwh/mo.
E(av)/12	367.22	kwh/m	Net monthly average energy imported to fill the deficit kwh/mo. which is <1000 kwh
H	$1,400.83	$/y	Actual SECO Invoice $/year after factoring solar credit
K= b*D(av)	$2,484.10	$/y	Annual cost of kwh imported (Purchased) per SECO Policy
L= a*C	$1,673.66	$/y	Annual credit of kwh exported from the grid based on SECO policy
M=K-L	$810.44	$/y	Net calculated electric utility cost to fulfil the deficit per SECO policy
M'=M/12	$67.54	$/m	Calculated monthly charge for fulfilling the deficit based on SECO policy
H'=H/12	$116.74	$/m	The monthly average payment per SECO invoices
N=H-L	$49.20	$/m	SECO monthly overcharge the calculated amount based on their published policy
R1=a*C	$1,673.66	$/Y	Annual credit of kwh exported to the grid per SECO Policy
R2=b*C	$1,948.49	$/Y	Annual charge of importing the same amount Exported per SECO Policy
R2-R1	$274.83	$/Y	Annual Loss in revenue per SECO Policy
(R2-R1)/12	$22.90	$/m	Monthly average Loss in revenue per SECO Policy
Q	$66.67	$/m	Additional Umbrella insurance for system > 10 kw
X	$329.24	$/m	Monthly loan payment
Y=Q+H"+X	$512.64	$/m	Actual Total Monthly payments for utility, loan, and insurance
Z	$381.91	$/m	Four years monthly average payment
F	$130.73	$/m	Additional monthly charges over 4 years average without solar

Figure 3. Four-Year Average Performance Summary (SECO and Enphase Data).

6. References

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