Feasibility of Energy Substitution in Nigeria: Solar Panels and Inverter Batteries

"An Analysis of Economic Viability Under New Electricity Tariffs"

Author: Solomon U. Okoro

Date: July 2024

Website: **GitHub - Solomon U. Okoro** ; **Personal website: Solomon U. O.**

Abstract

This paper evaluates the economic viability of substituting conventional energy sources with solar panels and inverter batteries in Nigeria, focusing on the impact of newly adjusted electricity tariffs in Nigeria for Ikeja, Lagos environs. The analysis employs Net Present Value (NPV) calculations over a 20-year period to compare solar, grid, and hybrid energy systems under varying financial and economic conditions.

1. Introduction

Context and Background

Nigeria faces significant challenges in its energy sector, including erratic power supply and rising electricity costs. Recent reforms in electricity tariffs reflect an attempt to realign prices with the actual cost of energy production. This study examines these reforms within the context of Ikeja, Lagos, where tariffs have been adjusted to 225 Naira per kWh.

Aims and Objectives

The primary objective of this study is to analyze the economic feasibility of different energy systems, namely solar, grid, and hybrid systems, to identify the most cost-effective solution under new tariff regulations. This paper also aims to provide a strategic framework for energy policy adjustments in Nigeria.

2. Overview of Inputs

Energy Consumption Profile

Detailed energy consumption data for a typical medium-sized home is analyzed, including daily usage patterns of various household appliances and systems. Table 1 below summarises the energy demand assumptions.

Table 1: Energy demand assumptions for a medium sized home in Nigeria

		Power Demand				
S/N	Load	Quantity	Wattage	Total Power (W)	Hours Used Daily (Hr/Day)	Watt Hour (Whr/day)
1	Lights	15	10	150	14	2100
2	Ceiling Fan	2	75	150	6	900
3	TV	1	95	95	8	760
4	Laptop + Charging Points	4	75	300	12	3600
5	Rechargeable Fan	4	30	120	20	2400
6	Freezer	1	250	250	12	3000
7	Fridge Freezer	1	200	200	12	2400
8	AC 2kvA	1	1800	1800	3	5400
9	AC 1.5kvA	2	1350	2700	3	8100
10	Water Pump	1	350	350	2	700
	Total			6,115		29,360

System Configurations and Costs

The study details the costs associated with solar panels, inverter batteries, and installation for both solar-only and hybrid systems, derived from a market survey conducted in May 2024.

Table 2: Cost assumptions for a Hybrid case (solar + grid power)

	Upfront Costs - **Hybrid**	Naira
1	Breakers, surge arresters, cables etc	430,000.00
2	Installation and logistics	170,000.00
3	Solar Mounting Rails	107,500.00
4	Battery Rack	48,375.00
	Total	755,875.00
	Amortised Costs	
1	Batteries - 4 units (Change every 4 years)	1,592,290.00
2	Solar Panels - 6 units (20 years Lifespan)	1,186,800.00
3	Inverter System	435,000.00

Table 3: Cost assumptions for a Solar only case

	Upfront Costs - **Solar Only (off-grid)**	Naira
1	Breakers, surge arresters, cables etc	430,000.00
2	Installation and logistics	340,000.00
3	Solar Mounting Rails	537,500.00
4	Battery Rack	241,875.00
	Total	1,549,375.00
	Amortised Costs	
1	Batteries - 20 units (Change every 4 years)	7,961,450.00
2	Solar Panels - 30 units (20 years Lifespan)	5,934,000.00
3	Inverter	2,175,000.00

Battery lifespan – 4 years (12V, 220Ah Tubular batteries), Solar Panels lifespan – 20 years (550Wp)
Electricity tariff at 225 Naira per kilowatt-hour.

3. Methodology

Economic Analysis Approach

The Net Present Value (NPV) method is utilized to evaluate long-term cost-effectiveness, incorporating a discount rate of 10% over a 20-year analysis period. Additional financial metrics, such as the sum of undiscounted cash expenditures, provide a broader perspective on cost implications.

Assumptions

Financial assumptions include a 3% annual increase in electricity rates and inflation, along with specific costs for battery replacement and maintenance.

4. Results

Comparative Analysis

Findings indicate that the hybrid system offers the most economical solution under the new tariff structure. In contrast, while the solar-only system presents higher initial costs, it becomes more economical than grid power when considering long-term, undiscounted cash flows (highlighted in orange).

Table 4: Results from economic analysis

Economic Metric	Hybrid (#'000)	Grid Only (#'000)	Solar Only (#'000)
NPV (10% DF)	21,446	26,989	33,323
Sum of Cash Exp.	44,687	61,968	56,631

5. Sensitivity Analysis

Impact of Variable Changes

The impact of variations in inputs like tariff changes, cost of Solar panels and inverters, and variation in energy usage on the Net Present Value (NPV) can be seen from Figure 1 to Figure 3 below per energy system analysed.

- The sensitivity analysis presented is for a +/- 15% variation in the inputs analysed.
- Material costs have no impact on the Grid Only case, as no materials are required.
- For the Solar Only case, tariff changes have no effect as expected.
- Lastly, in the Hybrid case, Tariff changes plus material cost changes have the most impact on the NPV.

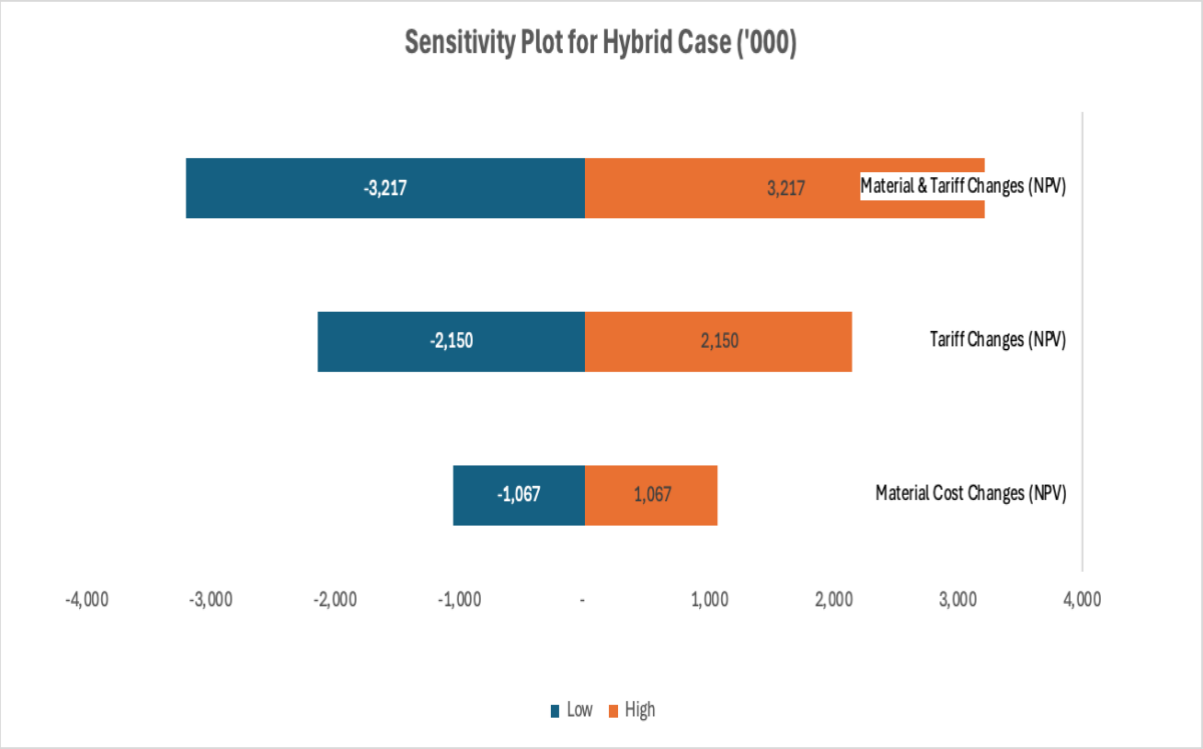

Figure 1: Sensitivity analysis for the Hybrid Energy System

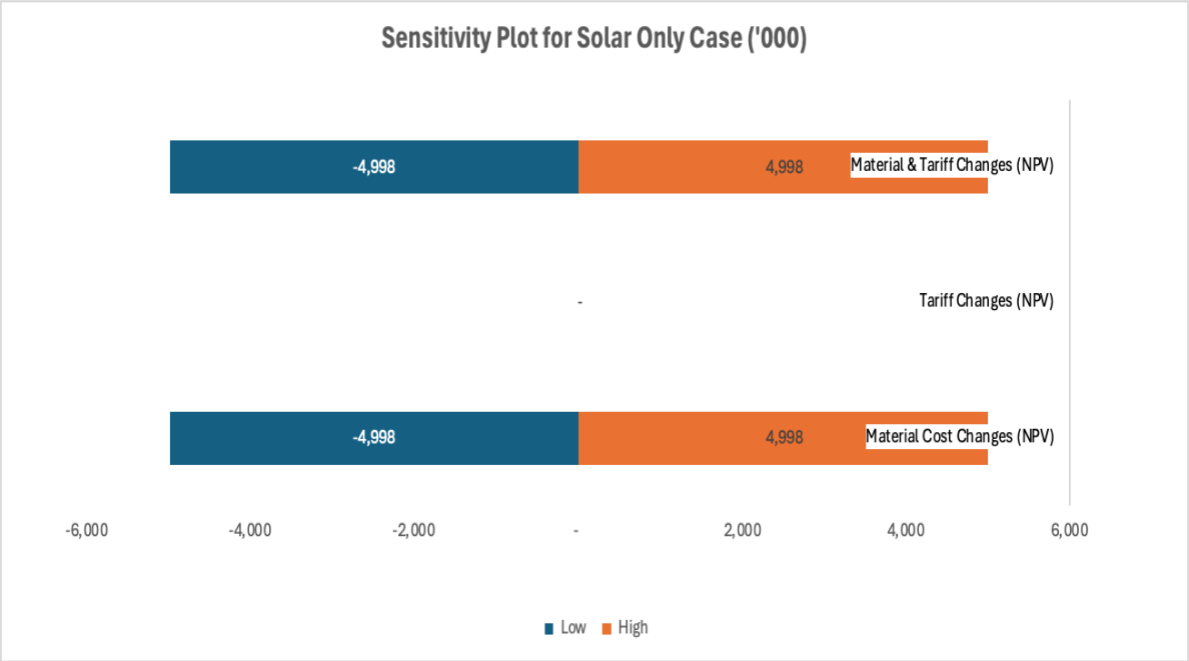

Figure 2: Sensitivity analysis for the Solar Only Energy System

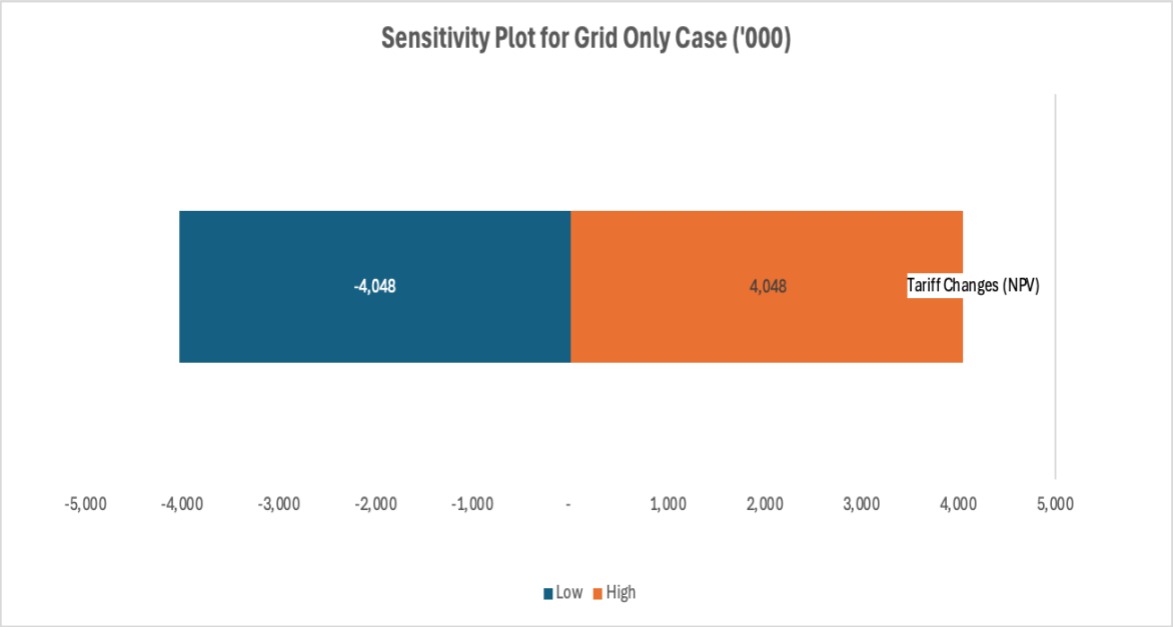

Figure 3: Sensitivity analysis for the Grid Only Energy System

6. Conclusion and Recommendations

Economic Feasibility

This analysis confirms that hybrid systems currently offer the most cost-effective energy solution in Nigeria, but solar power holds potential for greater economic viability as costs decline or tariffs increase.

Policy Implications

The paper recommends that the Nigerian government introduce incentives for solar adoption and consider flexible payment options for solar installations to enhance the attractiveness of off-grid solutions. If solar and inverter material costs go down 15%, solar only energy system becomes only one million Naira more expensive than grid electricity on discounted terms (10% DF), but notably 13 million Naira cheaper on sum of undiscounted cash expenses terms.

Therefore, with a spread payment for the solar costs as is available in western countries, it becomes cheaper on both economic metrics, which presents a good business venture.

Future Research Directions

Suggestions for future research include examining the environmental impacts of energy substitution and exploring technological advancements in solar and battery technology.

References

- Nigerian Electricity Regulatory Commission. View Tariff Details