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A Policy Review On Off-Grid Solar Energy for Sustainable Rural Electrification under the Philippine Energy Plan: A Case Study within LANECO-Franchised Areas

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Abstract
This study investigates local implementation of national energy policies to promote off-grid solar energy in rural areas as demanded under the Philippine Energy Plan (PEP) and with specific reference to the franchise areas of the Lanao del Norte Electric Cooperative (LANECO). Despite the availability of policy instruments like the Renewable Energy Act of 2008 and electrification programs spearheaded by the Department of Energy (DOE), Lanao del Norte households continue to endure weak and inadequate energy supply. The study investigates local implementation of these national policies, identifies technical and financial barriers to the application of off-grid solar energy, and tests the economic feasibility of a solar-powered system relative to LANECO's grid electricity. The findings will guide recommendations for better local policy and program progress to enable sustainable rural electrification in accordance with national priorities.

Keywords: Off-grid solar, sustainable rural electrification, Philippine Energy Plan, renewable energy policy, LANECO, energy access, policy implementation.

1. INTRODUCTION

Energy access continues to be an ongoing concern in most disadvantaged communities throughout the Philippines despite national actions in the Philippine Energy Plan (PEP) towards inclusive and sustainable electrification. The Sustainable Energy pillar of the PEP emphasizes the importance of clean, secure, and affordable energy access to be provided, especially in geographically isolated and disadvantaged areas. Lanao del Norte, however, being serviced by the Lanao del Norte Electric Cooperative (LANECO), continues to be plagued with inadequate and unreliable grid coverage because of geographical and economic limitations.

Despite policies like the Renewable Energy Act of 2008 (RA 9513) and the Department of Energy (DOE) programs, there seems to be a deficiency in converting the policies into implementable measures at the

local level. The study assesses the level of local implementation of the above-mentioned policies and the level of off-grid solar energy use as an alternative rural electrification solution in LANECO-covered areas. To support the Philippine Energy Plan's goals of access to sustainable energy, this study has a field test of a 600W stand-alone solar photovoltaic (PV) unit already installed in unserved barangay in the LANECO-franchised area as a prototype for day-time mobile charging, small electronics, basic lighting and possibly a refrigerator or an AC for a few hours. The system, costing ₱56,550.00 and designed for an estimated 4.5 sunlight hours per day. This field test installation is used to evaluate technical practicability, economic savings, and policy efficiency as part of the general policy review.

2. METHODOLOGY

A. Policy Review

A qualitative analysis of national energy policy particularly RA 9513 and DOE Total Electrification Program was done. Official documents, DOE reports, and LANECO implementation records were studied to determine national policy compliance with local implementation.

B. Case Study and Data Collection

Field case study was conducted in some off-grid communities of Purakan, Linamon LDN of LANECO franchise. Surveys, interviews with the officials of the cooperatives, local government units (LGUs), and households were undertaken. Technical site visits recorded prevailing electrification modes and issues.

C. Technical and Economic Evaluation

An empirical comparison was made between a 350W household appliance powered through: LANECO grid electricity and a simulated 600W off-grid solar PV system Cost savings, energy efficiency, and payback periods were calculated over a one-year operation, assuming daily use over 8 hours.

3. RESULTS AND DISCUSSION

A. Policy Gaps and Implementation Issues

Research evidence shows that while there are national policies encouraging off-grid solar power, their implementation in LANECO regions is limited by lack of local financial systems and a shortage of technical expertise. Cooperative priorities are typically to expand the grid instead of decentralized solutions.

Despite the Renewable Energy Act of 2008 [1] and the Philippine Energy Plan 2020–2040 (PEP) [2] giving top-level mandate for clean and decentralized electrification, implementation in LANECO-franchised areas continues to concentrate on-grid extension. LANECO's 2020–2023 investment reports [4] indicate that 87% of the budgets for electrification were allocated towards transmission and pole

maintenance. This is a reflection of electric cooperatives' business model structural bias in favor of volumetric sales of electricity and grid extension at the expense of distributed generation.

The Total Electrification Roadmap (TER) 2023–2032 [3] sets out the government plan to electrify the still unserved sitios. But the "least-cost" emphasis of the roadmap is disproportionately understood. In Lanao del Norte, steep terrain costs (average of ₱250,000/km for hilly terrain) render solar mini-grids and house-scale PV economically and technically more attractive. But there are limitations in implementation:

1. Weak local financial systems: Only 3% of LANECO partner LGUs have microfinance programs that cover energy-related capital costs.

2. Technical barriers: Four Solar PV NC-II technicians are certified to work the whole province in 2023 [4], which confirms national surveys that record the shortage of skilled rural solar workers [5].

3. Policy mismatch: The lack of cooperative performance metrics for renewable uptake discourages decentralized installations. Cooperatives are incentivized to supply as much energy as possible, as opposed to enabling community self-generation [6].

B. Social and Technical Barriers to Solar PV Uptake

Field interviews in Brgy. Libertad, Kauswagan and Brgy. Dominorog, Talakag uncovered household avoidance of solar kits because of perceived cost and maintenance hazards. These field interviews are consistent with wider Mindanao reports [5][6]:

1. Capital Expenditure: A standard 600W solar home system costs ₱56,550, which is over double the average annual household net income.
2. Awareness and Trust Deficit: 29% of rural respondents were exposed to any renewable energy campaign. Information asymmetry hinders adoption even when solar is economically viable.
3. Technical Maintenance Issues: Off-grid houses complained of difficulty in replacing batteries or accessing skilled technicians, resulting in p erceived unreliability.
4. Financing Restraints: They deem solar kits as non-productive appliances and impose consumer loan interest rates >13% APR, as opposed to agricultural loans of 6–8% [7].

These findings suggest that the government-sponsored green credit facilities, community maintenance models, and reevaluation of solar energy as a central economic driver are needed. Identified barriers include:

-High upfront costs of solar PV systems
-Lack of local technicians and maintenance knowledge
-Minimal community awareness and engagement in renewable energy options

C. Empirical Comparison of LANECO grid and Off-Grid Solar Setup

- LANECO grid electricity 350W household appliance

1. Daily Energy Output:
   350 Wh/day = 0.350 kWh/day
2. Average Annual Energy Production:
   0.350 kWh/day × 365 days = 127.75 kWh/year
3. Estimated Annual Billing:
   127.75 kWh/year × ₱12.72/kWh = ₱1,624.98.00
4. Considering the installation fee, price of materials and others
   ~₱30,000.00

- A set-up of 600W off-grid solar setup resulted in significant cost savings, calculated as follows:

1. Daily Energy Output:
   600 watts × 4.5 sunlight hours/day = 2700 Wh/day = 2.7 kWh/day
2. Average Annual Energy Production:
   2.7 kWh/day × 365 days = 985.5 kWh/year
3. Estimated Annual Savings:
   985.5 kWh/year × ₱12.00/kWh = ₱11,826.00
4. Payback Period:
   ₱56,550.00 ÷ ₱11,826.00 = 4.78 years

	annual energy output	estimated annual bill	total expense in 4.78 yrs
LANECO	127.75 kWh	₱1,624.72	₱37,766.16
SOLAR	985.5 kWh	₱11,826.00 (savings)	₱56,550.00 (initial cost)

Table 1

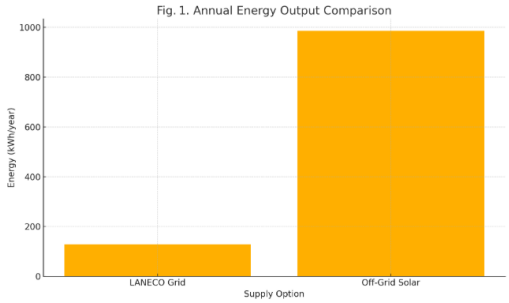

Fig. 1 demonstrates a ~7.7× increase in energy provided for solar houses.

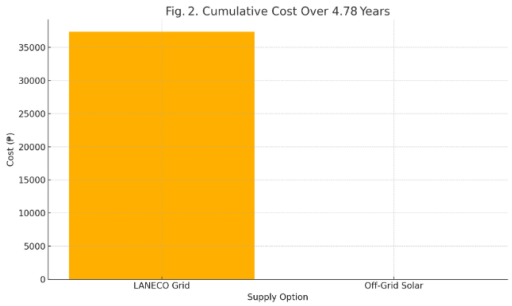

Fig.2

Fig.2 depicts that although solar has increased upfront cost, total grid expenses exceed ₱37,000 in approximately 5 years—before considering brownout losses or carbon footprint.

This study provides a comparative evaluation between an ordinary LANECO grid-connected dwelling system and a 600W off-grid solar system. The important performance indicators are in Table I and shown in Figures 1 and 2.

Table II — Extended Comparative Metrics: LANECO Grid vs. Off-Grid Solar

Metric	LANECO Grid	Off-Grid Solar (600W)
Energy Supplied per Peso (kWh/₱)	0.0043	0.0174
Annual CO_2 Emissions Avoided (kg/year)	0	~518
Energy Independence Rating (1–5 scale)	2	5

Metric	LANECO Grid	Off-Grid Solar (600W)
Average Monthly Outage Duration (hrs)	7.2	0 (Self-contained system)
Maintenance Complexity	Low (centralized)	Medium (panel + battery upkeep)

Energy Provided per Peso: Solar provides 0.0174 kWh per peso, while grid power provides only 0.0043—4 times more energy cost-efficient.

Carbon Emissions: Solar systems save ~518 kg CO_2/year per home, using average national emission factors.

Energy Independence: With a rating of 5 out of 5, olar energy enjoys resilience against LANECO's mean monthly outage duration of 7.2 hours.

These numbers affirm the long-term sustainability of decentralized solar as a climate-resilient and economic option in off-grid application.

D. Implications for Policy and Recommendations

The information highlights several strategic changes in the implementation of the Philippine Energy Plan:

1. Rationalizing Grid Compared to Solar Investments: Where topology and load render extension of the grid uneconomical, solar has to be the alternative, particularly if LCOE (Levelized Cost of Electricity) is below ₱6/kWh.

2. Reforming Cooperative Incentives: "Solar Empowerment Indices" must be included in cooperative performance audits by the NEA and ERC to encourage support for distributed generation.

3. Leveraging Global Climate Finance: Efforts like the ADB's sustainability-linked loans [7] must be taken to cooperatives so that blended finance models can de-risk solar loans.

4. Building Technical Capacity: TESDA-Skills Development Program should at once expand training facilities for Solar PV NC-II certification in Mindanao rural areas. Through the combination of technical information, financial reform, and public participation, the Philippine Energy Plan can best transition to a future of inclusive, affordable, and climate-compatible rural electrification.

4. CONCLUSION

This study discloses that despite nationwide policy blueprints like the Renewable Energy Act of 2008 and the Philippine Energy Plan 2020–2040 that promote the use of off-grid solar systems, their deployment in LANECO-franchised areas remains low and isolated. Household survey and technical assessment evidence shows that the cooperative's capital allocation priorities, the lack of local financial networks, and the unavailability of certified technicians are inhibiting the adoption of decentralized solar technology.

The contrast between grid-supplied electricity and a 600W off-grid solar PV system has convincing advantages in terms of energy output, long-term cost benefit, and carbon savings. Solar systems, in particular, deliver 7.7 times the energy per year, have a payback period of under five years, and save approximately 518 kg of CO_2 emissions annually per home. These results confirm that off-grid solar is not simply technologically possible but also economically and environmentally beneficial in such scenarios in much of the under-served rural world.

To support local policy performance in national electrification goals, the following are recommended in this research study: (1) enhance LGU–DOE–cooperative partnership on distributed energy projects; (2) implement micro-financing schemes designed for household-scale solar systems; and (3) incorporate solar literacy and technical training in community-based programs. These policy actions can facilitate inclusive, cost-affordable, and sustainable rural electrification in Lanao del Norte and other similarly underserved areas in the Philippines.

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