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Sustainability of PV System for Isolated and Fragmented Communities in Papua New Guinea

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Acknowledgement

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SUSTAINABILITY OF PV SYSTEM FOR ISOLATED AND FRAGMENTED COMMUNITIES IN PAPUA NEW GUINEA

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Abstract: The electricity accessibility in Papua New Guinea is one of the lowest with less than 15 percent of the population having access to electricity. Given over 80 percent of the population are subsistence farmers living in the rural areas compounded by the challenging topography of the country, extending electricity grid to these rural areas where some are very remote and isolated is not financially feasible. Nonetheless, the PNG Government is optimistic of electrifying over 70 percent of the populace by 2030 as envisaged in one of its Millennium Development Goals. The recently established Papua New Guinea Electrification Partnership under the APEC agreement will drive growth and development for many isolated and fragmented communities in the country through off-grid and grid connected electricity network. Off-grid electrification is more feasible by empowering rural communities to produce their own electricity through photovoltaic systems. The solar insolation in the country is 4-6 hours of sunlight all year around hence utilization of solar energy will not only benefit the rural communities but also contribute towards the global aspiration of promoting clean energy in the world thus alleviating impacts of climate change. Therefore, to accelerate electricity penetration in PNG requires collective input from all relevant stakeholders to support and empower the rural communities by providing necessary mechanisms and incentives so they become proactive partners in the development of off-grid electricity in the country.

Keywords: electricity accessibility, off-grid solar solution, solar insolation.

Presentation Outline

- ❑ Country Overview – Papua New Guinea
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- ❑ Challenges of Electricity Accessibility in PNG
- ❑ Indigenous Participation in the Energy Sector
- ❑ Basic Solar PV System Design and Implementation
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Country Overview – Papua New Guinea

Papua New Guinea	
	
Capital	Port Moresby
Region	East Asia & Pacific
Coordinates	9.30° S, 147.07° E
Total Area *(km²)*	462,840
Population	8,606,316 (2018)
Rural Population (% of total population)	87 (2018)
GDP *(current US$)*	23,431,596,214.01 (2018)
GDP Per Capita *(current US$)*	2,722.60 (2018)
Access to Electricity *(% of population)*	54.43 (2018)
Energy Imports Net *(% of energy use)*	no data
Fossil Fuel Energy Consumption *(% of total)*	no data
Source: World Bank	

- Over 800 indigenous languages
- 22 Provinces
- Abundant sources of natural resources; minerals, oil, gas, cocoa, coffee, copra, oil palm, etc.
- Abundant renewable energy sources; hydro, geothermal, solar, biomass, etc.

PNG Power System Overview

Source: PNG Power Limited National Power Development Plan 2019 – 2020

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INDEPENDENT CONSUMER & COMPETITION COMMISSION

PNG POWER Ltd

Department of Petroleum and Energy

PNG Power System Overview

GOAL	70% of households to have access to electricity by 2030
580MW	Total installed generation capacity
217,250MWh	Annual electricity generation
<13%	access to electricity

PROPOSED PROJECTS FOR INVESTMENT

- Policy, planning, and legislative framework – 80MW hydro project developed by Hydro PNG (IPP)
- Ramu 2 hydro PPP – 180MW project includes 30km long 132kV transmission line
- Port Moresby grid reinforcement
- Distribution network expansions
- Rural Electrification Programme
- District centres
- Subsidized solar household systems

Source: PACIFIC ENERGY COUNTRY PROFILES

- Access to clean, affordable and reliable energy has been a cornerstone for prosperity and economic growth in the beginning of industrial revolution.
- Despite having large energy resources, PNG suffers from low access to electricity, which limits opportunities for economic and social growth.
- Electricity access in rural areas is estimated to be under 3.7 percent.

Introduction

- Solar insolation in PNG is about 4-6 sunshine hours which is ample to generate electricity to meet rural household power requirements.
- Installation and maintenance of solar is simple, robust and reliable provided right design and application of storage systems.
- With basic training and awareness, solar based electricity is the way forward to improve electricity accessibility in PNG (especially rural areas).
- Solar has the potential to bring significant benefits to PNG Main Grids
- Displace expensive diesel generation at peak hours
- Reduce network losses, because of proximity to load
- In the longer-term, reduce burden of generation and network investments
- Reduce carbon emissions

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Emerging opportunity in off-grid solar lighting solutions (IFC)

- Average annual growth rate of 68% (market penetration increase from 2 to 60% of households)
- Current market US$259 million 60% of PNG households own off-grid solar lighting

"He mostly complained about doing his homework because he could not see clearly with the torch lights, which only worked for a short time," said Liferty.

"Because we used battery-operated torches, we would only let him spend less than an hour on his school work to save batteries for tomorrow's use. But now Norman is able to spend more time reading books under the lights, so we don't stop him."

Challenges of Electricity Accessibility in PNG

Challenging landscape and highly dispersed and diverse off-grid populations

Approximately 80 percent of PNG's population lives in small rural communities that are dispersed across the mountainous topography, which creates challenges for last-mile product distribution.

Market Structure

Monopoly in electricity service resulting in poor service at excessive cost. Open up electricity market and set reference pricing for energy.

Policy and Regulation

Institutional reforms required – roles and responsibilities of some energy departments not clearly defined rendering them ineffective in delivering government policies (MDG 2010 – 2030, 70 percent electricity cover, etc.)

Government Support

- Ad hoc government support in materializing plans and policy frameworks developed impedes electricity penetration.
- Lack of rural empowerment to indulge in electricity market.

Challenges of Electricity Accessibility in PNG

Environmental challenges

Salt and corrosion issues especially in coastal areas is a real challenge to maintain a robust system given lack of specific technical skills, knowledge, etc.

Access to skilled labour

Lack of trained solar installation specialists and electricians adds on to the challenge of extending electricity accessibility through off-grid PV solutions

Access to spare parts

Poor road conditions is a real nightmare in PNG. Some remoted rural areas are virtually isolated. Existing infrastructure in dilapidating states.

Poor telecommunication infrastructure

Poor communication network. PNG still catching up on digital infrastructure

Indigenous Participation in the Energy Sector

Communication and Information Technology and Energy Minister Sam Basil with PNG Chamber of Mines and Petroleum president Genia Acot at the energy policy dialogue and stakeholder workshop yesterday in Port Moresby.
– Picture courtesy of PNG Chamber of Mines and Petroleum

Basil wants energy authority to give power to all

June 8, 2018 The National Business

Article Views: 1,519

By LEMUEL LIGUNI

The proposed National Energy Authority will ensure that people in rural areas have access to affordable energy and landowners of future energy projects receive real benefits, says Energy Minister Sam Basil.

He said the authority was still a bill and would be proposed to Parliament after proper consultation with stakeholders in the energy industry.

Basil said this after the energy policy dialogue and stakeholder workshop hosted by the PNG Chamber of Mines and Petroleum in Port Moresby yesterday.

He said a core focus area for the authority would be to include landowners in energy projects and to achieve Government's target of providing electricity to 70 per cent of people in rural areas.

"Less than 15 per cent of people in PNG have access to electricity," Basil said.

"One of the objectives of the authority will be to ensure villages with power grid lines running through them have access to power.

"For rural areas where land is made available for hydro or wind generation for electricity we want to make sure landowners of these project areas are included."

Energy policy working group chairman Rowan Gabut said the authority would ensure landowners were given benefits similar to those in the petroleum industry. He said this would include 2 per cent royalty and up to 5 per cent equity benefit stakes in energy projects.

Gabut said other key areas included having the minister's support to drive the industry and for the Independent Consumer and Competition Commission (ICCC) to work closely with the authority.

He said ICCC's role was important to ensure reliable companies were given licenses to produce power for rural areas.

Gabut said the authority would also look at licensing downstream petroleum activities such as service stations and bottled gas retailers.

Basil said there are potential for dams in Northern and Central to produce hydro-electricity.

He said with the increasing demand for electricity from mining projects, plans for a dam at the head waters of the Purari River in Gulf may be possible in the near future.

PNG NATIONAL ENERGY POLICY 2018 – 2028

- *The Government recognizes that it is of crucial importance to promote and encourage citizens and national participation in the development of energy resources, downstream processing of energy sources, domestic market obligations of energy developers, rehabilitation of projects and the adequate human resourcing of energy projects.*

- The policy document;
  - ✓ aims to support the development of a modern, more renewable-energy based system.
  - ✓ establishing designated National Energy Authority, Energy Regulatory Commission, formulation of a Renewable Energy Policy, the unbundling of PNG Power Limited, and net metering tariffs for electricity generated from RE sources.
  - ✓ proposes new financing incentives to attract IPPs. Electricity Trust Fund (discussion open).

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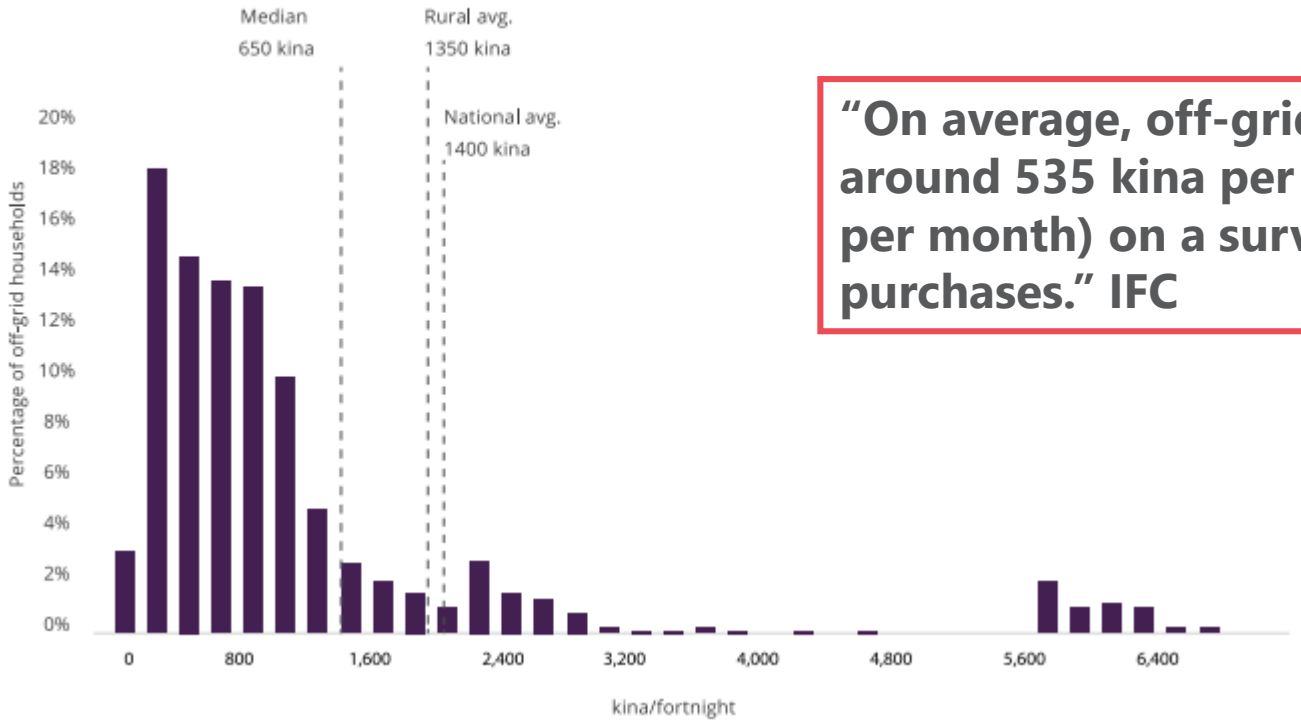
Indigenous Participation in the Energy Sector

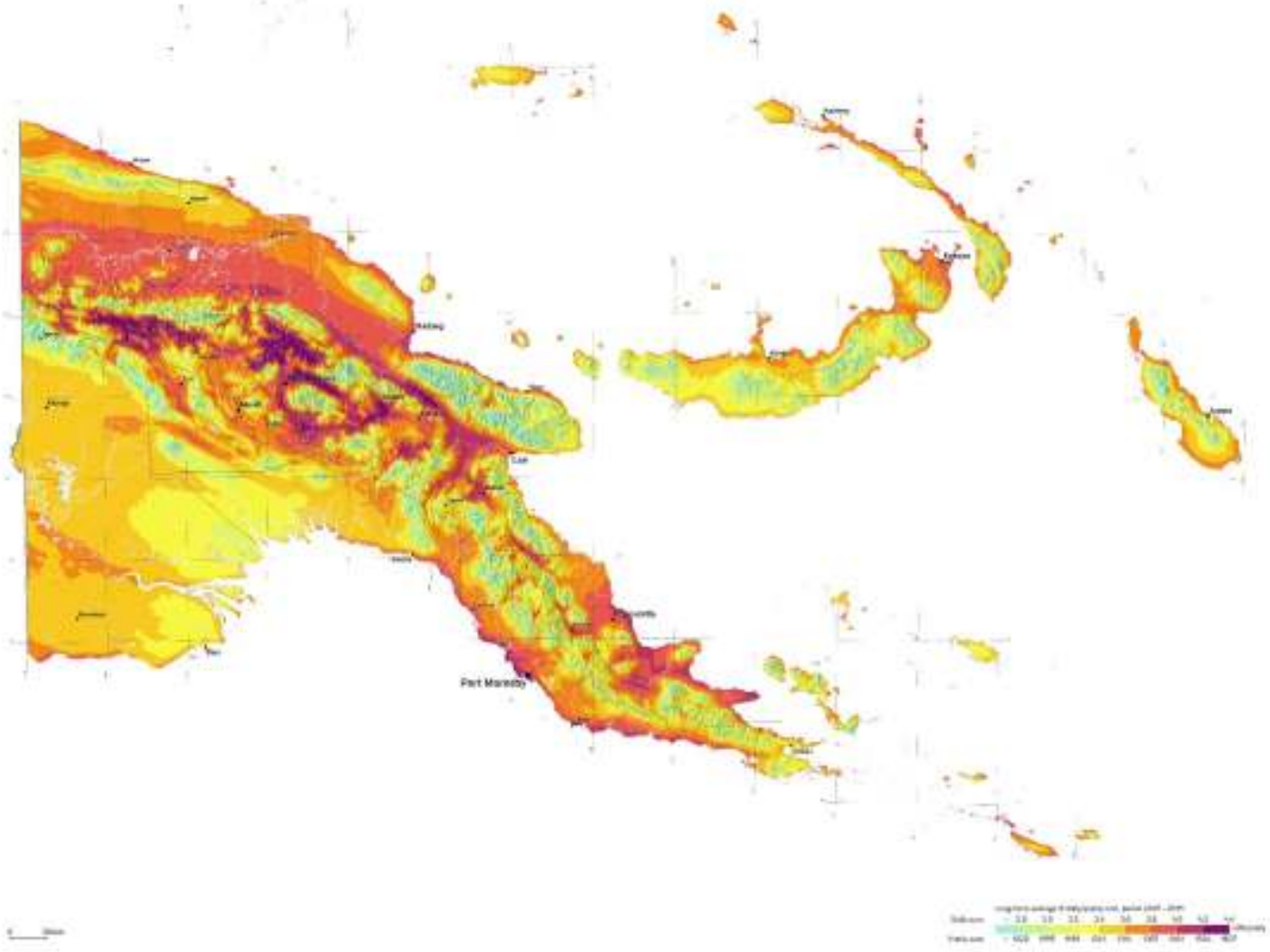
Figure 5 Household income distribution in rural PNG (in kina per fortnight, 2018)[43]



"On average, off-grid households spend around 535 kina per fortnight (about $329 per month) on a surveyed bundle of typical purchases." IFC

- ❑ Off-Grid solar PV system is the most cost-effective solution for a significant proportion of people lacking electricity access.
- ❑ There is an emerging opportunity to provide clean, sustainable and affordable off-grid solar solutions to under-served and off-grid energy consumers in PNG through quality 'pico- micro-powered PV systems' (PM-PVS).
- ❑ PV-Thermal (Fuel) hybrid System for Small Load Townships
- ❑ Micro-grid PV/Wind/Micro-hydro systems for Local Level Government (LLG) Centres

Basic Solar PV System Design and Implementation



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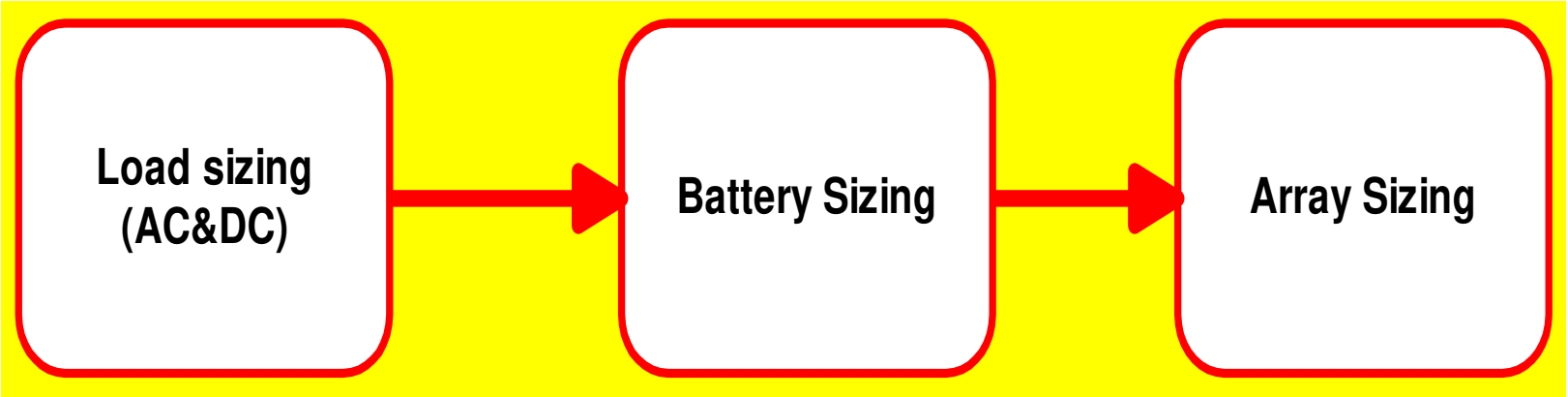
- PV evenly distributed throughout the year with diurnal variation.
- Good to very good PV Resource conditions
- Rather evenly distributed throughout the country
- Solar PV system sets to increasingly drive most of the electrical systems particularly in rural areas.

Basic Solar PV System Design and Implementation

Sizing Principles

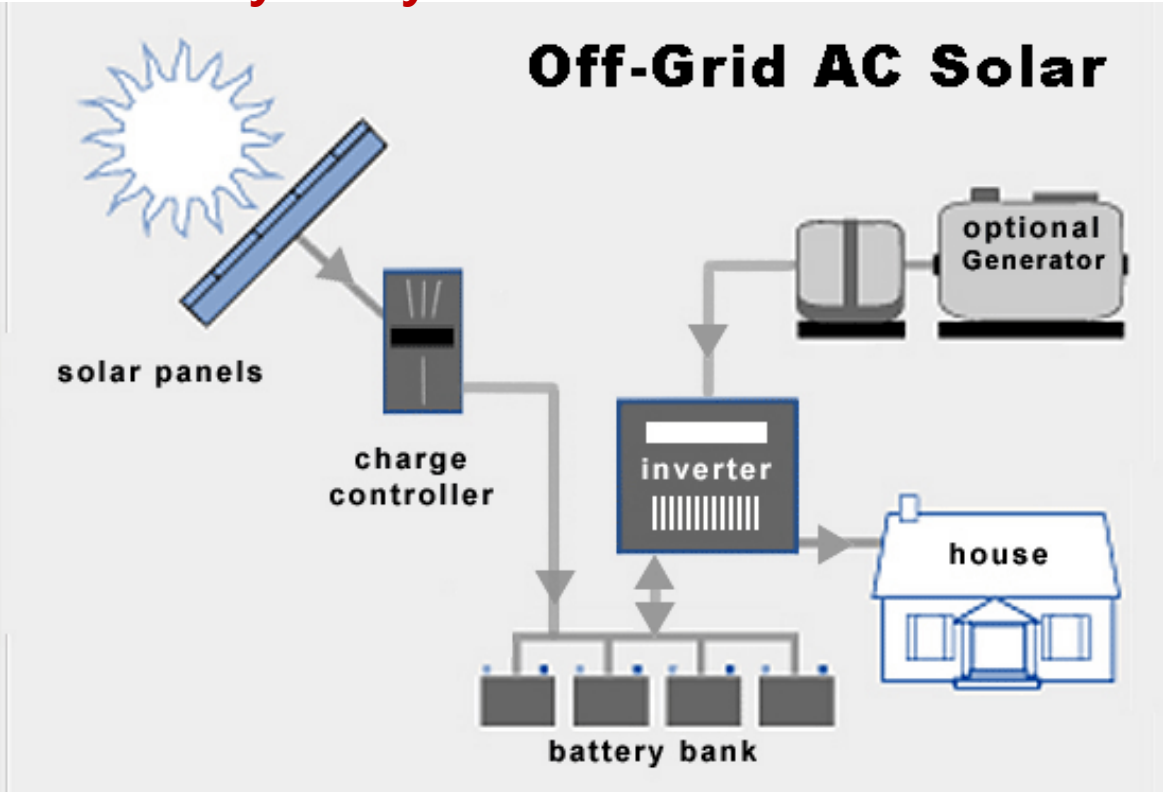
- The sizing principles for interactive and stand-alone PV systems are based on different design and functional requirements.



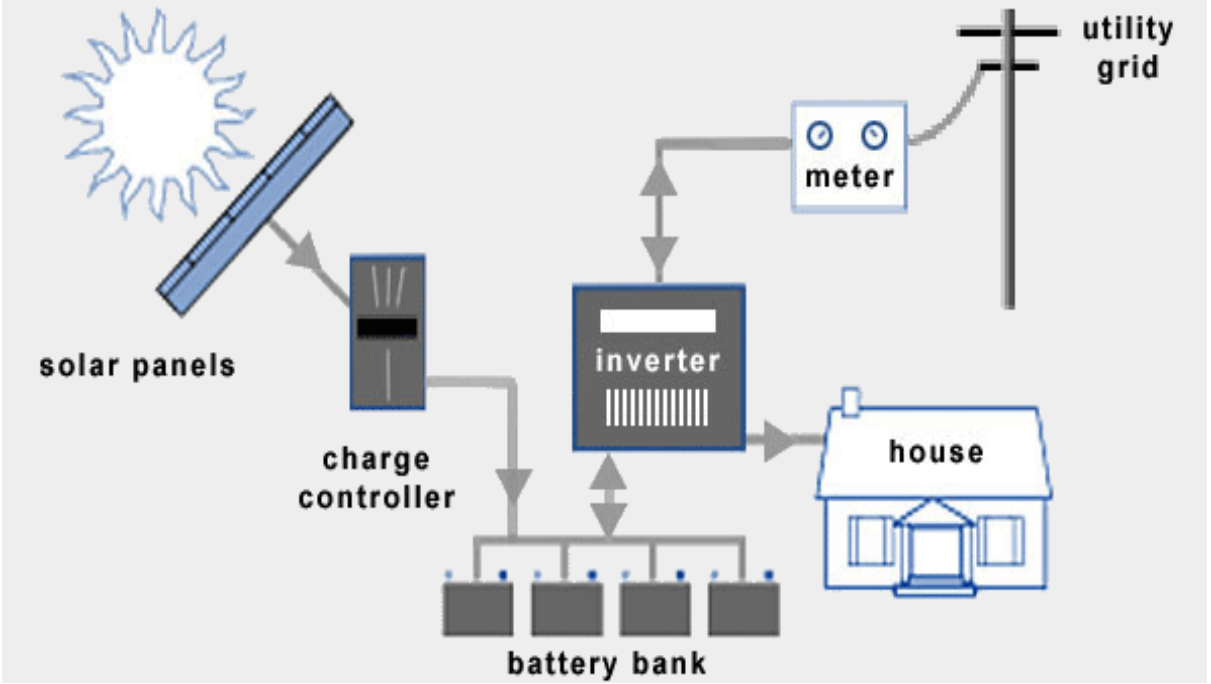
- Load influences every aspect of PV systems.
- Load profile must be accurately determined.
- Duty cycle or hours of operation for intermittent loads must be estimated correctly.

Basic Solar PV System Design and Implementation

Solar PV hybrid system



Grid-connected solar PV system



- Ability to sell power to the grid
- The inverter must meet standards
- Voltage, frequency, and phase must be within limits specified in IEEE1547.
- Output current harmonics - Current harmonics has to be filtered. Must be within limits specified in IEEE1547

Basic Solar PV System Design and Implementation

Table 2: Typical wattage requirements (the ratings are only estimates)

Appliance	Quantity	Rating (W)	Usage (h)	Wh/day each	Total Wh/day
Light	3	40	4	160	480
Cell-phone Charging	5	13	3	39	195
TV	1	60	4	240	240
Others	1	100	2	200	200
Total	**10**	213			**1115**

(i) 3x 18W Lights used for 4 hours daily;

$n_1 := 3 \quad P_1 := 40W \quad T_1 := 4hr$

$E_1 := n_1 \cdot P_1 \cdot T_1$

$E_1 = 1.728M \cdot J$ or $480 \frac{Wh}{day}$

The total energy requirement for a typical rural household is therefore;

$E_T := E_1 + E_2 + E_3 + E_4 \quad E_T = 3.996M \cdot J$ or

$E_T = 480W \cdot hr + 195W \cdot hr + 240W \cdot hr + 200W \cdot hr$

$E_T = 1115W \cdot \frac{hr}{day}$

Table 3: Cost estimate for a solar PV system for a typical rural area in PNG

Component	Quantity	Unit Cost (K)	Total (K)
250W Module	1	900	900
45MPPT-Regulator	1	2000	2000
300W Inverter	1	700	700
12V-100Ah Batteries	3	200	600
Ancillary Equipment, CBs, Fuses, Wirings, Connectors, tools, lugs, etc.	1	2500	2500
Sub-Total			**K6,700.00**
GST	10%		K670.00
Grand Total			**K7,370.00**

- Initial upfront (capital) cost is substantial as expected however, considering return on investment and other benefits this system brings, it is worth the spent.

- PNG Government to provide incentives and mechanisms to facilitate a conducive market for the people to embark in such undertakings with the purpose to improve their living standards.
- With large distances separating villages from urban areas becoming a disincentive to investment in energy transportation and grid extension to these areas, it is absolutely vital that the government seriously indulge all relevant stakeholders including private sectors if PNG is truly to achieve 70 percent electrification by 2030.

Socio-economic Impacts

Household savings

- Fuel cost have increased substantially (30%) in recent past. Off-grid solar lighting and solar PV systems could make significant household savings

National Savings

- As off-grid solar markets continue to grow, there will be a positive impact on the balance of payment and on foreign exchange reserves, as the import of batteries, torches, and candles are replaced by off-grid solar.

Education

- 38% of population aged 8 and older are not able to read and write, and in addition illiteracy rates are even higher in the Highlands (47%) and Momase (40%).
- The quality of learning in rural areas who do not have access to lighting for further studies during the night is quite low compared to age group of the same who have access to light. Teachers also need good lighting to prepare proper lessons plan.
- Access to clean, safe light helps students to study for an extra hour a night. If pupils have access to solar lights, head teachers report improvements in performance, attendance and motivation.

Health, Safety & Wellbeing

- Health implications of fuel-based lighting are two-fold: chronic illness due to indoor air pollution, and risk of injury due to the flammable nature of the fuels used. Kerosene lamps emit fine particles that are a major source of air pollution. These particles quickly become lodged in the bronchial system and can result in chronic disease and death.
- Solar lights reduce these detrimental health implications and provide clean and safe lighting environment.
- Solar lights also reduce the risk of fire and accidents and improve safety and security.
- With safer and brighter homes, children studying better at school and with more income available, families have a better quality of life.

Future Collaborations

Key areas needing assistance

1. Regulatory frameworks for off-grid renewable energy (RE)

- Legal and licensing framework
- Cost recovery and tariff regulation
- Grid interconnection/arrival of the grid
- Financial support for mini-grids
- Quality standards

2. Expanding the market base for off-grid RE solutions

- Pay-as-you-go model
- Government Trust Fund
- Road infrastructure
- Improving basic government services in rural areas
- Import exemptions (Tighten up compliance and vigilance on fake products)

Challenges

- Safety and security
- Road network
- Stimulating the demand in rural areas

Summary

- Electricity accessibility in PNG is one of the lowest in the world and the penetration level is moving at a snail's pace.
- Challenges faced include rugged mountainous topography, lack of government will and support to push the policies and aspirations to fruitions, and vertical market structure where monopoly in the power sector result in ineffective service and higher cost.
- Renewables in PNG is abundant but translating them for economic growth and prosperity still remains a challenge for PNG Government and people.

- Solar based electricity generations is a way forward for an accelerated electricity penetration because it is simple technology, easy to set up and maintain and is affordable provided government facilitates incentives and subsidies.
- Empowering of rural people to generate their own electricity through solar PV systems will see a paradigm shift and people's standard of living thus stimulating economic growth and live enrichment.

Thank You

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