Developing A Renewable Energy-based Off-Grid Electrification Master Plan for Remote Islands of Vanuatu along the Example of Four Islands

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Review Workshop

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Session 4: Recommended Institutional Arrangements & Financing

Policies & Regulatory Framework for Rural Electrification

1) Role of Department of Energy (and Meteo)
2) Role of the Utilities Regulatory Agency
3) Roles of Other Key GoV Ministries & Private Sector
4) **Gaps in Vanuatu's Existing Framework for Renewable Energy**

We'll skip 1) – 3) & concentrate on 4) above

Gaps in Vanuatu's Existing Framework for Renewable Energy

1) **World Bank survey** (2014) ranked Vanuatu poorly:

- planning for RE expansion
- legal framework
  (no formal mandate for DoE from COM or PSC)
- regulatory policies
- network connection and pricing
- public financial support, and
- difficulty of starting a new RE project

	RENEWABLE ENERGY	
Planning		Poor
Policies and Regulations		Poor
Pricing and Subsidies		Medium
Procedural Efficiency		Poor

Vanuatu's Perceived Readiness for RE
(WB 2014)

2) IRENA RRA: Renewables Readiness Assessment (2015):

- **Legislation URA & DoE** on authority & responsibilities
- No **off-grid market study** of probable market for RE mini-grids for tourism
- **Limited capacity** (or **training**) in GoV & private sector to sustain RE benefits
- Poor RE **data** acquisition, analysis and management
- No use of excellent free **software** to develop RE
  (e.g.: RETScreen© for RE technology HOMER© for mini-grids)
- Little use of **experience** in PICs or lessons from Vanuatu projects.
- No standard, **modular design** (solar home systems; RE mini-grids adaptable to wide range of requirements
  (minimizes spare parts & training needs; reduces installation & expansion costs)

The reports address all of these but can't cover all in a short workshop

Suitable Institutional Arrangements Depend on Magnitude of Electrification Effort

- *Updated NERM: 2016-2030:* **access** to affordable electricity to all Vanuatu citizens by 2030 (but **affordability** criteria not defined or explained)
- Magnitude depends on assumptions about: **Assume**:

▪ urban and rural household growth	2% urban (WB); 1.8% rural
▪ number of *on-grid* households connected by 2030	NERM goals met
▪ Lifetime of existing and planned off-grid RE	Long life for ‘pico-solar’ (VERD 1) *but unlikely*
▪ Islands/household considered to be ‘remote’	All incl. rural Santo
▪ the definition of electrification	Include pico-solar

Crude estimate is **16,200 households from 2017-2030** ***but could be much larger***

- Average of 1,250 per year — More likely to begin in 2018

Business Model for Remote Island Renewables-based RE

- **Assessments, feasibility & design** met by the GoV (donor grants & loans; local sources)
- Capital costs for **households:** met by the GoV (donor & local resources)
- Capital costs for **businesses** (e.g. bungalows): owners would pay (**what %**?).
- **Installation** costs: households contribute a portion
- **O&M**: households pay through periodic user fee
  (held for periodic replacement of components & to pay island-based technicians)
- User fee changes if O&M costs change (e.g. inflation)
  (**Fees set independently**, preferably by URA and DoE)
- **Private investment: li**kely for main grids (concessions); unlikely for remote off-grid.
- **Collection of fees**: not collected at village or by GoV; probably through mobile phone

Institutional Models

- The RESCO Model — no likely candidates in Vanuatu
- The NAMA Model — Poor PIC experience with community mgt
- Direct Government Management — Poor PIC experience for remote islands
- National Power Utility — OK for big complex RE (e.g. biofuel)
- National Renewable Energy Utility — Worked in Kiribati (Govt company)
- Regional Renewable Energy Utility — Best success in Ha’apai islands, Tonga
  (Joint National Govt, regional Govt & Community Mgt)
- Recommended Management Model — Modified Ha’apai model
  (for the 4 specific islands)

Regional Renewable Energy Utility

Based on: Ha’apai Outer Islands Solar Electricity Society, Tonga

- Multilevel management &oversight committee
- Consumers apply for PV service (pay installation fee & monthly fee = O&M costs)
- Fee set by utility – no meters (Vanuatu; recommend URA + DOE)
- Managed from district administrative center (manager, annual training, audited spare parts)
- Technicians (2+) at village or island (paid from fees; eventual SEIAPI certification)
- Revenues kept in utility bank account (Vanuatu: mobile phone payment option)
- Utility owns system (replaces panels, batteries & controllers)
- Used batteries collected (export & recycling)
- Strict disconnection (if non-payment after 2 months)
- Annual meeting of utility, local committee & % DoE (review fees, management, technician performance)
- Flexibility: consumer can get bigger system (but monthly fee increases too)

Role of the Department of Energy
(for off-grid RE-based electrification)

Formalize current *de facto* responsibilities:

- Strategic direction of energy development
- Planning, policy, funding proposals, facilitation and oversight
- Use external organizations for supply, installation & maintenance
  (‘private sector’ = SOE, RE utility, UNELCO, VUI, others)
- **Help address the gaps**: mandate, responsibilities, enforced standards, training etc.

Financing Mechanisms

General (primarily loan finance)

- Financial Mechanisms for Clean Energy for SIDS (ESMAP, 2015)
- Financing Green Energy in Developing Countries (GIZ, 2015)

Specific:

- The Vanuatu National **Green Energy Fund** (but not until early 2018?)
- Vanuatu Rural Electrification Program: **VREP phase 2** (possibly US$4 million)
- Private Sector (co-finance) (likely for grid-connected only?)
- Green Climate Fund (potentially highly significant)

Financing Requirements? Initial Rough Estimate

- 4 islands quickly surveyed: insufficient to cost national RE-based off-grid electrification
- Estimated program for 16,200 off-grid households
- From ***limited*** household survey sample (but also usage in Tanna, Malekula, Port Olry):
  - vast majority expected to use ≤ 1 kWh/hh/day & ***reported*** WTP << mini-grid O&M cost (solar home system sufficient; pico-solar often enough)
  - solar mini-grid O&M cost may be justified if consumption ≥ 2 kWh/hh/day
- With WB SREP data (Oct 2014), assuming 16,000 SHS & 300 solar mini-grids (grids for schools, clinics, admin and productive purposes e.g. businesses)
  - Initial capital cost: roughly US$33 million
  - Designs, institutional development, travel, O&M contracts, salaries, etc. Well over US$1m/year x 14: at least US$ 14 million
  - Contingencies, say: US$ 3 million

Final report will have more detailed costs for the 4 islands

> US$ 50 million

Payment of Users' Fees

Key sustainability issue: lack of reliable system so users consistently pay user's fee for O&M costs:

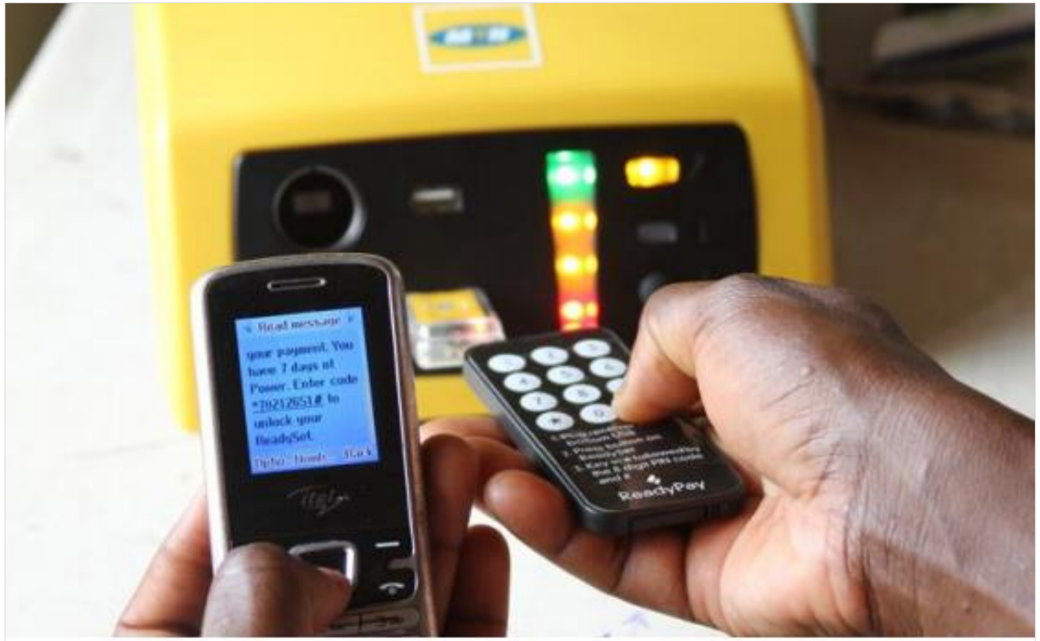
- fee provides funds for routine basic maintenance by village technicians
- fee creates financial reserve for components that *will* require replacement

Mechanism should:

- Set & maintain fee that recovers O&M costs (including battery replacement for PV)
- Independent mechanism to set fees (URA?) & adjust for inflation
- Removes from the community fee collection & decision to cut-off service to those who do not pay; and
- Avoids use of DC pre-payment meters (history of failure)

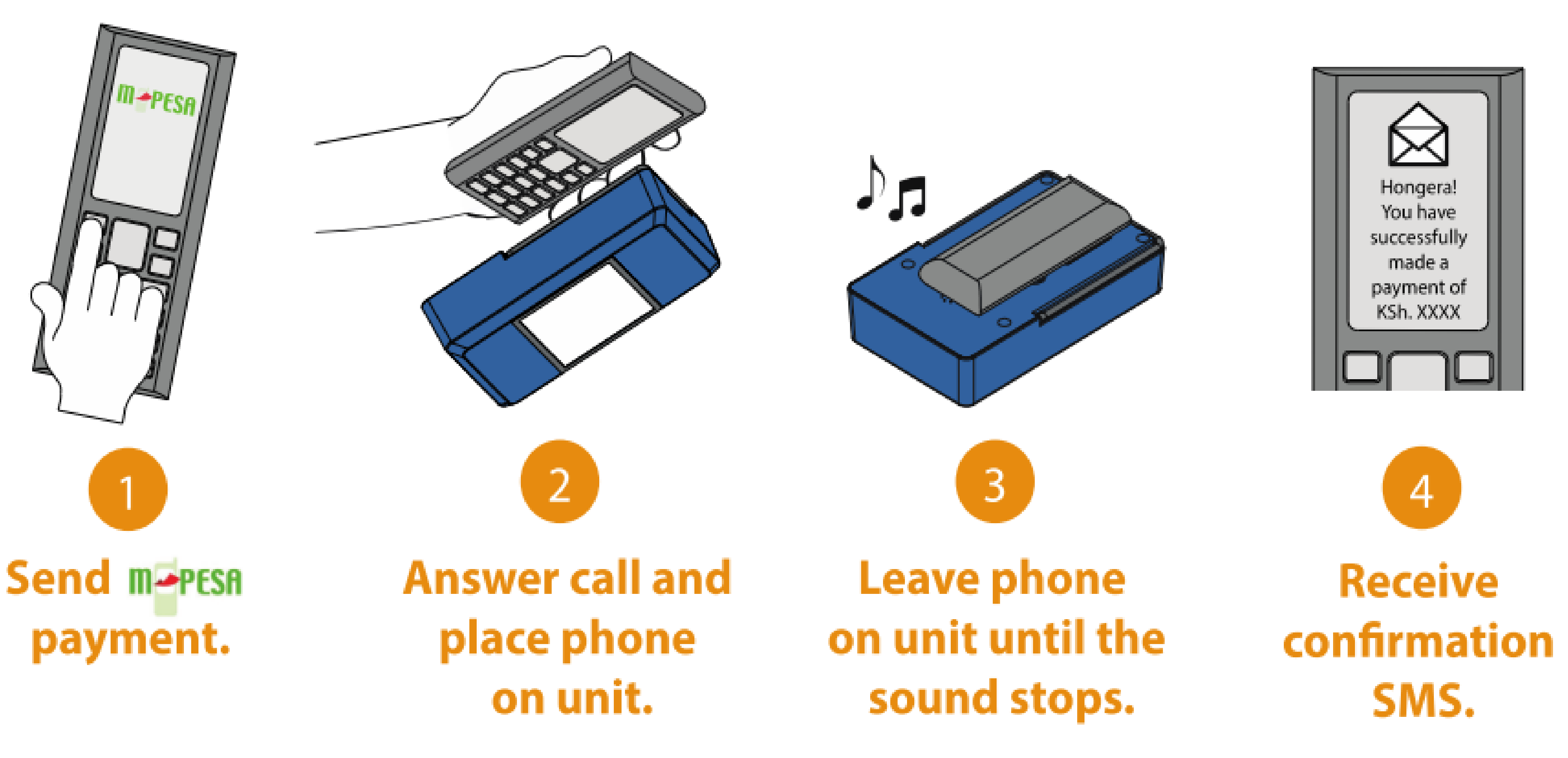
Payment through mobile phone recommended

- Vanuatu unique among PICs: large remote off-grid rural population with high mobile phone coverage
- Mobile phones used elsewhere; just beginning trials in PICs
- 25+ companies in Africa, Asia, Latin America support pre-pay solar energy
- Three basic components:
  - customer payments by mobile money or proof-of-payment codes sent by SMS
  - hardware ties energy use to payment
  - software processes payments & communicates with RE system, customers and agents
- **Can allow remote monitoring (usage; problems)**



Unlocking the Fenix 'ReadyPay' product (Fenix International, Inc.)

PV payment through Mobile Phone & Handheld Receiver



Loading proof-of-payment to the SoLite3 product (Angaza Design, Inc.)

Tangkiu Tumas

SUPPLEMENTARY MATERIALS

(Use if questions arise but not suited for projector display)

1) Activities that DoE should carry out support or arrange for RE

2) Overview of recommended solar technologies

1) DoE should support, carry out or arrange the following:

- obtain formal mandate for DoE from PSC or COM
- review legislation on authority / responsibilities of DoE & URA for off-grid electrification (and if necessary, update)
- independent study of staffing & financial resources to effectively implement off-grid electrification (for DoE & implementing authorities)
- Develop standard modular designs for robust climate-resilient and flexible SHS and solar mini-grids (later other RE)
- Work within GoV for endorsement & enforcement of standards
  (to be required for *all* future remote RE initiatives - donor, utility, NGO or GoV)
- Work with Vanuatu Institute of Technology (etc.) & arrange development of courses for RE system installers & maintenance technicians
- Support VIT (etc) to conducting RE training courses in Bislama for village technicians (operations, basic maintenance)
- Capacity building for staff in data acquisition, analysis &data management; develop & maintain up-to-date RE database
- Training (e.g. USP) in RETScreen® & HOMER
- Require certification of ni-Vanuatu in remote RE system installation
- Standard contract formats with clearly-described requirements of contractors, and the responsibilities of the GoV or the implementing organization, for the implementation and sustainable O&M of RE systems
- Working with the, develop (with URA & MFEM) appropriate legal framework for off-grid RE
  (including policies & regulations for user fees)
- Arrange assessment of off-grid market for RE for tourism facilities

2) Overview of recommended solar technologies

Key criteria:		**Determines**:
• Energy demand:	likely daily kWh load	type of installation (pico, SHS, grid)
• Power demand	kW	capacity kW peak to deliver the load

Technology decision needs to be made **individually** for each household depending on needs, willingness to pay and size of the overall village load

Mini-grid	Conventional 230 VAC delivered through a village scale grid
Micro-grid	230 VAC for school or office; short connections to nearby buildings
Solar Home System	Larger panel & batteries for DC or AC to single home or building
Pico-solar	Packaged kit, 5-30 Wp panel, pre-wired LED lights, phone charging

Characteristics of Pico-solar kits

- Purchased by hh (with subsidy?); no added cost until system fails (typically 2-3 years)
- Lighting quality basic (low wattage: barely see to get around the room) to very good (lights OK to read newspaper reading & school studies)
- Portable: lights can be moved room to room; sometimes outside too
- Ports (sometimes) to charge phones or tablets for charging; connect small battery operated radio
- Lifetime (with daily use) 2-3 years; new battery unavailable or costs > new pico-solar
  Effective monthly cost of 300 – 500 vatu (unsubsidized)
- Sizes available up to around 0.1 kWh/month of lighting and phone charging services.
- Failure affects only one household.

Characteristics of Solar Home System

Suitable for general household electricity (basic high quality lighting) up to major appliances (e.g. freezer)

- ~ 75 watts to >1 kW Most 100 - 300 Wp
- Cost effective from 0.2 to 60 kWh/month. Capacity fixed; Not easily or inexpensively expanded
- Typically 12V, 24V or 48V DC depending on system size &household needs)
  Can easily power AC appliances using separate inverter
- PV panel & battery permanently installed. Not a portable system
  (but can charge battery operated portable equipment: torches & power tools)
- Local trained village technician needs to be available for service a few times a year.
- Battery life from 5 to > 10 years. Depends on battery quality, usage patterns and
  regular preventive maintenance.
- O&M small system **~ 700 Vt /per month (basic lighting).** Increases as more services added.
- Cost effective for loads consistent from day to day (most households).
  - Most expensive for night-time use (power is from battery)
  - Somewhat cheaper with mostly day-time loads (e.g. most offices and schools):
    PV panels directly supply most loads (energy not from battery)
- Failure affects only one household.

Characteristics of Solar Mini-Grids

Single PV installation supplying a village, typically including most HHs, commercial & Govt facilities

- Expensive village grid to connect PV power source to each building served. (but 10kW PV grid for 20 homes (lights) little cheaper than 100 kW system for urban scale electrification to same homes).
- Dedicated building to safely house inverters & batteries (High ambient T → high O&M & lifecycle)
- Typically delivers 230 VAC; 50 HZ (therefore subject to new URA wiring rules?)
- Cost effective within 500m from PV. Longer range expensive: larger distribution wire size; or higher transmission voltage & step-down transformers)
- Village technicians for general O&M for battery voltage 48V DC & distribution voltage 240V AC. (Higher voltages require equipment & training not suited for village technician; external support costly)
- Cost effective for variety of loads occurring at different times (lower MD than simultaneous loads)
- Most cost effective for mostly day-time loads (e.g. most offices & businesses)
- Allows intermittent use of high-demand relatively low energy equipment (AC power tools; small kitchen appliances) which need costly inverter for SHS
- Failure affects **all** households
- Battery capacity shared among all users: potential for conflict, especially if PV undersized.
- Require land for power house & PV panels located without shade
- Rights-of-way usually needed for power distribution through land belonging to multiple owners

Characteristics of Solar Micro-Grids

Provides full 240 VAC mains quality power to a single facility: large home, school or office.

- Each micro-grid is a single customer: no shared resources as with mini-grid.
- No interconnecting grid is required except nearby buildings of same facility
- Suited to daytime loads (direct use of the electricity from PV) avoiding energy losses through battery.
- Best suited to loads reasonably consistent day-to-day (Both energy and demand capacity sized to fit facility's needs and provide reliable power.
- Well suited to facilities that need very high-reliability power supply: designs can incorporate inverter redundancy & excess battery capacity