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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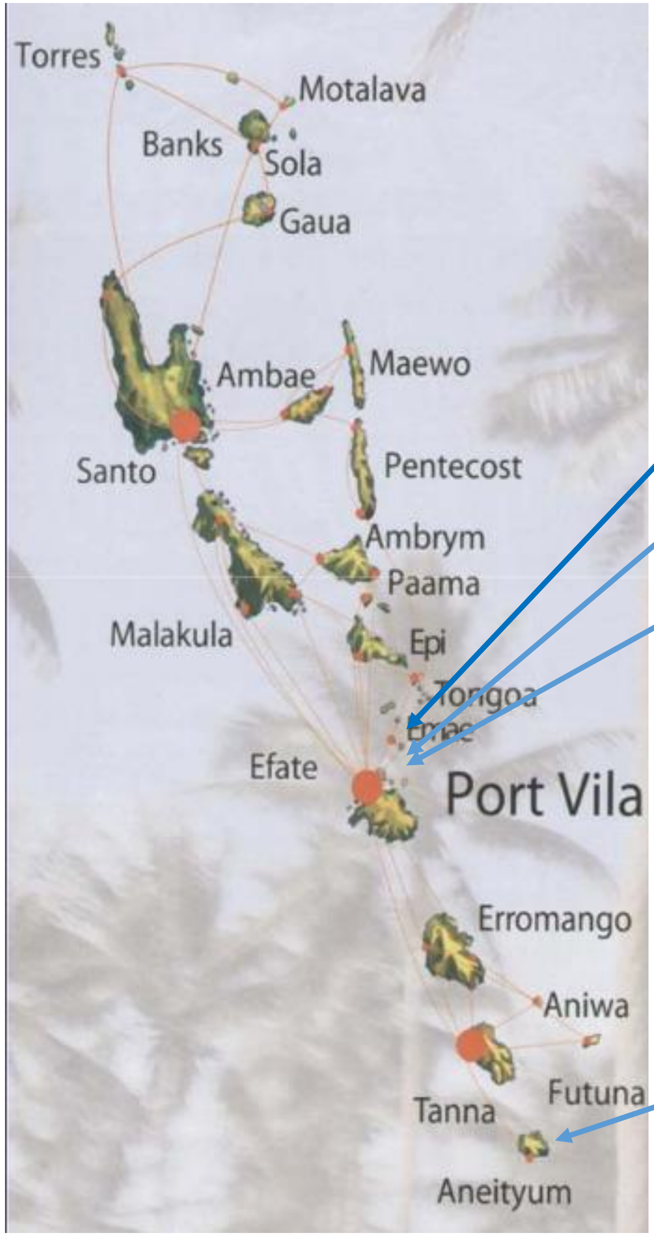
Session 3: Renewable Energy Resources & Technology Options



Only four islands visited.
Representative of remote Vanuatu?

Emae

Makira

Mataso

Aneityum

Two tasks:

1) Preliminary Design for the 4 islands
2) 'Masterplan' for remote off-grid locations

Six reports:

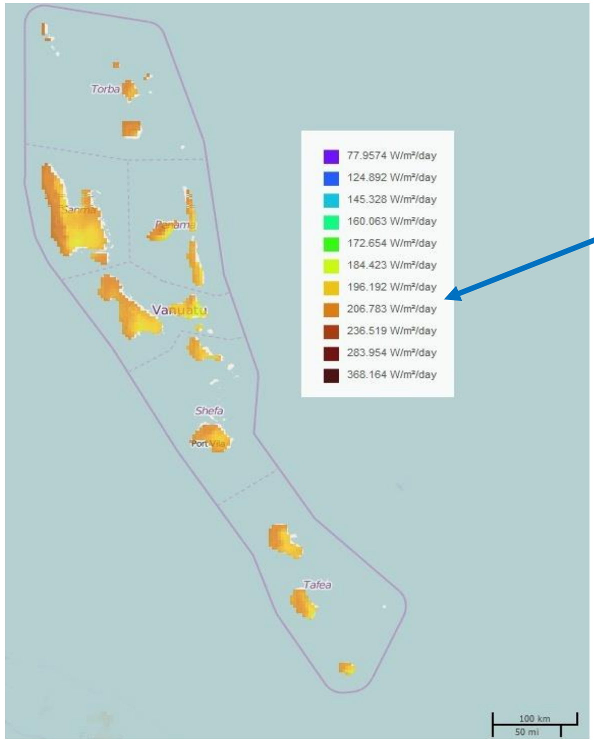
1) Inception Report (April)
2) Site visits & household surveys
3) RE resources & suitable technologies
4) Preliminary technical design
5) Institutional arrangement & financing
6) 'Master Plan' and Final Report

All (soon) available for download at DropBox

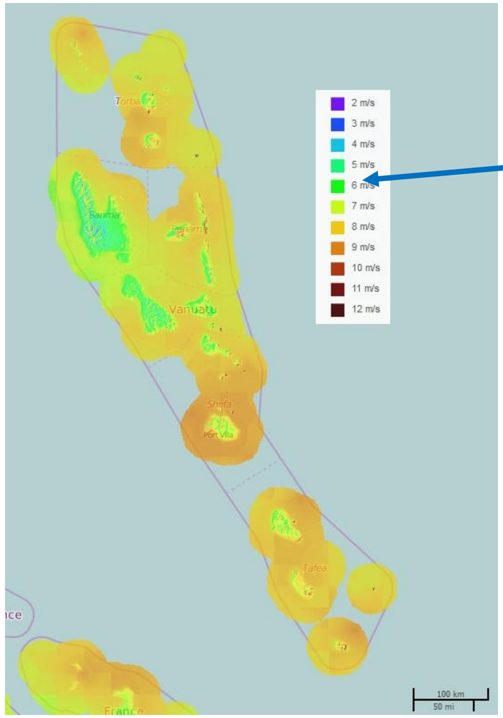
How to measure available renewable energy resource?

Data accurate & suitable for project design?	Solar versus wind
Value compared to other uses of the resource?	Copra/coconut oil for biofuel
Accessible to location with energy need?	Biomass, hydro, wind, copra
Transport to power plant?	Biomass, coconut oil
Landowners willing to sell or provide access?	Biomass, coconut, hydro
Susceptible to cyclone damage?	microhydro, coconuts, seawave
Suitable for small-scale rural electricity generation?	Geothermal, seawave, ocean thermal: NO

Vanuatu's solar and wind energy resource



About 200 watts/m^2/day



6 m/s average

Obstructions reduce wind speed by distance of 10-20 x obstacle height

Solar energy: good throughout Vanuatu

Indicative only, depends on cloud cover, tree shading, season, etc.

High energy input 10am-4 pm

Wind energy: OK but <u>very</u> site specific

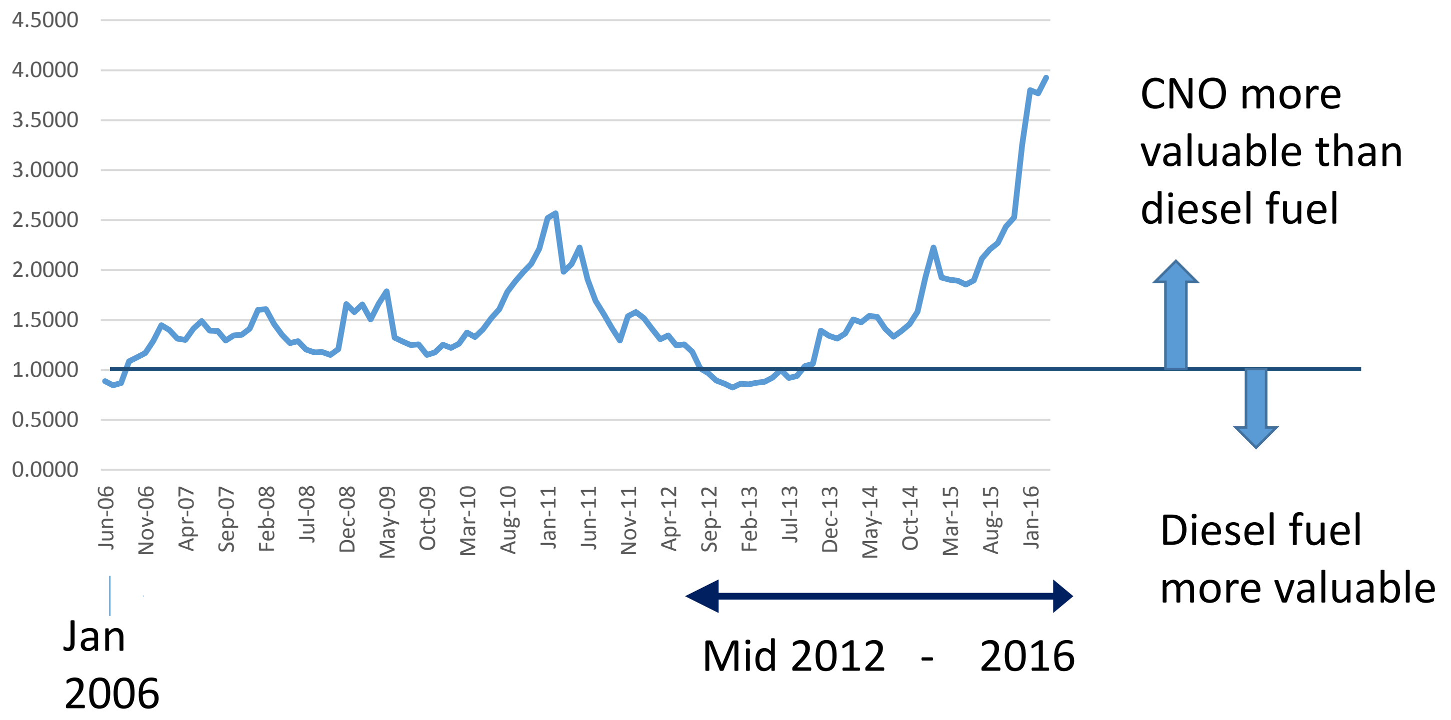
Broadly favourable (6 m/s) (**Aneityum good**)

Very site specific: 20% less wind → 73% less energy

6 wind monitoring stations: but where are the data?

Vanuatu's Biofuel Resource

Relative value of coconut oil vs diesel fuel:



Copra oil:

< 10% of land under coconut trees but excellent resource on some islands

Poor data by island on:

- Available resource
- Quantity economical to harvest
- Relative value of CNO versus fuel locally

Mini- Micro-hydro:

- Good technical potential for run-of-river
  (Often large seasonal variation)
- Water flow assessed at only a few sites
- Very vulnerable to damage during cyclone passage
  (Flow can be 100-1000 times normal)
- Source often far from village (therefore expensive)

Stream near Anelghowat, Aneityum

Biomass:

- Substantial potential from plantation waste – when trees mature
- No resource measurement since 2000
- Land disputes hamper development

Small-scale Renewable Energy Potential

	Solar	Wind	Biofuel	Microhydro
Emae	Yes	?	In 7+ years?	No
Makira	Yes	?	No	No
Mataso	Yes	?	No	No
Aneityum	Yes	Yes	No	Possibly but

Criteria for Preliminary Technical Designs

1) Climate Change and Natural Disaster Resilience
2) Consistency with Utilities Regulatory Authority Decisions (e.g. AC service and house wiring; user fees)
3) Consistency with Government of Vanuatu Regulations (e.g. battery disposal)
4) Component Reliability, Availability, Standardization & Capacity for Local O&M
5) Consistency with Government of Vanuatu Energy Sector Policies (e.g. Updated NERM: 2016-2030)
6) PV (and forthcoming) Guidelines: Sustainable Energy Industry Association of the Pacific Islands
7) Consistency with Electricity Demand Patterns (expected initial kWh/m & likely growth)
8) Lifetime Cost (e.g. higher initial cost → lower long-term costs & improved sustainability)

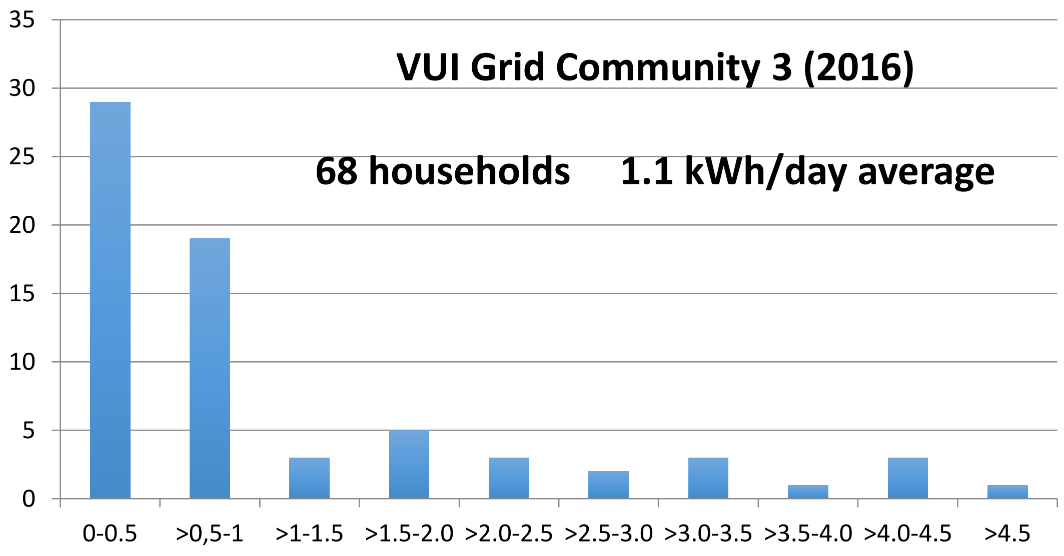
Suitable energy technology depends on energy demand:

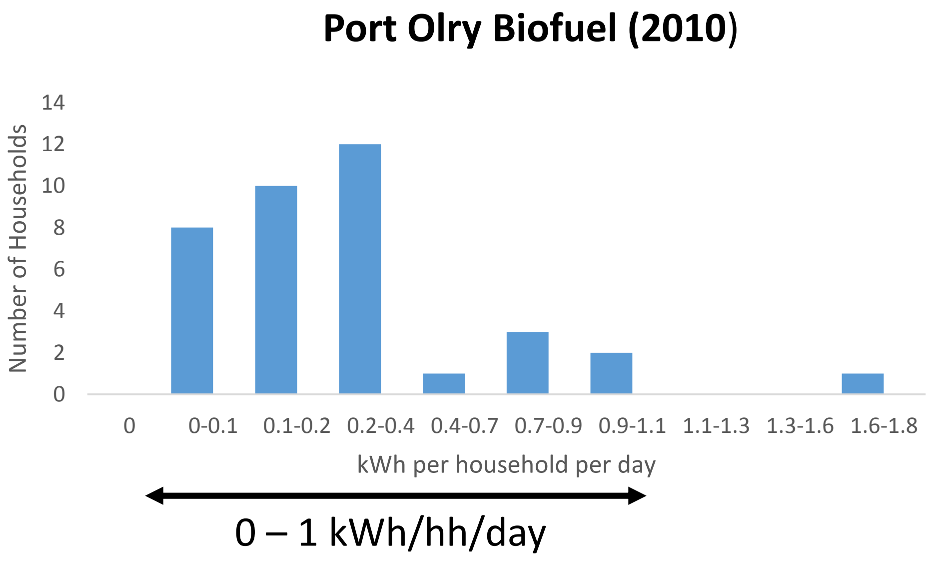
Newly electrified houses highly unlikely to consume more than rural HHs now on-grid:

- Tanna average: 0.6 kWh/hh/day (2002) and 1.1 kWh (2013)
- Malekula average: 0.6 kWh/hh/day (2002) and 0.7 kWh (2013)
- Port Olry biofuel: <0.5 kWh/hh/day (2010)
- Santo newly grid connected late 2015-early 2016): 4 communities average about 1.2 kWh

Likely to be < 1kWh/day with slow growth

and the pattern of energy demand:





Suitable energy technology also depends on who pays:

It is assumed that
- Initial investment costs mostly from GoV or donor
- Customer pays some of installation costs
- Customer pays O&M costs (including component replacement)

on customer’s the Willingness and Ability to Pay:

- Varies considerably but often too low for mini-grid and even SHS
- for some HHs, electricity is low priority and pico-solar PV is sufficient

and on community size, density, geography:

- Sparsely populated → individual home system
- Larger, compact community → mini-grid (maybe)

Tangkiu Tumas

Four reports available from DoE this week?

Soon online at DoE website?

Comments welcome to help us improve the study

(but as soon as possible)

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Supplementary Slides
if questions arise

Coconut-based Biofuel *

Potential Advantages	Potential Disadvantages	Resource
• **Similar to diesel: relatively simple to operate** • **Local employment & cash income** • **Continuous local supply of copra** • **Lower imports of diesel fuel** • **Relatively scalable** • **Reduced pollutants compared to diesel fuel**	• Copra supply sensitive to price changes • More maintenance than diesel system • Requires skills in oil production and in electricity generation and distribution • Requires drying & milling infrastructure • Variable fuel quality depending on copra drying, milling, filtering • Restricted to communities where mini-grid is practical	• Widely available in Vanuatu, particularly in north and central islands; less applicable in Torba

* For CNO. CME (esterified) is similar but more complicated, requiring coconut oil processing

Solar PV

Potential Advantages	Potential Disadvantages	Resource
• **Highly scalar/modular; suited to wide range of demand** • **Low maintenance** • **Suited to individual homes or buildings and mini-grids.**	• Intermittent • Battery storage expensive • Battery life limited, especially if over-discharged • Requires shade free access to sunlight between at least 9am and 3pm • Substantial land area needed for community scale installations	• Energy input limited to daylight hours • Some seasonal variation • Good resource in unshaded locations throughout Vanuatu

Micro-hydropower

Potential Advantages	Potential Disadvantages	Resource
• No fuel imports • Reliable; low maintenance • Continuous supply if flow is adequate	• Water flows seasonal; may require backup (battery) • Not easily scalable • Site specific design required Can be destroyed during extreme flows, highly susceptible to cyclone damage • High capital costs per kW • Usually restricted to communities where mini-grid is practical	• Flow monitoring required over several years

Small Scale Windpower

Potential Advantages	Potential Disadvantages	Resource
• Scalable • Can be suited to individual homes or buildings and mini-grids. • For one supplier, repair and maintenance available from New Caledonia	• Intermittent, requires battery storage or backup • Can be damaged/destroyed by high winds (highly susceptible to cyclone damage) • Limited local O&M skills • Expensive; unlike some RE tech, prices not dropping much • Little technical development at small scales • Few small machines designed for tropical, oceanic environments • Limited PIC experience with small systems (which has been poor)	• Very site specific • Wide seasonal variation in wind speed and available energy **50% higher wind speed → 3.4 x more energy in wind**