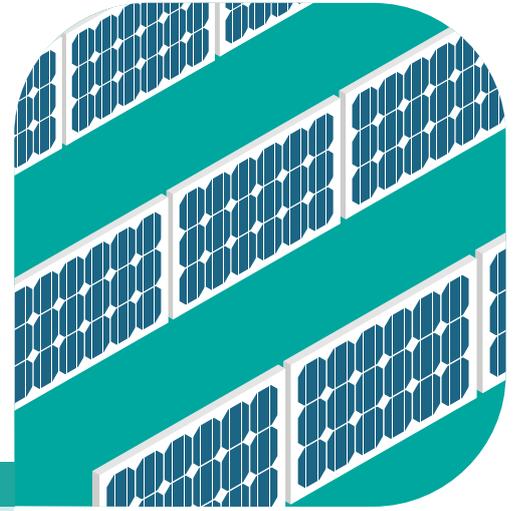




VANUATU

RENEWABLES READINESS
ASSESSMENT



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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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VANUATU

RENEWABLES READINESS
ASSESSMENT

FOREWORD

from the Ministry of
Climate Change and
Natural Disaster

The Ministry of Climate Change and Natural Disaster has the great honour and pleasure to introduce this Renewables Readiness Assessment (RRA) report.

Vanuatu has been a supporter of the International Renewable Energy Agency (IRENA) from the beginning, and we were particularly excited about the opportunity to engage in such a process. This assessment has been very important, because for the first time it has brought together Vanuatu's energy suppliers, energy regulators and energy users as a group to discuss and develop specific actions. These will help us meet National Energy Road Map (NERM) targets and reduce our dependence on imported fuels.

Vanuatu is blessed with abundant renewable energy resources, including solar, geothermal, wind, biomass and biofuel. However, it is highly dependent on imported fossil fuels. In recent years, the high cost of that imported energy has seriously hampered social and economic development. Reducing the need to import expensive fossil fuels, therefore, has been recognised as important to Vanuatu's future.

In 2013, the government adopted the NERM, which establishes a path to greater energy independence. In making this the basis for our energy policy, we started out by setting realistic targets for replacing imported fuels with locally available renewable energy sources. Renewable energy development can be more fully achieved when there is more collaboration between the government, the private sector, community leaders and land owners.

Vanuatu has already started some of the actions recommended in this RRA. We have begun major development of the solar, wind, geothermal, biofuel and hydropower resources present in our country. The timing of the assessment could not be better, and we expect that its recommendations will form the core of our plan of action to reach the targets of the NERM. The Ministry would like to express our gratitude to IRENA for making this possible, and we look forward to a long and fruitful relationship in the future.

**Ministry of Climate Change and Natural Disaster
Republic of Vanuatu**

FOREWORD

from the IRENA
Director-General



Across the Pacific, small island states face daunting costs for fuel imports and recurrent risk from global oil price volatility. The Republic of Vanuatu has resolved to improve its energy security and contribute to combatting climate change based on a balanced portfolio of indigenous renewable energy resources.

The country's Renewables Readiness Assessment (RRA), undertaken in co-operation with the International Renewable Energy Agency (IRENA), has produced a holistic evaluation of the sector and identified key actions to overcome barriers to increased renewable energy deployment. This is a country-led process, with IRENA providing technical support and expertise to facilitate consultations among different national stakeholders.

Since 2011, more than 20 countries in Africa, the Middle East, Latin America and the Caribbean, and the Asia-Pacific region have undertaken the RRA process, which generates knowledge of best practices and supports international co-operation towards the accelerated deployment of renewable energy technologies. Vanuatu, a strong and consistent supporter of IRENA's mission, is one of those countries.

Vanuatu has demonstrated its commitment to the transition to an independent, sustainable energy future. The National Energy Road Map laid out in 2013 charts the country's path to obtaining electricity access for all citizens through major increases in renewable energy use. Implementation will depend on establishing clear roles for the Vanuatu Department of Energy, the Utility Regulatory Agency and other institutions, as well as effective co-ordination with development partners.

Integrating renewables into Vanuatu's existing power infrastructure requires a comprehensive grid assessment study and the adoption of standards to ensure grid stability under specific local conditions. The expansion of off-grid applications, meanwhile, calls for enhanced capacity and additional standards, with a focus on scaling up solar home systems and solar-based mini-grids in rural areas.

With the continued decline in technology costs and an abundance of renewable energy resources in Vanuatu, the economic case for building a sustainable energy system based on indigenous sources is strong.

IRENA wishes to thank the Honourable James Bule and his team at the Ministry for Climate Change for the warm welcome they extended and for the commitment they exhibited in conducting this study. Our shared view of a better energy future will continue to underscore our mission to facilitate further RRAs in the Pacific and beyond.

I sincerely hope that the outcomes of the consultations will strengthen Vanuatu's pursuit of accelerated renewable energy deployment. IRENA stands ready to provide continuing support in implementing the actions identified, as the country lays the foundations for long-term energy sustainability.

Adnan Z. Amin
Director-General, IRENA

TABLE OF CONTENTS

LIST OF FIGURES	VIII
LIST OF TABLES	VIII
LIST OF BOXES	VIII
ABBREVIATIONS	IX
EXECUTIVE SUMMARY	XI
I. INTRODUCTION	1
1.1 Country profile	1
1.2 Energy for development	2
1.3 Renewables Readiness Assessment process in Vanuatu	2
II. OVERVIEW OF THE ENERGY SECTOR	5
2.1 Energy supply and demand	5
2.2 Electricity supply through grids	6
2.3 Renewable electricity tariffs, feed-in tariffs and net-metering	7
2.4 Access to electricity	9
2.5 Renewable energy potential	11
2.6 Institutional framework	15
2.7 Energy policies	16
2.8 Human capacity	17
III. SCALING UP RENEWABLE ENERGY: RECOMMENDATIONS AND CHALLENGES	19
3.1 Effective implementation of NERM: policy review and development-partner coordination	19
3.2 Grid-connected renewables	20
3.3 Off-grid renewables	22
IV. THE WAY FORWARD: STRATEGIES AND ACTION	25
V. REFERENCES	33

LIST OF FIGURES

Figure 1 Map of Vanuatu	01
Figure 2 Energy supply and demand in 2011 in tonnes of oil equivalent	05
Figure 3 Proposed geothermal production area on Efate in Vanuatu	11
Figure 4 Port Vila load curve for weekdays and Sundays (2013)	14

LIST OF TABLES

Table 1 Utility capacity by energy source (September 2013)	07
Table 2 Utility tariff structure	08
Table 3 Overview of recommended action emerging from the RRA	25

LIST OF BOXES

Box 1 Vanuatu Electricity for Rural Development	10
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ABBREVIATIONS

ADB	Asian Development Bank
CNO	Coconut oil
DoE	Department of Energy
EU	European Union
FIT/s	Feed-in-tariff
Gwh	Gigawatt hours
GDP	Gross Domestic Product
IPP	Independent Power Producer
km	kilometre
kW	kilowatt
kWp	kilowatt-peak
kVA	kilovolt-amp
MW	megawatt
NERM	National Energy Road Map
O&M	Operation and Maintenance
PPA	Power Purchase Agreement
PV	Photovoltaic
RRA	Renewables Readiness Assessment
SEIAPI	Sustainable Energy Industries Association of the Pacific Islands
SHS	Solar Home System
UNELCO	Union Electrique du Vanuatu Limited
URA	Utilities Regulatory Authority
VANREPA	Vanuatu Renewable Energy and Power Association
VERD	Vanuatu Energy for Rural Development
VUI	Vanuatu Utilities and Infrastructure
Wp	watt-peak

USD 1 = VUV 108.64 (Vatu) on 12 June 2015



Solar Water Heaters, Grand Hotel Port Vila
Photo: H. Wade

EXECUTIVE SUMMARY

Located in the western Pacific Ocean, Vanuatu is an archipelago of 80 islands supporting a population of about 234,000. The majority of these inhabitants live in rural areas and rely on subsistence agriculture and barter to meet most of its daily needs. Economic growth has been driven by foreign investment in tourism and land development. Economic growth is above average compared to other independent Pacific nations, but is largely urban with little effect on rural incomes.

The primary energy supply is dominated by biomass (mainly for rural cooking) and petroleum (urban energy and transport). Modern energy carriers are used largely in urban areas. The Vanuatu Department of Energy (DoE) estimates that 80% of urban and 17% of rural households have electricity access. Two private utilities, Union Electrique du Vanuatu (UNELCO) and Vanuatu Utilities and Infrastructure (VUI), serve four concession areas through grids. The utilities are regulated by an independent government agency, the Utilities Regulatory Authority (URA).

Vanuatu has drawn up a National Energy Road Map (NERM) which acts as the energy policy. NERM charts a direct path to major increases in the use of renewable energy and access to electricity by all citizens. The 65% renewables target for 2020 is ambitious but achievable. Renewable energy accounts for about 43% of total electricity generation at present with sources including hydropower, coconut oil (CNO), wind and solar. Access to electricity for rural households is a major priority of NERM since most of these (83%) remain without electricity in 2013. Meeting the NERM energy access goal would create a huge market for renewable energy technologies since they are the most cost-effective solution for off-grid electrification in rural and remote areas. However, a historic inability to keep off-grid renewable energy projects going both financially and technically has prompted concerns that they cannot be sustained in the long term.

Vanuatu has an excellent solar resource. It is available throughout the populated areas of the country and could be used to generate electricity to offset the cost of imported fuels. Several solar photovoltaic (PV) projects with a total capacity of more than 2.6 megawatt (MW) are under consideration. Interest from independent power producers

(IPPs) in solar PV electricity generation has been increasing. The URA has established regulations for connecting private solar installations to the grid. Moreover, a 4 MW geothermal plant is expected to go on stream before 2020, and some hydropower may also be added. The URA is also in the process of developing Power Purchase Agreement (PPA) formats for the private generation of power from renewable energy to feed into the grid. To fulfil the aims in NERM, it is necessary to establish and enforce technical standards for grid-connected systems and regulatory capacity for small scale distributed generation systems.

To meet the NERM targets, the utilities, government and development partners will probably need private sector support to install renewable electricity generation at the scale needed within the required time. For this reason, much of the discussion during the Renewables Readiness Assessment (RRA) focused on actions to encourage private investment in renewable energy.

Recommended actions

Actions needed to reach the NERM targets were divided three categories during stakeholder interviews and group discussions, as described below.

Institutions and policy

- **Review enabling legislation and other documents relating to URA and DoE responsibilities and tasks, and align them with NERM.** Propose changes and additions to legislation as required to provide the institutional authority and responsibility needed to meet the NERM targets.
- **Support URA and DoE roles in NERM.** Prepare an operating plan that includes human, physical and financial resources needed by both DoE and URA to support NERM implementation in 2014-2020. Seek that support from government and/or development partners.
- **Facilitate coordination among development partners.** DoE and URA should prepare project documents designed to carry out the action needed to achieve NERM goals, and circulate them among development partners. This will help retain development partner focus on NERM goals.

¹ 2009 data

Grid-connected renewables

- **Prepare dynamic models of the Vanuatu grids.** In order to assess the ability of the four Vanuatu grids to accept inputs from highly variable solar and wind generators, each one will need to be modelled. This will allow the utilities to predict the effect of rapidly fluctuating input changes at various points on the grid, and will require external expertise and development partner funding.
- **Establish nationwide standards for grid-connected solar and wind systems.** These types of standards help ensure installations are of good enough quality and meet the stringent safety and technical requirements essential to the healthy growth of the sector. Furthermore, national standards will help ensure all installations are compatible with each other. This will prevent the problems from unfavourable interactions between private solar generators on the same grid.
- **Training and capacity building.** Local contractors will need to be trained to ensure they understand and can competently apply the standards and guidelines for the renewable energy installations they construct and maintain. Capacity for inspection, monitoring and compliance will also be necessary to confirm that installations continue to meet relevant standards and can be safely connected to the grid. For long-term capacity building, it will be necessary to work with local training facilities to provide training appropriate to the renewable technologies utilised. These include Vanuatu National Training Council, Vanuatu Institute of Technology, Vanuatu Rural Development and Training Centre Association and other institutions.
- **Finance for the private sector installation of grid-connected renewables.** The Government of Vanuatu should consider working with multilateral development banks to obtain low interest loan funds providing concessionary rates to commercial entities with significant daytime loads. These include, for instance, supermarkets and tourist facilities intending to install grid-connected solar to offset those loads. The Government of Vanuatu should also consider using development partner funds to finance grid-connected solar on its own property as a cost reduction measure. This action has already begun since the United Arab Emirates has funded grid-connected solar projects to be installed at government offices and the parliament buildings.

Off-grid renewables

- **Design an institutional approach for sustaining off-grid electrification using Solar Home Systems (SHS) in homes and public buildings.** The DoE should review the institutional approaches used in Fiji, Tonga, the Solomon Islands and Kiribati to keep rural SHS installations continuously running. It should work with them to design a structure appropriate to Vanuatu. More than 10,000 SHS installations have sufficed to provide users with multiple lights, radios, mobile phone and portable light charging. These range from 100 Watt-peak (Wp) in Kiribati to 200 Wp installations in the Marshall Islands. The level of service they provide is comparable to that usually accessed by households connected to rural grid extensions. It therefore counts as full rural electrification.

The more successful Pacific island approaches use a combination of external and local support and include systems that collect reasonable fees in cash form. Alternatively, as in the Solomon Islands, payment is accepted in the form of agricultural produce or handicrafts with a known value. Technical support may be provided by a contractor, as in Fiji, or a locally trained person supported by the DoE, as in Tonga. Another option is to form an organisation specifically to support rural solar installations, as in Kiribati and the Solomon Islands. The experience of these countries has been shaped over more than two decades of trial and error. It should inform the design of the most fitting institutional structure for SHS and mini-/micro-grid rural solar implementation in Vanuatu.

- **Develop standard designs for SHS and solar mini-grids.** For long-term, reliable service, off-grid SHS designs need to meet the typical load requirements of rural households and provide sustainable operation in harsh environments. Designs should be modular so that installations of different sizes can be produced using the same components – particularly batteries. This will ensure that end-users receive the size of installation that meets their needs and ability to pay for maintenance.

The generation cost of solar mini-grids has fallen below that of rural diesel, so these should be selected by villages and larger rural public facilities like hospitals and schools. Sustainable operation and maintenance (O&M) is an important consideration with mini-/micro-grids, so the DoE should prepare a standard, modular design with suppliers and external

experts with knowledge of Vanuatu. The design would consist of a standard set of panels, batteries and inverters for stand-alone power production. For additional power and overall capacity, multiple modules can be connected together. This modular approach enables standardised maintenance and spare parts storage and greatly simplifies construction. Development partners and private investors should be required to meet these standards. A standard, modular design of this type was created by the Ministry of Foreign Affairs and Trade of New Zealand. It has been used to convert diesel mini-grids to solar in Tokelau, the Cook Islands and Tuvalu.

- **Build capacity for sustainable use of off-grid solar technology.** Using local education institutions, develop the necessary courses to provide installers and maintenance technicians with long-term training options, focusing on off-grid SHS and solar mini-grid installations. Due to the use of battery storage and low voltage direct current inputs, this training will be substantially different from that required for grid-connected solar generation.
- **Increase access to electricity in rural areas.** It is recommended that Vanuatu develop a specific strategy in association with development partners: for rapidly expanding rural electricity provision to households and villages using renewable energy; review past programmes and explain their problems and failures; propose strategies for expanding rural electrification in a programmed and rational manner in order to optimise installation and maintenance resources; and determine the criteria for selecting the electrification type best fitted to the targeted areas. Options for village electrification include a solar mini-grid or SHS on individual homes or financing a grid extension to the area. Alternatively the distribution of pico-solar type devices could be arranged, or various implementation methodologies combined.
- **Conduct an off-grid market study.** Work with tourism authorities and the private sector to assess the probable market for solar mini-grids for new tourism installations and to replace existing diesel generation. If demand is sufficient, set up a programme to promote solar mini-grids to replace existing diesel generation and to install them in newly-constructed facilities by developing appropriate attractive finance.

The following consolidated eight core activities are recommended to create the foundations for renewable energy in Vanuatu:

1. **Ensure the policies, regulations and legislation needed to support NERM are in place.** Legal, administrative and regulatory barriers must not obstruct the fulfilment of NERM targets. Legislation on the authority and responsibilities of URA and DoE need to be reviewed in particular. If necessary, their authority and responsibilities need to be updated so that NERM targets are met.
2. **Create dynamic models of the four concession grids to determine how well they accept solar or wind connection at various grid entry points.** Utility grids are unsure how solar input will affect grid operation and therefore prefer to ban solar, rather than accept the risk. This is a major barrier against opening the utility grids to private solar inputs. By preparing a dynamic model of each of the grids, the Vanuatu utilities can predict the effect of inserting solar or wind power into the grid from any feeder. This will allow a wide range of private solar inputs into their grid without fear of system damage.
3. **Implement and enforce national standards for on-grid solar installations.** Enforcing standards for on-grid solar installations greatly increases both consumer and utility confidence in the technology, simplifies training requirements and introduces routine maintenance. The utilities in Vanuatu already use Australian standards for their operations. In association with the Pacific Power Association, the Sustainable Energy Industries Association of the Pacific Islands (SEI-API) has proposed regional guidelines for solar on-grid generators. These accept that each island country is in a different situation, and ensure that local conditions, both technical and environmental, are taken into consideration in national standards and guidelines.
4. **Create an institutional approach for off-grid SHS and mini-grid system O&M based both on prior experience in other Pacific islands and failed projects in Vanuatu.** People in remote rural areas have limited cash, and these circumstances require a special type of institutional system to support rural energy systems maintenance. This must be able to provide the necessary services in these areas to meet the needs of the rural households in a sustainable manner.

5. Prepare a standard, modular design for SHS and solar mini-grids adaptable to a wide range of requirements. A standard modular design for low voltage direct current off-grid solar installations simplifies training requirements and minimises spare parts stocks. At the same time, maintenance becomes feasible for rural technicians. Standard designs proven in the field provide investors with the confidence they will be an economical and reliable source of off-grid power.
6. Prepare a standard, modular design for solar mini-grids adaptable to a wide range of requirements. This standard design would provide higher power, three-phase alternating current installations for off-grid use employing multiples of a standard module. A standard modular design can result in increased system reliability, lowest cost O&M, simplified training programmes and minimal requirements for spare parts storage.
7. Build capacity for on-grid and off-grid renewable energy technologies. There is little chance of sustainable operation of renewable energy systems without the local capacity to install and maintain them. Both urban and rural technical capacity will be needed. Local educational institutions with an understanding of the educational needs of the local students will be best suited to providing the necessary capacity building if properly supported.
8. Facilitate financing to increase private investment in renewable energy and energy efficiency. Once the technical and institutional aspects private investment in renewables are addressed, access to finance will be necessary to support the heavy front-loaded investment needed to install the equipment.



I. INTRODUCTION

1.1 COUNTRY PROFILE

Vanuatu's 80 islands are mostly volcanic and spread over 710,000 square kilometres (km²) of the western Pacific Ocean. Of these islands, 65 have permanent populations. The country's 2009 census showed Vanuatu had a total population of around 234,000, or 47,373 households, inhabiting a total land area of 12,190 km². About 75% of the population live in rural areas, with around 19% in the capital city of Port Vila. The remaining 6% are situated in the smaller urban area of Luganville. With an annual population growth of about 2.8%, the 2014 population is estimated at around 269,000, with the urban growth rate around 1% higher than that of rural areas.

Figure 1: Map of Vanuatu



Source: Google Maps

The boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

With a gross domestic product (GDP) of approximately USD 821 million in 2013, the average per capita GDP in Vanuatu has reached USD 3,086. This represents a year-on-year real GDP growth rate of 2.8%.² GDP is expected to have risen by 3.5% in 2014 compared to 2013 indicating upward economic growth after a three-year period of low growth. Agriculture, fishing and tourism are the major contributors to GDP, and tourism is the most likely to be affected by energy policy.

In 2013, the value of imported goods exceeded the value of exports by a factor of more than 5 to 1, with petroleum constituting a substantial proportion of imports. Exports consist largely of copra, beef, timber, kava and coconut oil (CNO). Income from tourism has recently grown and has steadily reduced the current accounts gap between imports and exports.

Economic growth has been driven by increased foreign investment in tourism and land development, but the growth is urban and has little effect on rural incomes. Only around 10% of GDP comes from rural areas. Most rural residents have relatively poor access to cash and depend on subsistence agriculture and barter to meet many of their daily needs. Around 75% of Ni-Vanuatu³ inhabitants live in rural areas, and many have less than a dollar a day in cash income.

² According to the latest published figures from the Australian Department of Foreign Affairs.

³ Ni-Vanuatu refers to all Melanesian ethnicities originating in Vanuatu. It also refers, more generally, to nationals and citizens of Vanuatu, whatever their ethnicity.

1.2 ENERGY FOR DEVELOPMENT

To continue Vanuatu's socio-economic development, the Government of Vanuatu has prioritised the increased use of affordable, high quality forms of renewable energy. This is reflected in the strategic vision embodied in National Energy Road Map (NERM), which has been created and adopted as the guiding document for developing the energy sector in Vanuatu. By creating NERM, the Government of Vanuatu has put a high priority on energy development. It is making efforts to provide the rural population with increased electricity access as well as making electricity more affordable through greater use of indigenous energy resources.

Most commercial and industrial businesses are in urban areas, but the high electricity tariffs there have inevitably had an adverse impact on their operations. One NERM goal is to at least stabilise the cost of electricity generation by investing in renewable energy systems that offset diesel fuel use. Where possible, they want to effect a reduction in tariffs by adding renewable energy generation that is cheaper than diesel. Solar, wind and hydropower installations generating at a lower cost than diesel are already in place. In addition, geothermal energy under development may also prove to be less costly than diesel generation.

Outside the utility concession areas, only 17% of rural households have access to electricity. Large scale implementation of cost-effective, pico-solar lighting schemes is the first step to getting rural electrification up and running. Affordable installations of this type can provide basic access to electricity for quality lighting and mobile phone charging and are greatly in demand from the rural population. Larger solar installations are to be installed in schools, health centres and other government facilities that need more electrical service than the pico-solar systems can provide. Technology is not the key challenge affecting rural electrification. This lies rather in securing the funds and human capacity needed to sustain the installations in the long term.

With renewable energy system costs falling worldwide, the islands are experiencing new opportunities for energy independence. The first step towards further developing renewable energy in Vanuatu is to understand the gaps and identify the action that should be taken to narrow them.

1.3 RENEWABLES READINESS ASSESSMENT PROCESS IN VANUATU

The Renewables Readiness Assessment (RRA) methodology is used to conduct a comprehensive

assessment of a country's readiness in terms of renewable energy development. The resulting consultations produce a portfolio of actions that are needed to address key issues.

The background to the Vanuatu RRA process is the Government of Vanuatu's endorsement of NERM. This set a policy target to achieve 65% of Vanuatu's electricity use through renewable energy by 2020. The RRA provides guidance for formulating specific and practical actions in selected priority areas that can enable Vanuatu to increase the use of modern forms of renewable energy. The RRA results are based on a comprehensive assessment of the current status of the Vanuatu energy structure with a particular focus on renewables. The outputs come primarily from a multi-stakeholder consultation that brought together user stakeholders and representatives from the energy providers. They discussed the issues that need to be addressed, and outlined the actions needed to move Vanuatu towards the targets set out in NERM.

The RRA has the following aims:

- Conduct a comprehensive review of renewable energy development at present in Vanuatu to improve understanding of the sector.
- Identify and analyse the key issues associated with and arising from the development and utilisation of renewable energy resources.
- Present the opportunities for scaling up renewable energy development and deployment, discuss the specific issues to be addressed, and prepare specific policy recommendations.
- Produce a portfolio of actionable initiatives developed jointly by participating stakeholders. This can capitalise on the renewable energy development opportunities revealed by examining the renewable energy subsectors and by extensive discussions with multiple stakeholders.

The RRA process was led by the DoE at the Vanuatu Ministry of Climate Change Adaptation and Natural Disasters, in close collaboration with an IRENA RRA team. An issue paper was written to identify in advance the key barriers to scaling up renewable energy applications in Vanuatu. It also served as a key background document for the discussions that followed.

To facilitate close cooperation and coordination between the Government of Vanuatu and development partner organisations, the actions

identified are to suit both development partner support structures and those in Vanuatu. A workshop was organised in Port Vila to bring together all the principal stakeholders in Vanuatu's renewable energy development. It charted the optimal path and identified projects related to renewable energy that can help reach NERM goals and targets.

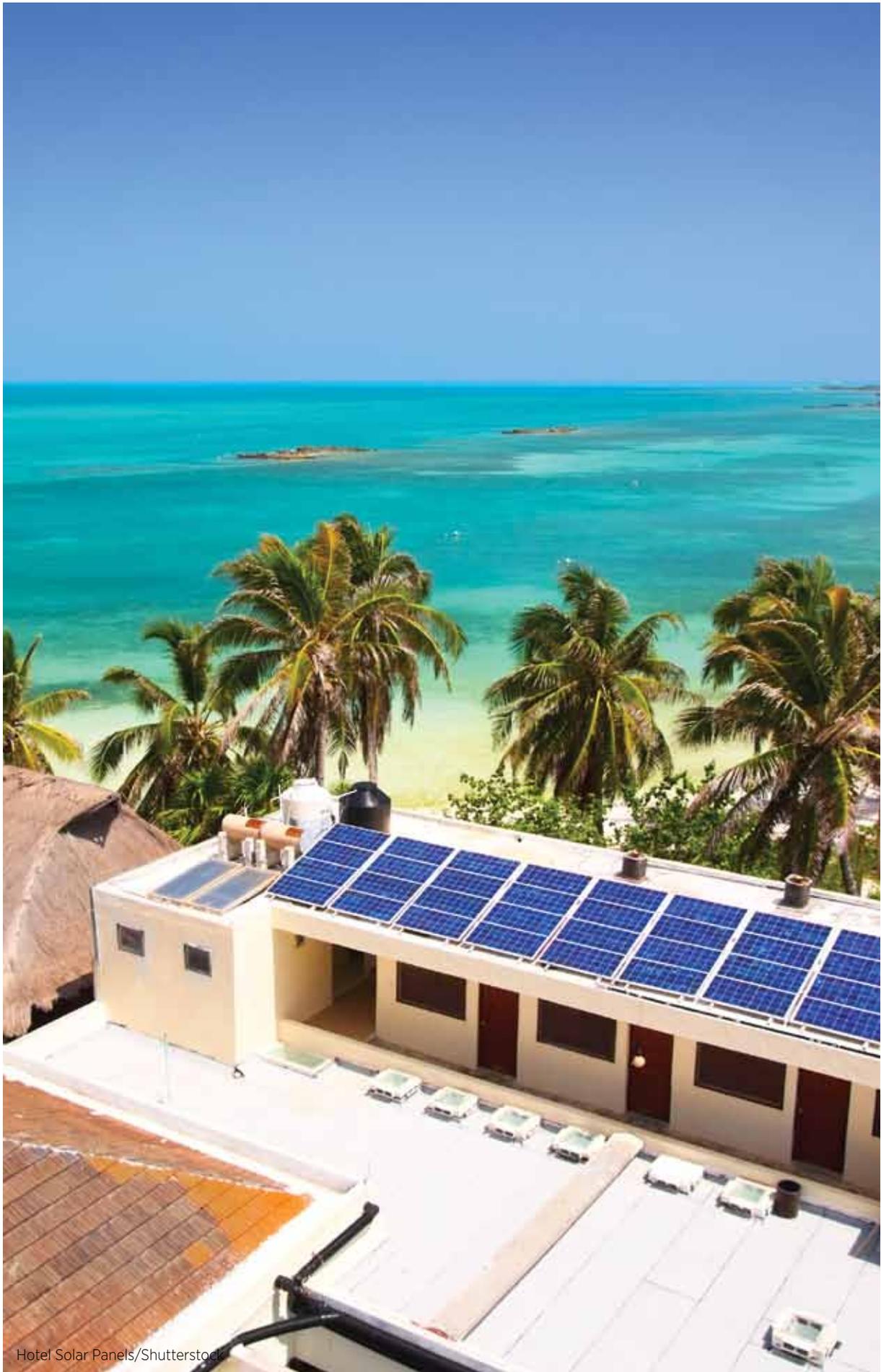
Interviews and follow-up discussions took place. They yielded in-depth understanding of the matters

discussed at the workshop, different perspectives, and stakeholder advice and thoughts on how to tackle them. This is an important complementary function in the methodology.

The key findings from the RRA study have indicated that Vanuatu will be able to reach the key 2013–2020 renewable energy targets in NERM. This depends on effective measures to improve the enabling environment for renewable energy development and sufficient support from development partners.



Origin LPG depot, Port Vila
Photo: H. Wade



Hotel Solar Panels/Shutterstock

II. OVERVIEW OF THE ENERGY SECTOR

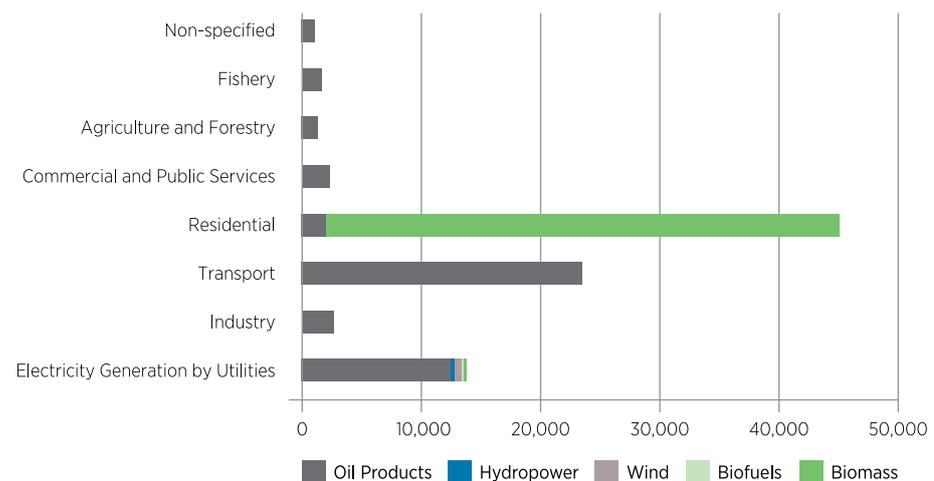
The energy infrastructure within the Vanuatu archipelago varies significantly. The government has established concession areas for private utilities to distribute electricity through power grids on parts of the islands of Efate, Tanna, Malekua and Espiritu Santo. The grids provide electricity services mostly through generation with diesel gensets and also through hydropower, wind and solar power. The combined distribution network covers 33% of total households in Vanuatu. Outside the concession areas, electricity access is minimal and is on an individual generation basis, mostly through small diesel or petrol generators with some use of renewable energy - mostly solar.

As a result of the declining cost of solar and wind energy technologies, applications of solar and wind power systems have recently been increasing in both urban and rural areas. To keep abreast of the rapid development of the energy sector, DoE capacity has been reinforced, and the Vanuatu NERM was developed and adopted by the government. This is the first guiding document of this kind in Vanuatu. While this is a major step forward, the challenge of effectively implementing NERM remains.

2.1 ENERGY SUPPLY AND DEMAND

Energy demand in Vanuatu is met primarily by biomass and oil products, as shown in figure 2. Biomass is a major energy source, as three quarters of the population still live in rural areas where it is the dominant energy source for cooking. Petroleum is a major energy source too since transport, urban cooking and electricity generation are fuelled mainly by petrol, liquefied petroleum gas and diesel fuel.

Figure 2: Energy supply and demand in 2011 in tonnes of oil equivalent*



* toe
Based on data from King and Mackay, 2012.

Vanuatu has no known fossil fuel resources. All petroleum products consumed have to be purchased from international markets and shipped to Vanuatu. The Pacific Petroleum Company is the sole petroleum fuel importer in Vanuatu. This company provides a portfolio of oil products, 63% of which are diesel, around

15% jet fuel and petrol each, and the remaining 7% kerosene and avgas (aviation gasoline). In 2011, petroleum products⁴ accounted for nearly half the total primary energy supply, while biomass for cooking provided the other half. Modern renewable energy sources, such as hydropower, wind, solar and biofuels, provide the remaining 1,000 toe (see figure 2). There is great potential for a higher renewable energy share by adding solar, wind, geothermal, biofuels and hydropower facilities.

If biomass is taken into account, the residential sector is the largest energy user. This indicates that a large number of households still rely on traditional biomass for cooking and crop drying, while their use of modern energy forms of bioenergy is still limited. In contrast, the direct use of fossil fuels accounted for only 4% of total household energy consumption in 2011.

The transport sector remains the largest consumer of petroleum products, accounting for 55% of total petroleum products imported in 2011. When combined with the consumption of diesel fuel for power generation, the residential and transport sectors accounted for 84% of total oil imports for the same year.

The consumption of petroleum products by industrial, commercial and public services accounted for less than 10% of total oil imports. This suggests that the industrial and commercial sectors may be still underdeveloped in Vanuatu. Furthermore, electric power may be the preferred form of energy used by these sectors.

According to the 2011 data, the combined primary energy used by agriculture, forestry and fishing was modest - less than that of either the industrial, commercial or public service sectors.

2.2 ELECTRICITY SUPPLY THROUGH GRIDS

Electric power is supplied either through an urban grid or by off-grid power systems. Although there are also small private and semi-private electricity producers at tourist facilities, and in

some villages, more than 90% of electricity is generated and delivered by Union Electrique du Vanuatu Limited (UNELCO) and Vanuatu Utilities and Infrastructure (VUI). UNELCO is a subsidiary of GDF Suez in France. It serves the entire island of Efate (which includes Port Vila, the largest city in Vanuatu), and the urban areas of Tanna and Malekua. VUI is a subsidiary of the Pernix Group based in US, and serves Luganville, the second largest city.

UNELCO and VUI are currently serving nearly 14,000 customers - more than one quarter of the total population. As shown in table 1, the combined utilities had a total generation capacity of 34.79 megawatts (MW) and generated 70 gigawatt-hours (GWh) in 2013. Renewable energy sources accounted for 43.6%, including CNO at 21.8%, wind at 12.8%, hydropower at 8.7% and solar at 0.3%. It was estimated that electricity generated by renewable energy sources saved about 11 million litres of diesel imports.

Except for the 600 kilowatts (kW) Sarakata River hydropower station commissioned in 1995 (Utilities Regulatory Authority (URA), 2010), all the other grid-connected renewable energy generation facilities were built after the fuel price spike of 2008.

As with most Pacific islands, reducing energy import costs has been a key driver for the quick adoption of renewable energy sources as an alternative to imported fuels. Solar photovoltaic (PV) system and wind turbine costs have declined rapidly over the past few years. This means solar and wind power have become attractive options for stabilising, if not reducing, the overall energy generation costs throughout the Pacific islands.

Vanuatu diesel fuel power generation has fallen from 90% in 2009 to 56.4%. This is due to increased hydropower capacity in Luganville, more CNO replacing diesel fuel, and a 3 MW installation of wind capacity by UNELCO near Port Vila. At present, as much as 43.6% of electricity is produced from renewable energy sources. The actual amount varies from day to day due to the variability of solar and wind resources.

⁴ About 42,600 toe

Table 1: Utility capacity by energy source (September 2013)

Concessionary areas	EFATE	ESPIRITU SANTO	MALEKULA	TANNA
	Port Vila power station	Luganville power station	Lakatoro power plant	Lennakel power station
Generation capacity				
Number of installed diesel generation sets	10	8	4	4
Diesel capacity (diesel fuel + CNO) (MW)	26.5		0.5	-
Diesel capacity without CNO (MW)	-	2.9		0.5
Hydropower (MW)		1.2		
Diesel + hydropower capacity (MW)	26.5	4.1	0.5	0.5
Wind (MW)	3.02			
On-grid solar installed by the utility (MW)	0.07			0.04
Grid-connected solar*(MW)		0.040	0.020	-
Total capacity (MW)	29.59	4.14	0.52	0.54
Total (MW)	34.79			
Utility generation				
Diesel used (million litres)	13.5	0.24	0.2	0.5
MWh** produced	59,529	725	721	9,044
Diesel %	72.60	65.78	95.88	20.36
CNO %	17.73	29.93	0.00	0.09
Hydropower %	0.00	0.00	0.00	79.56
Wind %	9.51	0.00	0.00	0.00
Solar %	0.18	4.30	4.12	0.09

* Government of Vanuatu project

** Megawatt-hours

Sources: URA website (www.ura.gov.vu), UNELCO technical reports, VUI technical reports

2.3 RENEWABLE ELECTRICITY TARIFFS, FEED-IN TARIFFS AND NET-METERING

The electricity tariff is a combination of a fixed unit charge related to non-fuel power generation and delivery costs, and a variable component adjusting for fluctuating fuel and other costs. As table 2 shows, the tariff for households with low usage is tiered. The factors 'P' and 'Pc' represent tariff cost factors, providing for varying costs and updated as costs change.

For households on the UNELCO grid with low usage, the first 60 kilowatt-hours (kWh) per month are charged VUV 0.34 x P per kWh. Where P is set at 55.56 (mid 2014), which makes the lowest tier tariff 18.89 VUV/kWh. This is approximately 0.205 USD/kWh, less than half the typical cost of a utility based on diesel generation. For 60-120 kWh usage, the tariff is

VUV 1.21 x P (VUV 67.22 as of May 2014 or approximately USD 0.73). Finally, residential customers in this tiered low usage rate who use over 120 kWh per month are charged the very high rate of VUV 3.00 x P (VUV 163.86 or around USD 1.78/kWh). However, URA has clarified that the tiered tariff for UNELCO customers alone is a subsidised rate only available to customers who normally use less than 120 kWh a month. An additional restriction only allows a 5 A or 10 A single phase connection. Customers on the tiered tariff can use more than 120 kWh in any particular month and must pay the very high rate of VUV 3 x P for all usage over 120 kWh. However, if they use more than 120 kWh for three consecutive months, they are transferred to the 'Other Low Voltage Customers' rate at a flat rate of VUV 1.21 x P (VUV 67.22 or about USD 0.73) plus a monthly charge of VUV 5 x P per subscribed kilovolt-amp (kVA) for all usage.

Table 2: Utility tariff structure*

UNELCO		
Customer group	Price/kWh (VUV)	Monthly fixed charge
Small domestic customers	Up to 60 kWh = 0.34 x P 61 - 120 kWh = 1.21 x P Over 120 kWh = 3.00 x P	0
Other LV* customers	1.21 x P	5 x P per subscribed kVA
LV business licence holders	0	0
	0.87 x P	20 x P per subscribed kVA
Sports fields	1.00 x P	None
Public lighting	0.54 x P	None
High voltage users	0.70 x P	25 x P per subscribed kVA
VUI		
Interim LV	Up to 60 kWh = 0.38 x Pc 61-120 kWh = 0.97 x Pc 121-180kWh = 1.80 x Pc Over 180kWh = 1.10 x Pc	None
Sports fields	1.00 x Pc	None
Public lighting	0.54 x Pc	None
High voltage users	0.70 x Pc	25 x Pc per subscribed kVA

*May 2014 - P = 55.56

*Low voltage

Source: URA

URA states there are around 5,300 domestic customers on the tiered tariff, and around 4,200 domestic customers on the 'Other Low Voltage Customers' tariff. Thus two different tariffs for domestic customers are set according to usage. The government provides no external subsidy, so the utility must recover all its costs through its overall tariff structure.

Commercial and industrial customers also have tariffs adjusted as costs change through a factor (P), as shown in table 2. However, this is calculated in a simple way, *i.e.* per kWh price plus a charge based on the power demand by the user.

VUI serves the Espiritu Santo concession area and has a lower tariff than UNELCO due to a high percentage of lower cost generation from hydropower. UNELCO tariffs are adjusted monthly, but VUI has a fixed tariff valid for 12 months.

URA published rules in mid-2014 for net-metering and feed-in tariffs (FITs) for customers wishing

to install their own solar generators and connect them to the grid. This is discussed in detail in section 3.2. Small residential customers will receive credits for any solar generation not used by the home that is fed into the grid. The credits can be used to offset the cost of any grid power used in the home. They are carried forward to the end of each billing period, at which point the credits will be reset to zero. This approach allows households owning solar to feed electricity into the grid during the daytime when household loads are low. In turn, households are permitted to take the same amount from the grid later without charge. By resetting the credit to zero at the end of each billing period, residential customers are discouraged from installing solar systems that will generate more than their home use.

Commercial and industrial customers will be allowed to connect private solar generators to the grid through a separate meter. They will be paid a FIT of 18.89 VUV/kWh (around USD 0.21), which is used to offset their monthly bill.

2.4 ACCESS TO ELECTRICITY

It is estimated that 33% of all Vanuatu households have access to electricity, and only around 17% in rural areas. Thus, about 67% of all households do not have access to electricity. Many of those are in areas with grid concessions.

Access in concession areas

UNELCO and VUI are working towards implementing an 'Improved Access to Electricity' project. This is aimed at households lacking access in the grid concession areas or immediately adjacent to areas suitable for grid extension. This project is funded by the Global Partnership on Output-Based Aid through the World Bank. It allows consumers on a low income still without a connection to receive assistance to gain electricity access through grid extensions.

Access outside the concession areas

Most of the electricity outside the concession areas is produced by small diesel generators operated by communities or government stations. Diesel-powered mini-/micro-grids are typically used by tourist facilities. Although a number of solar electrification projects have been set up in rural areas, keeping these going in the long term remains a real challenge. Few systems survive more than five years in NERM, the government objective is to provide 100% of rural households with electricity access by 2020 through individual home systems and basic power products. To meet that target, a significant amount of support from the development community is required. The cancellation of the large Vanuatu Electricity for Rural Development (VERD) programme funded by Australia needs to be filled by other development partners if Vanuatu is to achieve its target access to electricity. More details about the VERD programme can be found in box 1.

The VERD programme did not get beyond the early planning stages. However, its concept and key components have provided valuable inputs for understanding what has to be done to achieve the electricity access target. Building on the VERD programme, the World Bank has stepped in to close this gap. It is implementing some of the major components that had been included in the programme.

Another program with a focus on rural areas and access to electricity for poverty population is the United Nations National Appropriate Mitigation Action (NAMA). Under the support from the United Nations Development Programme, developing a detailed NAMA document is underway. The document will provide design of programs that will increase access to electricity for low-income households in rural communities. When completed in mid-2015, the NAMA is expected to add impetus for providing access to electricity in rural areas.

Off-grid systems powered fully or partly by solar PV can undoubtedly provide the most cost-effective solution for remote rural electrification in areas distant from the grid with low per capita demand. The cost of a low-capacity power supply solution for off-grid households, known as pico-solar PV systems, is about USD 20-100. This depends on the type of product. These systems typically provide one portable LED light and often include a connection for phone charging.

Some critics argue against the classification of the pico-PV system as rural electrification because of the extremely limited energy services it can provide. However, it is in great demand by villagers, as they see it as an improvement to their quality of life and a cost-saving solution compared to kerosene night lighting. Using direct sales for cash from retailers to end-users simplifies the business model.

The purchaser is responsible for the installation, proper operation and entire maintenance of the pico-solar units. Solar panels and LED light are robust, so the battery is the only component likely to incur a significant maintenance cost. However, these units have only been in place in large numbers over the past two or three years, so it is too early to tell whether units can be sustained after batteries are exhausted and need replacement.

Over the past 20 years, several projects for rural electrification have provided Solar Home Systems (SHS). The SHS has had the capacity to deliver a higher level of energy services than pico-solar but at a cost of USD 800-1,000. The 1999-2002 PREFACE project funded jointly by France and Australia is one example. This focused on rural health centre and school electrification, and included staff housing at those facilities. It provided installations of 150 watt-peak (Wp) each for 20 schools and health centres, and systems of 75 Wp each on 40 houses in Torba, a remote province in Vanuatu.

The main challenge has not been installation but sustainable Operation and Maintenance (O&M) of renewable energy systems. A study funded by the Asian Development Bank (ADB) entitled 'Access to Rural Energy' is currently considering ways to avert O&M breakdown in off-grid installations. This study will prompt a programme aimed at increasing rural electrification through hydropower for on-grid generation and grid extensions to households and businesses lacking electricity across Vanuatu. It focuses on three areas: (a) improving the overall plan for distribution network extensions (b) conducting feasibility studies to determine the practicality of expanded low cost electricity generation using hydropower (c) increasing the supply of affordable, grid-connected electricity to households in targeted provincial centres.

Box 1. Vanuatu Electricity for Rural Development

'Vanuatu Electricity for Rural Development' (VERD) was meant to address the challenge of low access to electricity in rural households (17%), health centres (17%) and schools (42%). It was funded by AusAID (Final Programme Design Document - December 2011).

VERD was designed as a USD 18.6 million programme lasting six years. It aimed to strengthen government capacity for planning and supervision, sustainably manage escalating consumer demand, and establish an enabling environment for a robust private sector engagement to meet that demand. Its six components are outlined below.

1. Funding mechanisms developed, approved and operational: (i) the Rural Lighting Subsidy Scheme (up to AUS 2.78 million with high quality solar PV lighting to 80% or more of households); (ii) the Public Institution Electrification Scheme (up to AUS 5 million for basic electrification of at least 90% of rural schools and health centres).
2. Vendor accreditation: accreditation of Rural Lighting Subsidy Scheme vendors and the larger Public Institution Electrification Scheme electrical system developers.
3. Consumer protection standards: participatory establishment and management of technical and quality standards for equipment and services.
4. Skills development: enhancement of core skills through local and national partnerships.
5. Raising awareness: promotion and responsible use of campaigns for public, civil and private users of off-grid electricity systems.
6. Institutional development: energy section vision, institutional roles, staffing and resourcing agreed and in place.

A VERD team was to be established within the energy section of the Ministry of Lands and Natural Resources. It was to use predominantly national staff supplemented by two full-time advisers and short-term technical advisers as needed. After six years, the Government of Vanuatu would have assumed full responsibility for key functions.

The VERD programme was expected to start in 2012, but the Government of Vanuatu was unable to provide all the agreed inputs (mainly the approval and introduction of local energy staffing positions). In 2013, AusAid, which had recently moved to the Australian Department of Foreign Affairs and Trade, cancelled VERD. In late 2013, the Government of Vanuatu upgraded the energy section to an energy department within a new Ministry of Climate Change. It advertised for new staff to fill the positions recommended by AusAID, but it was too late to salvage the VERD programme. The World Bank has worked with the Government of Vanuatu to reconsider, prioritise and locate funding support for the elements of the VERD initiative lost when the programme was cancelled. Since then, VERD has been renamed VERP (Vanuatu Electricity for Rural Program) and is moving ahead.

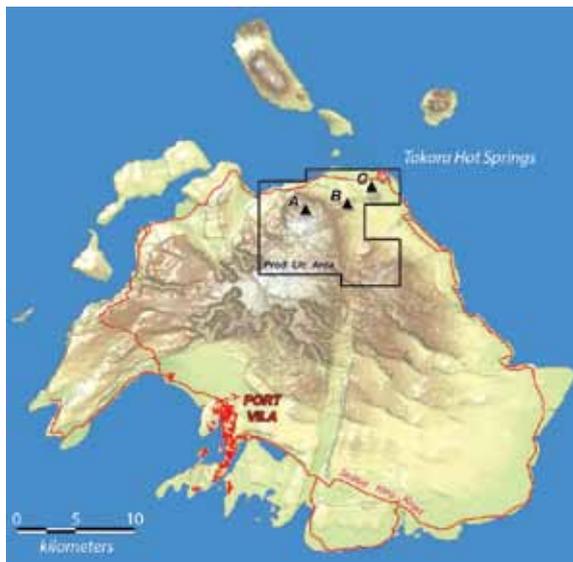
2.5 RENEWABLE ENERGY POTENTIAL

Geothermal

Geothermal energy works reliably and continuously, requires limited land area for installation, often generates electricity more cost-effectively than diesel plants, and provides base load generation.

In the 1990s, geothermal reconnaissance surveys carried out on the islands of Efate, Tongoa, and Vanua Lava revealed the existence of two active geothermal areas on Efate with useable temperatures greater than 50°C at Takara and in the Teuma Graben. In 2010, this finding prompted the Vanuatu government to request that the World Bank conduct a study to assess the geothermal potential of Efate. Figure 3 illustrates the areas with high geothermal potential.⁵

Figure 3: Proposed geothermal production area on Efate in Vanuatu



Source: www.kuthenergy.com/vanuatu

The boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

KUTh Energy of Australia (now owned by Geodynamics, Australia) was granted a 30 year exclusive production licence to develop geothermal projects in Efate. In the licence, a minimum tariff of VUV 23.9 (about USD 0.25) was set for geothermal power with consumer price index adjustments along with the carbon credits that accrue to the project. Power Purchase Agreement (PPA) negotiations are under way between Geodynamics, URA and UNELCO, but by mid 2014 no final agreement had been reached. A major component of the cost of power is the cost of exploration drilling. International support for the geothermal project throughout the initial, higher-risk, exploratory phases would have a

disproportionate impact. They would affect the PPA energy cost that Geodynamics could offer in the PPA or that could at least clarify the viability of the source. The Environmental and Social Impact Assessment study began in May 2014, and exploration drilling was expected to commence before the end of 2014. Access to land is a significant concern. Through a National Geothermal Taskforce, the government is working with land owners to facilitate access to the needed land for the preliminary work and for its later use in geothermal resource development.

If the exploratory drilling confirms the resource could be developed, the first phase would include constructing a 4 MW net capacity plant. Construction would start within three years after the PPA is signed. This could be followed by phase two with a second 4 MW plant. Initially there were concerns about proper regulation since the transmission line and the geothermal plant would not be in the concession area allocated to UNELCO. However, UNELCO has now been granted the concession for the entire island. This avoids any significant legal problems related to UNELCO investments that could lie outside the concession boundary - mainly transmission lines.

Biomass

Around 43,600 toe of fuel wood is burned each year for cooking and crop drying. Almost all the fuel wood is used in rural areas, as people in towns cook mostly with liquefied petroleum gas or kerosene. However, some wood and charcoal is available in urban markets for cooking. There is no evidence that this level of wood use is detrimental to Vanuatu's forests. Deforestation in Vanuatu appears to be tied mainly to agricultural expansion and logging.

Although saw log yields in Vanuatu are currently around 10,000 cubic metres (m³), the sustainable harvest level has been estimated at 38,000-60,000 m³ logs per year. It is possible, therefore, that substantial forest production waste could be used as feedstock in future as forest plantations expand and mature. This could be used for electricity generation both for powering the forest products facility and providing electricity to nearby villages.

Biogas

A pre-feasibility study of a new Port Vila municipality managing an anaerobic sludge sewage treatment facility was completed in 2012. It was funded by ADB Project Preparation Technical Assistance. If this goes forward as planned, the facility may be running in 2015. Biogas generated by the facility would be captured and utilised for electricity

⁵ Vanuatu: Efate Geothermal Power and Island-Ring Grid Development Framework

generation. Estimates show 275 megawatt-hours (MWh) of electricity per year can be generated by the proposed facility. This could be enough to provide the energy needed by the treatment facility itself.

Biofuel

In the late 1990s and early 2000s, Vanuatu was the regional leader in the development of CNO for fuel. This was used both as a direct replacement for diesel fuel and for blending with diesel fuel or kerosene for general diesel engine use. Due to changes in the market for CNO, as well as a biofuels levy, the cost of the blended fuel rose above diesel fuel. As a result, the general use of blended CNO and diesel fuel rapidly declined. UNELCO is now the primary user of CNO as fuel, consuming a blend of CNO and diesel at two of its diesel generation stations (GR 1 tag and GR 2 tag). The raw materials are from local coconut growers, but UNELCO does all the processing. It is, therefore, able to control the quality of the product to meet the requirements of its engines. The consumption level is linked primarily to CNO availability, which depends on market competition and to some extent on weather conditions. Very little CNO was consumed in 2010 and 2011 - less than 1% at one station and around 4% at the other. Recently, the proportion has been substantially higher. The utility has also reported using CNO as its principal form of fuel at its 320 kW Rapides station.

At Port Olry, the European Union (EU) assisted in the development of a 40 kW generator designed to use CNO as a fuel and to serve 260 households (around 1,000 people). To start with, the facility ran relatively well. However, copra prices have risen, and a sealed road has been constructed that links Port Olry to Luganville. After the road was finished, farmers were able to get a better price for their oil in Luganville, and supply to the Port Olry installation became less attractive. The Port Olry project has had other operational problems too, including a broken oil press, improper handling of copra resulting in mould, and copra quality degradation. Nevertheless, it is still running.

The EU included the following three additional biofuel generation projects in its First Energy Facility programme (2007–2013). The Government of Vanuatu (including provincial governments) was a partner in each one.

- Torba: villages of Mosine and provincial capital Sola. The plan was to install two 13 kVA generators in Mosine and two 36 kVA generators in Sola.
- Penama province: villages of Lolowai, Longana and provincial capital Saratamata. The plan

was for two 20 kVA generators in Lolowai, two 29 kVA generators in Longana and two 29 kVA generators in Saratamata.

- Malampa province: villages of Lavalsal Fotinweiu, Vao, Orap and Wala (Northeast coast of the island of Malekula). This project was originally intended for CNO generation with local distribution. However, UNELCO was planning a new generation plant in Lakatoro. As a result, the EU project for Malampa was modified into the construction of a 26 km grid extension. Its purpose is to allow UNELCO to supply electricity from Lakatoro to around 3,500 people in that area.

Unfortunately, the CNO component of the project has not proceeded on schedule. Due to the problems at Port Olry, there were concerns that the Government of Vanuatu would not provide the necessary co-financing. However, by mid-2014 the Government of Vanuatu component had been allocated from the remaining assets of the Sarakata Special Reserve Fund, and the project remains in the pipeline.

The further development of CNO as a biofuel replacement for diesel faces a considerable number of barriers outlined below.

- Copra supply infrastructure: a consistent supply of copra is required if biofuel is to be a commercial success. Supply from local farmers varies both in terms of quantity and quality. UNELCO set up a company to manage its own coconut plantation and enter into long-term supply arrangements with other copra farmers. The company then sells the manufactured oil only to UNELCO and is not allowed to export without UNELCO approval.
- Copra supply outlook: many existing coconut plantations have a large number of unproductive, senile trees that need to be replaced to maintain a consistent, long-term supply.
- Quality control: oil from export producers is often of variable quality. Even if manufactured from good quality copra, it often needs additional refining to reduce the content of particulates and contaminants. This is one of the reasons UNELCO has decided to handle all its own oil manufacturing and refining.
- Generator technical issues: few engine manufacturers will allow the use of CNO and still honour their warranty. Some will allow CNO blended with diesel fuel up to a certain

percentage, and a few do allow pure CNO as a fuel without warranty problems. A CNO/diesel blend of up to 30% has been used by Samoa utility Electric Power Corporation (EPC) with no engine damage. Meanwhile, 15% CNO has been used as a trial by several island utilities without damage. Thus, it is not a high risk blend in out-of-warranty engines, though the CNO must be properly filtered and refined.

- Copra price: from the late 1990s up until 2010, cooking using CNO was unfavourable, and its use in cosmetics was minimal. As a result, the price tended to be below that of diesel fuel. In recent years, demand for high quality CNO has surged. This is due to publicity about its health benefits in cooking and the use of CNO as a base for skin creams and cosmetics. There is concern that the increased demand will cause the average price of refined CNO suitable for utility use to be consistently higher than imported diesel fuel.
- Lost tax and export earning revenue: imported petroleum products are a major component of revenue for the government. This is because around 40% of the retail price of fuel is government tax through a combination of Value Added Tax, import duty and energy tax. The import duty for petroleum products is at VUV 26 per litre (/l) (about USD 0.29/l). This means the loss of revenue runs into millions of dollars if domestic CNO is used to replace imported diesel fuel.

Solar energy

Solar has been a minor component of on-grid generation. Only 70 kilowatt-peak (kWp) of solar PV has been installed on the UNELCO Port Vila grid. Another 20 kWp is on stream for UNELCO in Malekula, and 40 kWp is connected to the VUI grid in Santo. This consists of 20 kW supplying the Northern District Hospital while both Samma provincial headquarters and College de Santo receive 10 kW each.

The EU Energy Facility programme is now in progress. It includes support for a 1 MW solar installation to feed the Port Vila grid as well as support for grid extensions to un-electrified peri-urban households. The site chosen for the 1 MW solar farm is near the existing wind farm at Devil's Point, Northwest of Port Vila. The initial funding was expected to have been derived from a combination of funds from the Government of Vanuatu, UNELCO and the EU. However, the Government of Vanuatu has been unable to provide the required co-finance for the project. This makes the status of the project unclear though it still appears likely to be implemented.

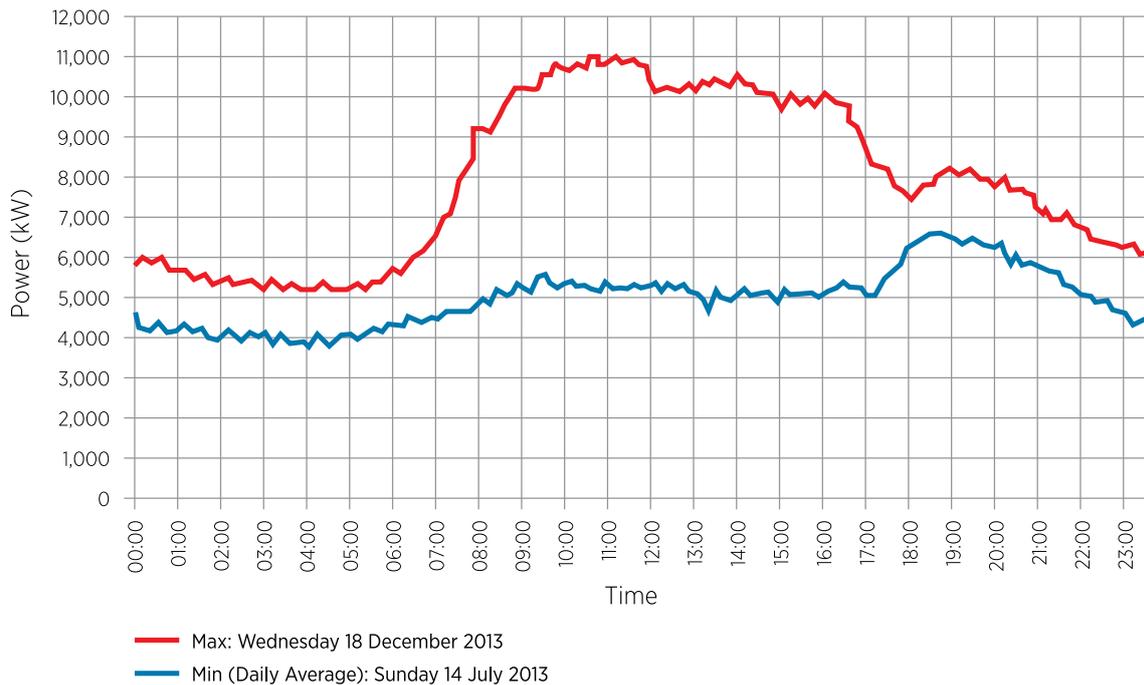
Vanuatu Sun Power has proposed a 1.1 MW solar PV installation Southeast of Port Vila near the Teouma River. It would be privately built and operated and is under consideration by UNELCO and the URA. If built, the installation would sell solar power to UNELCO through a PPA.

In 2014, the United Arab Emirates–Pacific Partnership Fund conducted a feasibility study to develop three grid-connected installations in Port Vila amounting in total to 501 kWp. These would include a 357 kWp ground-mounted solar panel array at Parliament House and a 44 kWp rooftop installation and 100 kWp ground-mounted installation at the Vanuatu Meteorology and Geo-Hazard Department (Meteo). When installed, annual fuel savings are estimated at USD 233,674 at current fuel prices.

As with the 1 MWp installation enabled by the EU fund, the United Arab Emirates–Pacific Partnership Fund project would have little impact on the tariff. The installations will be turned over to the Government of Vanuatu, which plans to sell power to UNELCO through a PPA. The project's total share of generation will only be a few percent. Any change in the tariff to be expected from this particular solar installation will therefore be low, even if the government sells the power to UNELCO at a low cost. However, the cost of solar generation is fixed for the productive life of the projects. This means that as diesel prices rise, the rate of tariff increases slows down. At present, Vanuatu primarily benefits from the planned grid-connected solar project by increasing its energy security through an indigenous energy resource and an improved export/import value ratio from lower fuel imports.

As shown in figure 4, the UNELCO load at Port Vila declines significantly and shifts its peak from day to night-time at weekends and during holidays. This makes it more difficult to match large scale solar generation with the load. Without energy storage, solar power appears to be a good match for the load on weekdays but a relatively poor match at weekends. If the proposed 2.6 MW solar power comes on stream, it may be necessary to take at least part of the solar power off stream at weekends and holidays. This would avoid stability problems caused by a 50% solar penetration of the load at midday that could occur on a sunny Sunday. Special control systems and/or storage batteries could be installed to allow full solar generation to be accepted by the grid. However, the cost-effectiveness of that option will need to be compared to any potential revenue loss resulting from taking a proportion of solar power off the grid at weekends.

Figure 4: Port Vila load curve for weekdays and Sundays (2013)



Source: UNELCO

The proposed 2.6 MW solar power will probably supply 10% of Vanuatu’s power needs. However, along with the existing renewable energy inputs from CNO, hydropower and wind, this should be enough to provide over half Vanuatu’s power generation through renewables. This would be more than 10% greater than the 2015 NERM target and less than 15% short of the NERM target of 65% by 2020. The development of hydropower and geothermal resources plus additional wind and solar inputs should make it possible to meet or exceed the 2020 NERM electricity generation goal.

Wind energy

Wind energy monitoring has indicated a resource of 7.2 metres per second (m/s) at a 55 metre hub height. As a result, UNELCO signed a contract to install eleven 275 kW Vergnet wind turbines on tilt down⁶ towers at Devil’s Point near Port Vila. This amounts to 3,025 kW of capacity developed with funding through the European Investment Bank. Output has varied considerably. The wind farm contributed 13.4% of UNELCO power generation in August 2012. The results are sufficient to indicate economic benefits from additional wind installations in areas showing reasonable wind speeds near population centres. UNELCO is considering adding up to four 275 kW wind turbines to the existing wind farm over the next year or two.

In 2012, the EU awarded a project to the NGO Vanuatu Renewable Energy and Power Association

(VANREPA) to install thirteen 420 W wind turbines with fold-down towers. These are located at Futuna and Aneityum in the South. The installations were to include batteries to allow for power storage. Although the equipment was procured and delivered, the EU terminated the project for non-performance, inadequate reporting and project management problems.

The project focused on installing wind turbines at key public institutions, and included the installation of battery banks with sufficient capacity to enable households to recharge home-based batteries. To manage this project, a Renewable Energy Service Cooperative was to be set up. A billing system for energy delivered to users and for maintenance services, rental of efficient lighting kits and household battery recharging was to be established to sustain the cooperative. Training would have been provided on the operation, maintenance, and financial management of the installed systems. The project was also to identify and promote new opportunities and income-generating activities for local entrepreneurs. The components are currently in storage. According to VANREPA, an additional USD 70,000 is needed to complete the installations and establish the necessary institutional structure.

To support the further development of wind energy, a number of wind survey masts are now in place collecting data. Through the Pacific Islands Greenhouse Gas Abatement and Renewable

⁶ These types of tower are needed to protect the turbines during cyclone passages.

Energy Project and the International Union for the Conservation of Nature Oceania Regional Office, the government has installed six 34 metre wind monitoring towers. These are in each of the six Vanuatu provinces, including Tanna, Tongoa, Malekula, Santo, Pentecost and Vanua Lava. Remote data logging is installed on some masts. They transfer data directly to the project office on a daily basis, making collection more reliable. In the second phase of the project, local governments are pursuing funding through the Secretariat for the Pacific Regional Environment Programme for technical assistance to analyse the data collected. This would be the basis for a wind resource assessment and map to confirm the resource potential.

Hydropower

Due to the relatively small size of the individual islands and their limited watershed areas, few permanent streams are large enough for cost-effective power generation by the utilities. By 2013, the only hydroelectric plant in Vanuatu connected to a utility was on the Sarakata River in Espiritu Santo and serves as part of the VUI generation mix (URA, 2010). It is a run-of-river type of facility with a 1.2 MW capacity.

ADB carried out pre-feasibility studies for two mini-hydropower sites in Vanuatu as part of its 'Access to Rural Energy' study. The Malahura site in Malampa province would include 1.2 MW capacity turbines with a dam and reservoir and 20 km of transmission lines. The Wampo River at the Santo site is proposed to be run-of-river with a 3 MW capacity and associated transmission lines. The proposal is to finance them both privately. However, no investors had shown interest by 2013, as the concessionary terms are not deemed attractive. As the first step in a feasibility study for another site, UNELCO has installed water flow monitoring equipment on the Teama River on Efate.

Besides these utility-grade projects, a few small village or facility-specific pico-hydropower units are in operation and more could be developed. On Maewo, a 75 kW micro-hydropower project made possible by Austrian and Italian funding through the International Union of Conservation of Nature is currently under construction. The first phase of the project concentrates on the civil works, which include the power house, and was due for completion by 2014. The second phase will focus on transmission, distribution and household connections. However, project completion is subject to funding availability.

Rural electrification activities

To support programmes seeking to provide electricity access in rural areas, UNELCO set to work on a Rural Electrification Master Plan in 2007 to examine over 3,000 sites. It identified 1,700

possible power generation sites that could provide electricity to rural populations. Detailed design work has been completed on 100 facilities. In 2007, the first project was launched in Port Orly, located at a remote part of Espiritu Santo, to provide CNO-fuelled electricity to 300 families. Technically, the project has worked reasonably well, though there have been problems with oil supply, and fuel filters have clogged up. The system runs for nine hours a day during the week and 15 hours on Sundays. The tariff is one of the highest in the Pacific at 150 VUV/kWh (around USD 1.60/kWh) and is charged through prepayment meters.

In 2003, VANREPA, a Non-government organisation, was established. The aim was to manage renewable energy projects for development partners and sell solar lighting kits and energy efficient stoves through its retail spinoff Green Power. Through Green Power, VANREPA teamed up with the Vanuatu Women Development Scheme to provide microfinance for pico-solar kits. A World Bank programme concentrating on pico-solar type devices helps fill the gap left when Australia cancelled the VERD project. These have panel capacities of around 5-30 Wp, one or two small LED lights and a mobile phone charger. These will be supplied to rural households. In line with the NERM targets, this USD 15 million programme is being developed to cover project preparation, technical assistance and investment. These systems may not be sufficient to provide power for rural economic development as it is generally defined. However, low cost devices of this type can provide at least some of the electricity services desired by rural households. If a system is set up to collect and properly dispose of spent batteries and other components, it can be a reasonable entry point for the provision of basic rural electricity services.

The World Bank concept also includes the provision of electricity access to approximately 600 schools and health centres in rural areas without access to electricity. This uses mini-/micro-grid solar installations that would provide alternating current power for office machines, education and health equipment.

2.6 INSTITUTIONAL FRAMEWORK

Department of Energy

Until early 2012, the Energy Unit within the Ministry of Land and Natural Resources was responsible for energy programmes in Vanuatu. The unit was then renamed the Department of Energy, Mines, and Mineral Development. However, its energy section remained understaffed with only three permanent employees and a small but varying number of short-term staff paid by specific projects.

In early 2013, a new Ministry of Climate Change Adaptation, Meteorology, Geohazards, Environment and Energy was formed. It included the new DoE strengthened by new recruits. This was responsibility for formulating and implementing energy policies and legislation, managing energy projects, and working with development partners to prepare projects that need funding.

For many years, the government has faced major energy challenges in the form of high electricity costs and limited electricity coverage. Except for concession areas served by UNELCO and VUI, it is responsible for rural electrification, including supervising facility design, installation, finance and O&M. Given its very limited financial resources, the government has previously dealt mainly with externally funded, small-scale renewable energy technologies. In recent years, renewable energy projects have been financed primarily through the Sarakata Special Reserve Fund (ALM, 2009), using fuel savings from the 1995 Japanese-funded, UNELCO-operated hydroelectric system near Luganville. To replenish the fund, customers were charged at the regular diesel generation rate. The value of the fuel saved by the hydropower installation was placed in the fund to finance rural electrification projects, including grid extensions and payments for Luganville street lighting. However, an audit of the fund by the regulatory authority in 2010 found major discrepancies, so the fund was frozen and deactivated. In 2014, the government agreed to allow the money still in the fund to be used to cover its share of the EU Energy Facility project for CNO development for the electrification of villages in the provinces of Torba, Penama, and Malampa.

Utilities Regulation Authority

With support from Australia, URA was established in 2008 to regulate the utilities. On the basis of the 2007 Utility Regulatory Authority Act and its 2011 amendment, it primarily manages the electricity concession agreements and the utilities operating in those concession areas. URA itself consists of three commissioners appointed in writing by the minister in charge of finance. At least two of the commissioners are citizens of Vanuatu. URA has greatly strengthened regulatory supervision of the private utilities operating in concession areas, and has also greatly increased the transparency of tariff adjustments and utility operations. The performance of Vanuatu utilities is monitored under the Utility Regulatory Authority Act. Any cost savings arising are to be passed on to consumers through tariff adjustments mandated by URA. The tariffs are designed to allow for full cost recovery and a reasonable profit for the utilities. At the same time, they meet the government's needs in providing affordable electricity access for the

maximum number of Vanuatu inhabitants in the concession areas.

URA is facing new challenges now that larger-scale renewable energy systems are feeding the grid, both managed by utilities and privately owned. These large-scale renewable systems will increase the complexity of setting tariffs, particularly regarding solar and wind generation, which are variable renewable energy sources. In recent months, it has published net-metering and FIT regulations for private sector grid-connected renewable energy generation. These apply to small-scale installations like solar generators on residential rooftops, and larger-scale Independent Power Producers (IPPs) that will operate under a PPA with the utilities.

A third area of future concern is the need to establish and enforce safety and technical standards for small public electricity systems installed in rural Vanuatu outside existing utility concession areas. Although basic electrical utility standards have been established using an Australian model, adjustments may be necessary to meet conditions specific to Vanuatu. In future, community and local government diesel mini-grids may be converted to solar power. The proliferation of many different types of designs for these mini-utilities would make maintenance costly, as it must then be tied to the company that sold and installed the equipment. To avoid this problem, technical standards and design guidelines for mini-grids, particularly those powered by solar, may need to be created and enforced. This will help ensure the installations are consistent in design, and thereby also in maintenance, and will use components known to function satisfactorily and reliably in the Vanuatu environment. Furthermore, standards and guidelines of this kind help training institutions focus maintenance training on common design approaches across Vanuatu. This would make maintenance less costly and more readily available.

2.7 ENERGY POLICIES

National Energy Policy 2009

In 2000, the Council of Ministers endorsed a vision for a 100% renewable energy economy by 2010, but no significant follow-up activities resulted. An energy policy and action plan, the National Energy Policy Framework, was prepared and endorsed by the Council of Ministers in August 2010. This process was assisted by the Pacific Community's Applied Geoscience and Technology Division. The policy includes:

- reliable and affordable modernised forms of energy for rural areas

- institutional reinforcement
- reliable and affordable urban electricity
- renewable energy promotion
- promotion of CNO as a biofuel through tax incentives, national biofuel standards and support for the coconut industry
- promotion of energy efficiency and conservation

Although the 2009 Energy Policy is technically still in effect, its components have been incorporated into NERM. This has become the primary basis for energy planning and policy.

National Energy Road Map 2013–2020

The Vanuatu NERM was endorsed by the Council of Ministers and publicly launched in 2014 as the primary guiding document for energy planning. Building on the National Energy Policy Framework and associated strategy, it sets out targets and priorities for energy delivery, increased electricity access, affordability and energy security. It identifies policy, legislative and regulatory changes needed to enable the required investment in the energy sector. This RRA aims to assist the government in developing an action plan to reach the NERM goals.

The energy sector targets for 2020 are important NERM components, as follows:

- electricity production: 40% of generation from renewable energy by 2015 and 65% by 2020
- a 10% improvement in diesel generation efficiency by 2015 and 20% by 2020
- access to electricity within concession areas: 75% of households connected to the grid by 2015, 90% by 2020 and 100% by 2030
- access to electricity close to concession areas: 33% of households connected to the grid by 2015, 90% by 2020 and 100% by 2030
- access to electricity in off-grid areas: 100% household access to electricity via individual home systems and basic power services by 2020
- access to electricity for public institutions: 90% access by 2015 and 100% by 2020
- petroleum costs: reduce the distribution cost of petroleum products by 5% in 2015 and 10% in 2020

- petroleum standards: improvements in health, safety and environmental standards to be met by all operators by 2020

NERM is intended to be the basis for attracting and coordinating contributions to the energy sector by development partners in Vanuatu in order to reach the above targets.

Meeting the NERM targets will help mitigate climate change by replacing fossil fuels with renewable energy, but affordable energy is its major focus. As it states: *“...rather than an agenda of promoting renewable energy driven solely by global climate change concerns as an end in itself, increasing the share of renewable energy substantially in Vanuatu - on and off-grid - is expected to be the least-cost way to developing the sector.”*

2.8 HUMAN CAPACITY

The Energy Policy, the Rural Electrification Master Plan and NERM were created with local inputs from stakeholders and strong support from outside Vanuatu. The use of external capacity is required since there is insufficient local capacity to carry out the tasks. These development partners can be expected to continue to work with the Government of Vanuatu towards meeting the NERM targets and implementing the policies. However, the capacity both in government and in the private sector to sustain the benefits once they are achieved is limited and needs to be rapidly developed. In particular, capacity building for government institutions in data acquisition, analysis and data management is needed. Additionally, training in the use of existing computer models for renewable energy development, including HOMER and Retscreen, would be of value.

The rapid increase in off-grid installations that include SHS and solar mini-grids will require extensive training in solar system installation and maintenance. Existing training institutions in Vanuatu will need help in developing and conducting training courses. This will prepare Ni-Vanuatu for operating and maintaining the large numbers of off-grid renewable energy generators and small-scale distribution systems intended to meet local needs in rural areas.

While equipment and system design standardisation will make the training programmes easier to design and introduce, training needs remain substantial. Local language training in the required technical fields will thus need to be developed within secondary and tertiary technical training institutions.

Furthermore, training in small business development and operation will be required to support the facilities implemented under NERM and other energy development programmes.



Wind Farm/Shutterstock

III. SCALING UP RENEWABLE ENERGY: RECOMMENDATIONS AND CHALLENGES

The scale-up of renewables in Vanuatu is driven forward by two interrelated fronts: high electricity tariffs and the low overall rate of access to electricity. Electricity is without doubt an important prerequisite for improving living standards and economic growth.

The electricity needs can be met by scaling up renewable energy applications in Vanuatu. This is thanks to the rich renewable energy resources the country benefits from, as well as the dramatic decline in the cost of several renewable energy technologies. This is the basis for the Government of Vanuatu's NERM renewables target of 65% of electricity generation by 2020.

However, reaching the targets would need more actively engaged players from the private sector to deploy and operate additional renewable energy systems. This would require immediate action with support from both government and development partners. They need to overcome the key obstacles affecting private sector participation in renewable energy development on both technical and non-technical fronts.

The actions required to reach the NERM targets were discussed in stakeholder interviews and group discussions. Although many actions are in progress, three areas of concern were acknowledged to be of high priority for further development to reach the NERM targets. These are as follows:

- policies and coordination for effectively implementing NERM
- grid-connected renewable energy development
- off-grid renewable energy development

3.1 EFFECTIVE IMPLEMENTATION OF N.E.R.M.: POLICY REVIEW AND DEVELOPMENT-PARTNER COORDINATION

Context

Energy development in Vanuatu is largely the result of DoE, URA, utility, development partner and private sector actions. To meet the NERM targets, effective cooperation and coordination of these stakeholders will be necessary. Each stakeholder must have clearly defined authority and responsibilities under the legislative frameworks for achieving the NERM targets.

The RRA workshop discussions have shown that the existing legislative frameworks and policies are largely adequate in terms of developing desired renewable energy action and projects needed for NERM implementation. However, some revisions may be needed. In particular, legislation is lacking related to institutional responsibility for off-grid standards and structures. Also lacking is a legislated basis for DoE, thereby making it more vulnerable to radical changes in its structure according to changes in government.

Challenges

Within the political and development partner framework, the following challenges need to be addressed:

- To carry out the actions necessary to achieve the NERM target, the relatively new DoE and URA may need additional authority and resources. There is a need for greater clarity on the institutional roles, functions and responsibilities of each of these two important entities. The capacity they should build to take the actions needed to achieve the NERM targets requires greater clarity.
- Effective coordination of development partner activities has been a persistent challenge. Renewable energy projects have been largely driven by donors with a lack of effective coordination between each another. This has often resulted in the isolated implementation of individual projects that would have otherwise benefited from sharing experiences. If development partner resources were deployed more effectively, project results would be more sustainable. Another problem caused by ineffective intra-donor coordination is the lack of standardisation in project designs and components. This means it is challenging to build local installation and maintenance capacity and develop a proper inventory of spare parts needed to sustain project operation supported by different development partners.

Recommended actions

Action 1: review enabling legislation and policies relating to URA and DoE powers and duties

An overall review of existing legislation and policies is needed, with the aim of proposing required changes and additions. This will clearly define the necessary DoE and URA institutional authority and responsibility to properly carry out the actions to achieve the NERM targets. The review can be carried out jointly with other key stakeholders.

This would be particularly applicable for rural electrification, given that it suffers from a significant lack of coordination and regulation. For example, it has been widely recognised that off-grid SHS and solar mini-grid installations are unlikely to be sustained without proper standardisation and institutional supervision. However, the legislation justifying URA focuses on utility regulation, and may not allow it to establish standards or regulations for private off-grid self-generation. Enabling legislation may be necessary to allow URA to extend its regulation to establish off-grid standards and design guidelines for SHS and mini-/micro-grids used for self-generation. If that is not considered an appropriate task for

URA, the legislation should give another agency the authority and responsibility to set and enforce standards and guidelines for off-grid solar. DoE could be a suitable candidate for this task.

Action 2: support URA and DoE roles in fulfilling the NERM

An operational plan including human resources, physical requirements and financial resources and their budgets would naturally follow from a definition of the institutions' roles and responsibilities. This would enable the two agencies to carry out the programmes and take action to achieve the NERM targets. The operational plan would provide a basis for DoE and URA to communicate with the Government of Vanuatu and/or development partners to seek budgetary support. The resources sought in the proposed plan should be adequate to implement the planned actions through to 2020 to ensure targets are reached.

Action 3: facilitate coordination among development partners

In partnership with URA, DoE should prepare project documents designed to carry out the actions needed to reach the NERM targets, and circulate them among development partners for their input and commitment. This would effectively use the resources from the development community. Working closely with donor agencies would help ensure that renewable energy projects are implemented in a coordinated fashion. This not only reduces any overlapping efforts but also makes sure the national technical standards are applied by project implementers/developers.

3.2 GRID-CONNECTED RENEWABLES

Context

Thus far, wind development has been largely limited to Devil's Point near Port Vila, the site of a 3 MW installation. Expansion is planned for 2014 and 2015.

Only relatively small solar generation systems have been connected to the grid, and all of those are owned either by a utility or government. Installations by commercial or residential users or investors and developers have yet to appear. As discussed above, it would make sense to draw on private sector resources to scale up investments in renewable energy so the target of 65% by 2020 is achieved cost-effectively.

Following the RRA workshop, URA announced its preliminary decision on net-metering and FITS

in May 2014 and requested public comments. Following that feedback, a final order was issued in August 2014. This allows low voltage small commercial and residential customers to connect their private solar installations to the grid, provided the installation complies with technical standards. As a further measure, URA also announced its decision in June 2014 to pursue the development of regulatory guidelines for IPPs and PPAs. This is considered an important step towards opening up the power market to IPPs on the Port Vila grid. Another 1.5 MW solar generation capacity is proposed for the Port Vila grid over the next few years. An IPP of 1 MW would be expected to provide this, with the rest from the Government of Vanuatu. Additionally, URA has received an application to install a private 1.1 MW solar plant through an IPP. Negotiations for a PPA will be needed if the decision is made to proceed with this development.

Challenges

Although the UNELCO 3 MW wind farm is successful, adding the proposed 2.6 MW solar installation along with another 1.1 MW wind capacity may cause problems for the Port Vila grid. If a large number of small-scale solar PV installations are also connected to Port Vila distribution lines, they will cause additional concerns from a technical perspective. This is explained below.

- The capacity of each grid to accept electricity inputs from variable renewable energy sources at various points on each grid is unclear. Distributed generation, typically involving rooftop solar PV, might raise less concern about instability in the grid compared to large-scale solar/wind farms configured as centralised power generation facilities.
- There are no published standards for grid-connected renewables specifically for Vanuatu, although a blanket basic standard that follows those of Australia is in effect. Clear regulations, technical standards specific to Vanuatu's environmental conditions, operational standards and the legal basis for interconnection with the concessionaire's grid need to be made clear to all parties. This would help develop significant private sector involvement with IPPs and net-metering.

Besides these technical matters, the utilities also have financial concerns regarding grid-connected generators owned by customers. This is because the installations will, in effect, take those customers off the grid, while still expecting the utility to provide backup power on demand.

A further challenge is the lack of experience in running grid-connected renewable energy systems

within Vanuatu's commercial and industrial sector. Building capacity to support the installation and maintenance of these systems will be necessary if they are to be sustained in the long term. Capacity building may also be needed within the utilities to prepare staff for inspection, standards enforcement and monitoring renewable energy installations.

Financing investment in small-scale renewable energy generators for buildings is a final challenge. In particular, the government will need the financial resources from development partners to install renewable energy generation on government facilities. The private sector will need banks to supply affordable finance to install renewable energy generators on its buildings.

These concerns translate into private sector challenges, which could jeopardise investor confidence for investing in grid-connected distributed generation from variable renewable sources. Such issues should therefore be effectively addressed.

Recommended actions

Action 1: conduct a grid assessment study focusing on grid stability

A computer model of the grid (Port Vila, Luganville, Tanna and Lakatoro) needs to be constructed. This will allow the Government of Vanuatu and utilities to determine and predict the effect of potential irregular input changes at entry points on the grid when solar or wind generation is connected. The model will help utilities assess the extent of the impact and will help prevent them from arbitrarily refusing a connection because of its unknown effects. Each of the grids therefore needs to be assessed and modelled using an appropriate software tool. The model will help the utilities predict the effect of rapidly fluctuating input changes at any point on their grid. It will help the Government of Vanuatu ensure that connections are not arbitrarily denied without clear cause.

To make the model results more useful, a comprehensive grid evaluation is required including the present state of the infrastructure and quality of service. This would minimise potential grid operation issues caused by variable renewable energy sources.

The completion of this proposed study should be followed by a training programme. This would equip the utilities with the knowledge necessary to use the model and understand its results. They could then predict the effects of different types and sizes of renewable energy generators to be

connected to the grid at various points. Utility staff will also need to be trained in modifying the model when there are changes to the grid. Given the lack of experience in this area in Vanuatu, technical assistance will be needed to both develop and apply the model.

Action 2: prepare and publish comprehensive standards for grid-connected renewables specific to Vanuatu conditions

In association with UNELCO and DoE, URA needs to establish specific standards relating to equipment used for private grid-connected renewable energy generation, systems design and construction, and grid connection techniques. These standards may largely be the same as those used in Australia. However, changes and additional sections are probably required to address the difficult environmental conditions found in Vanuatu. This includes salt corrosion, high humidity, high ambient temperatures and cyclones.

Action 3: training and capacity building

Local contractors will need to be trained to understand the standards and guidelines for renewable energy installations and competently build and maintain the systems. Capacity for inspection and monitoring, as well as compliance activity to confirm that installations continue to comply with applicable standards and are safe for grid connection. For the capacity building to be available for the long term, it will be necessary to work with local training facilities. These include Vanuatu National Training Council, Vanuatu Institute of Technology and the Vanuatu Rural Development and Training Centre Association, among others. They can provide training relevant to the renewable technologies utilised. Programmes for training and certification of solar technicians exist within the Sustainable Energy Industries Association of the Pacific Islands (SEI-API) framework and could be used in Vanuatu. However, minor modifications may be needed to adapt them to local conditions.

Action 4: finance for private sector installation of grid-connected renewables

If the NERM targets are to be reached, the Government of Vanuatu should consider using the funds provided by development partners to finance grid-connected solar generators on its own office buildings.⁷ This process has already begun since the United Arab Emirates funded grid-connected solar projects for the government's Meteo office and the parliament building. In addition, the Government of Vanuatu should consider working with local banks

to access low interest funds that can be provided by multilateral development banks. These can make arrangements for financing the purchase and installation of private grid-connected renewable power generation.

3.3 Off-grid renewables

Context

The NERM goals include access to electricity for 100% of households by 2020 through individual home systems and basic power products. Approximately 67% of Vanuatu households have no access to electricity; around 17% of these are urban and 83% rural. If VERD can be funded by the Government of New Zealand through the World Bank, it looks as if it will be possible to achieve this particular target under NERM.

Challenges

Perhaps the biggest challenge to off-grid renewable energy systems is sustaining them. The critical rural electrification challenge is not so much technology but rather the lack of good institutional structure and human capacity to provide the proper O&M.

Given the remoteness of Vanuatu rural communities and their lack of economic activity, special attention must be given to the type of institutional arrangements for sustaining rural energy systems. These should place emphasis on the maintenance of the energy system and the provision of sufficient funding for its operations. Furthermore, the NERM operational plan needs to support DoE institutional capacity for implementing and sustaining projects. This action plan must take into account the allocation of resources to enable a critical review of DoE institutional structure and staff needs. This is because the current DoE structure is designed to support VERD implementation - not that of NERM.

The remoteness of the installations is a clear disadvantage. It makes O&M challenging from both technical and non-technical perspectives. The effectiveness of different business models depends on specific local settings. In Vanuatu, it looks as if community and end-user O&M has not worked. Despite project designs that have included arrangements to collect sufficient money from users to pay for all O&M costs, user payments have not been consistent. In some cases, the funds collected have typically been used for other purposes. As a result, most of these projects cannot be sustained once batteries collapse. The battery is a crucial component of the system, and ensures the availability of electricity when

⁷ Often air-conditioned, thus consuming a large amount of electricity.

the renewable energy resources are low or not available at all. However, the need for batteries increases the cost of energy delivered by the installation, and greatly increases the cost and difficulty of sustaining off-grid installation. It also adds a layer of environmental management. This is because lead-acid and nickel-cadmium batteries in particular are an environmental hazard if not disposed of properly. Implementing a system for recycling spent batteries is a difficult but essential part of the off-grid electrification process, but this has yet to be addressed.

There are other major concerns. One is the lack of national standards and guidelines for designing off-grid solar or wind systems for public installations like schools and health centres. Another is O&M of privately owned renewable energy equipment used for supplying electricity to private premises. As a result, each project created to install solar or wind systems is likely to use different components, different installation standards and different approaches to keeping the installations going.

This means it is difficult and expensive to devise training programmes and ensure local shops and contractors to stock sufficient spare parts. Moreover, the lack of standards and design and maintenance guidelines may lead to the promotion and use of components unsuited to the Vanuatu environment.

Major investments in rural tourist facilities are anticipated, because tourism is growing, particularly in areas distant from existing grids. Facility developers for off-grid tourism are likely to propose diesel generation to meet electricity demand. Today, solar mini-grids can provide cheaper power than diesel in rural areas, and should be promoted by DoE instead of small diesel-powered grids. However, the lack of maintenance and installation capacity in rural areas will need to be overcome to achieve widespread acceptance of solar mini-grids for off-grid tourism facilities.

Recommended actions

A workable institutional structure is needed for a number of purposes. These include sustaining off-grid installations, creating and enforcing necessary standards and guidelines, capacity building to develop skills for design, installation and O&M, and encouraging private investment in off-grid renewable energy. The following actions are proposed to address this issue.

Action 1: design an institutional approach for sustaining SHS off-grid electrification of households and public buildings

An institutional structure is required to meet the need for sustained O&M of off-grid renewable power systems at an acceptable cost to end-users. The community O&M approach tried without success in Vanuatu has also not worked well elsewhere in the Pacific. DoE should review the institutional approaches used in Fiji, Tonga, the Solomon Islands and Kiribati that have been relatively successful in sustaining rural SHS installations. It should work with them to design a structure adapted to Vanuatu. Over 10,000 SHS installations (ranging from 100 Wp each in Kiribati to 200 Wp each in the Marshall Islands) provide enough electrical services for users to have multiple lights, radios, and mobile phone and portable light charging.

They can provide a level of service comparable to that usually accessed by households connected to rural grid extensions, and can therefore be considered full rural electrification.

The most successful institutional approaches have used a combination of external and local support. They include arrangements to collect reasonable O&M fees, either as cash or, in the case of the Solomon Islands, in the form of agricultural produce or handicrafts with a known value. Technical support may be provided by a contractor, as in Fiji, or by a locally trained person supported by the energy ministry, as in Tonga. Alternatively this could be supplied by an organisation specifically formed to support rural solar installations, as in Kiribati and the Solomon Islands. The experience of these countries has been shaped over more than two decades of trial and error. This should be used when designing an institutional structure for SHS and mini-/micro-grid rural solar implementation best adapted to Vanuatu conditions.

Despite this, Vanuatu is unique in the Pacific because it has a large remote off-grid rural population with a high mobile phone penetration. The mobile phone network could be useful in developing a methodology for sustaining SHS and other forms of off-grid electrification as well as for communicating support requests. This could form a solid foundation for creating a workable institutional approach to sustaining SHS for off-grid electrification. Allowing customer payments through the mobile phone network should also be considered.

Action 2: develop standard designs for SHS and solar mini-grids

For long life and reliable service, off-grid designs need to fulfil environmental requirements while meeting the loads of Vanuatu rural public facilities and households. The designs for SHS and solar mini-grids should be modular so that installations of various sizes can be produced using the same components. This approach can help ensure that end-users receive the appropriate size of installation for their needs and that maintenance requirements can be satisfied at the lowest possible cost.

This is important for the coordination of overall donor activities relating to the renewables sector. It also helps develop government institutional capacity to sustain the operation of the energy system. Projects are often driven by donors, but very little is done to coordinate their activity. This has led to different system designs for each project and difficulty in maintaining the systems in the long term. Standard designs for renewable energy projects will help ensure effective coordination and will allow resources and experience to be shared. This can benefit DoE, private sector contractors and individual projects.

In recent years, the solar power cost has fallen sharply. Solar mini-grids now usually have a lower generation cost than rural diesel generation. They should thus be the preferred option for village electrification, remote tourist facilities or the electrification of larger rural public facilities like hospitals and schools.

DoE should work with suppliers and external experts to prepare a standard modular design that would work well in Vanuatu for these types of installations.

A standard modular design would consist of a specified set of panels, batteries, charge controllers and, in the case of mini-grids, stand-alone inverters for power production. The standard design should be very specific and include only components selected as appropriate for Vanuatu. Development partners and private investors should be required to meet these standards. To obtain increased power levels, multiple standard modules can be connected to expand the capacity of the overall system. Through this modular approach, maintenance can be standardised, spare parts stocks more easily maintained, and construction greatly simplified.

A standard modular design for mini-grids of this type has been created by the New Zealand Ministry of Foreign Affairs and Trade. It has been used to

convert diesel mini-grids to solar in Tokelau, the Cook Islands and Tuvalu, and could be applied to Vanuatu with only minor modifications.

Action 3: enhance capacity for sustaining off-grid solar technology

It is not practical for contractors, government or the utilities to provide the necessary training on a regular, continuing basis. Vanuatu has local educational institutions aware of the need. If properly supported, they can do a good job of providing this training.

It is recommended that the necessary courses for off-grid SHS installations and solar mini-grids be developed through local educational institutions. These courses need to become available within long-term training programmes for solar PV installers and maintenance personnel. Due to the use of battery storage and high current, low voltage direct current inputs, this training will be substantially different from that required to sustain on-grid solar generation.

Action 4: develop a strategy for increasing access to electricity in rural areas

In association with the World Bank programme for expanding rural electricity access in Vanuatu, a detailed strategy is recommended to rapidly increase renewable power provision to rural households and villages. A review of past programmes is critical to determine the reasons for their problems and failures.

Strategies should be developed to expand rural electrification in a programmatic and rational manner that will efficiently use the resources available. Furthermore, identifying selection criteria for the type of electrification best suited to the target areas is required. This will determine whether village electrification should take the form of a solar mini-grid, SHS on an individual household, a grid extension to the area, pico-solar device distribution or some combination of these.

Action 5: conduct an off-grid electricity market study for tourism

To evaluate the market for solar mini-grids, it is essential to work with tourism authorities and the private sector. Only then can solar mini-grids replace diesel generation in tourist facilities. If market demand is sufficient, a programme must be established to promote the installation of solar mini-grids in newly constructed facilities. The programme should include attractive finance arrangements for the private sector for such installations.

IV. THE WAY FORWARD: STRATEGIES AND ACTION

The following table identifies the recommended actions emerging from the RRA that are not already being implemented. While the RRA brings together the widest possible range of stakeholders to identify and discuss renewable energy in Vanuatu, this activity is only a snapshot of the situation. It includes recommendations at the time of the RRA.

Many other issues and actions needed are undoubtedly present and must be taken into account. While the assembled stakeholders recognised these actions as important, they are not in any particular order of priority.

Table 3: Overview of recommended actions emerging from the RRA

<p>Policy, regulation and legislation: identify any gaps in background policies, regulations and legislation that may cause failure to reach any of the NERM targets</p>	<ul style="list-style-type: none"> • review enabling legislation and other documents relating to DoE powers and duties and align them with NERM needs • support URA and DoE roles in NERM • facilitate coordination among development partners
<p>On-grid renewable energy: actions to work towards the NERM target of 65% of electricity generation from renewable energy</p>	<ul style="list-style-type: none"> • prepare dynamic models of the Vanuatu grids • prepare and publish comprehensive standards for grid-connected renewables specific to Vanuatu conditions • train and build capacity of local contractors and monitoring officials • finance private sector installation of grid-connected renewables
<p>Off-grid electricity access: actions to work towards the target of 100% access in Vanuatu by 2020</p>	<ul style="list-style-type: none"> • design an institutional approach for sustained operation of SHS for off-grid electrification of households and public buildings • develop standard designs for SHS and solar mini-grids • build capacity for sustained off-grid solar technology • develop a strategy to increase access to electricity in rural areas • off grid market study

These recommended actions have been combined where possible. Seven major activities have been defined to help create the foundations for renewable energy development and support NERM. The strategy is not to create specific hardware implementation projects but rather to minimise the barriers to implementing sustained renewable energy projects. The activities selected are described below.

ACTIVITY 1

Ensure that the policies, regulations and legislation are in place as needed to support NERM

Sector(s)	Policy, regulation and legislation
Description	<p>NERM is the driving document for renewable energy with its very specific targets and time scale. The necessary policy, legal, regulatory and implementation structure is needed to achieve the targets. The two primary actors in implementing NERM are DoE and URA. This activity is intended to help ensure that these two institutions have the resources and legal support to carry out their respective tasks.</p> <ul style="list-style-type: none"> • Determine the activities necessary to complete NERM and reach its targets. Review those activities and define the actions, responsibilities and associated authority needed by DoE and URA to fulfil their roles. • Write the necessary regulations, policies and legislation to allow NERM to be implemented properly to meet its targets. • Obtain and provide the resources considered critical for DoE and URA to carry out all the activities necessary to meet the NERM targets
Actors	DoE, UNELCO, VUI, URA, Ministry of Finance, Ministry of Justice and Social Welfare, World Bank, other development partners
Timeframe	12 months
Keys to success	<p>As a key precondition, NERM must be considered one of the very highest priority government actions. Availability of the relevant resources will depend on the priorities the government sets for implementing NERM.</p> <ul style="list-style-type: none"> • effective cooperation, coordination and collaboration among stakeholders • external expertise made available to assist as needed through development partner support

ACTIVITY 2

Prepare dynamic models of the four concession grids to evaluate the acceptability of connecting solar or wind at various grid entry points

Sector(s)	On-grid renewable energy
Description	<p>Each of the four concession grids has different characteristics and will react differently to external inputs from renewable generators. Each of the grids should be modelled using internationally recognised software. This needs to provide a reliable prediction of the dynamic response of the grid to renewable energy inputs of various types and amounts at any point on the grid. This will help the utilities determine whether proposals for additional generation from IPPs of all sizes can be accommodated safely on the grid without causing any concern for grid stability. Training will also be required on the use of the model and its applications to match any modifications made to the grid.</p>
Actors	UNELCO, VUI, development partners
Timeframe	8 months
Keys to success	<ul style="list-style-type: none"> • availability of data from the utilities for input into the model • adequate funding to model all four grids • use of a model complex enough to provide dynamic response data, and simple enough for use by local utility personnel following reasonable on-site training

ACTIVITY 3

Create national standards for on-grid solar installations

Sector(s)	On-grid renewable energy
Description	Standards and design guidelines are needed for grid-connected renewable energy installations. This will ensure that renewable energy implementation by development partners and private developers/ investors is appropriate for Vanuatu. It will minimise the variety of designs and components installed throughout the country. With design standardisation, components and activities based on best practice compiled from the Pacific region and the rest of the world, O&M costs can be minimised and training requirements simplified. This would also help provide a level playing field for investment by locking out cheap but low quality installations that may pose a hazard either to the owner or the utility.
Actors	DoE, UNELCO, VUI, URA
Timeframe	18 months
Keys to success	<p>Technical standards for grid-connected renewable energy systems that focus on safety and general good practice can be based primarily on industrialised country standards. They can be sourced from Australia and New Zealand, Europe or the US. Specific design guidelines should be based on successful implementations of similar systems within Pacific islands with tropical, wet, hot and salty environments and occasional cyclone passages. Assistance from SEIAPI and development partners will be useful as well as ‘South-South’ discussions with other Pacific island countries and territories that have renewable energy standards in place.</p> <ul style="list-style-type: none"> • Before any standards can be set, an agency must be named by the government to develop and enforce them, presumably either DoE or URA. That agency will need to take the lead in establishing standards. • Support from development partners will be needed to enable the necessary interactions with other Pacific island communities and SEIAPI. • Standards and guidelines need to be set up as quickly as possible to clearly define the renewable energy market before the implementation of large-scale NERM commitments has begun.

ACTIVITY 4

Create an institutional approach for off-grid SHS and mini-grid system O&M based on prior experience in other Pacific island countries and territories, as well as failed projects in Vanuatu.

Sector(s)	Off-grid renewable energy
<p>Description</p>	<p>Throughout the Pacific, off-grid solar installations have rarely lasted long. This is mainly because of the lack of an institutional structure responsible for obtaining and retaining the funds necessary to replace exhausted batteries. For a 200 Wp SHS, for example, a monthly collection of VUV 700 per month can accumulate enough to replace a good quality battery at the end of its 7-10 year life. However, it has proved to be very difficult both to make the necessary collection from users and prevent the collected money to be used for other purposes. The same problem has occurred with public facilities using solar mini-grids and larger SHS installations. Over the past 20 years, countries with a large number of off-grid installations have evolved institutional structures that provide reasonably well for long-term maintenance and battery replacements. Access to Tongan, Fijian, Solomon Island and Kiribati experience would be very useful to inform off-grid electrification that includes SHS and mini-grids on schools, health centres and some households. It would help create a design for an off-grid institutional structure that could function well in Vanuatu.</p> <ul style="list-style-type: none"> • Promote and participate in a symposium dedicated to communicating both successes and failures in sustaining systems in countries with large numbers of off-grid solar installations. • Draw on the experience of mobile phone operators with off-grid facilities, as well as those using solar to power those facilities. Specifically, their experience of remote solar power system O&M should be considered when designing the off-grid management institution.
<p>Actors</p>	<p>DoE, local contractors, Digicel, Telecom Vanuatu, URA, Ministry of Education, Ministry of Health</p>
<p>Timeframe</p>	<p>10 months</p>
<p>Keys to success</p>	<p>The Ministry of Education and the Ministry of Health are to receive large numbers of solar installations for rural facilities and for staff households of those facilities. They must agree to support the sustainable operation and maintenance of solar power systems in those facilities.</p> <ul style="list-style-type: none"> • Information from other Pacific islands and from local off-grid solar projects is used for criteria to design the institutional approach for Vanuatu to avoid unnecessary repeated mistakes made in other Pacific islands. • The structure created needs to have its own resources allocated and not depend on other agencies

ACTIVITY 5

Prepare a standard, modular design for SHS suited to a wide range of requirements

Sector(s)	Off-grid renewable energy
Description	SHS are the mainstay of off-grid rural electrification in remote rural areas for most Pacific island countries. However, keeping them running in the long term has been difficult. The inconsistent use of components and designs has been one serious problem with SHS in several island countries, including Vanuatu. This makes it difficult to provide training for maintenance personnel and stock spare parts. In particular, the use of different batteries for different installations has made proper battery replacement difficult, since spare batteries have limited shelf life and are expensive to stock. Where possible, all installations should thus use the same standard batteries connected in different ways to achieve different system capacities. For example, a basic design can be created at 12 V, an intermediate one at 24 V and a large one at 48 V. Each can use the same battery unit but doubling system voltage will also double the kWh capacity of the SHS.
Actors	DoE, UNELCO, VUI, URA, local contractors, development partners
Timeframe	6 months
Keys to success	<p>The designs should be based on Pacific island experience. All components must be known to provide reliable service and meet the stringent environmental requirements of the islands.</p> <ul style="list-style-type: none"> • It is impractical to maintain a large stock of spare batteries. It is therefore important that the same model of battery is used for all installations, and that the chosen battery is readily available off-the-shelf from suppliers. • Because of the high cost of accessing remote sites for service and component replacements, only high quality components used in a conservative design should be considered.

ACTIVITY 6

Prepare a standard, modular design for solar mini-grids suited to a wide range of requirements.

Sector(s)	Off-grid renewable energy
Description	<p>Solar mini-grids have been successfully used to replace small diesel power systems. It appears likely, therefore, that a number of solar mini-grids will be installed for rural public buildings and off-grid tourist and commercial establishments over the course of NERM. Based on past experience in the Pacific, a key component to their success is availability of capacity to properly install and maintain the systems. This is a very serious issue for rural Vanuatu given the difficulty of access to many rural sites. To ensure adequate capacity for their installation O&M in place, there needs to be reasonable commonality in the design and choice of components for solar mini-grids. A number of simple units consisting of modestly sized individual solar generation modules can be combined to create a complete solar mini-grid system well into the hundreds of kilowatts. This has been shown by New Zealand in its support of outer island solar mini-grids for Pacific island communities. This modular approach allows installation and maintenance training on a fixed, consistent, single small generation module design rather than a wide range of systems of varying sizes and configurations. This approach also greatly reduces the need to maintain a stock of a wide variety of spare parts to suit varying system sizes.</p>
Actors	DoE, UNELCO, VUI, URA, local contractors, external experts, development partners
Timeframe	6 months
Keys to success	<p>The designs must be based on Pacific island experience that clearly demonstrates all components can meet the stringent environmental requirements of the islands while still providing reliable service.</p> <ul style="list-style-type: none"> • enter into discussions with the New Zealand Ministry of Foreign Affairs and Trade regarding its standard design for remote island mini-grids • representatives from Vanuatu, preferably including local contractors, should visit installations in either Tokelau, Cook Islands or Tuvalu that follow those standard designs • obtain the required funding for field visits and external expertise

ACTIVITY 7

Capacity building for on-grid and off-grid renewable energy technologies

Sector(s)	On-grid and off-grid renewable energy
Description	To meet the NERM targets, a number of on and off-grid installations will be required. While installations owned by the utilities can use in-house capacity, little capacity exists outside the utilities that can provide proper installation and maintenance of these renewable energy systems. Training on the standard hardware selected for renewable installations under NERM, and on the basic principles involved in installation, will be essential for them to last in the long term.
Actors	Technical training institutions such as University of the South Pacific, Vanuatu Institute of Technology, Vanuatu National Training Council, DoE, Ministry of Education, development partners, SEIAPI
Timeframe	24 months
Keys to success	<p>Standard designs are needed for on-grid and off-grid renewable energy installations before hands-on training in those technologies can take place. Lecture-based course content can be prepared prior to any actual construction. However, in the long term, training should concentrate on hands-on experience in the actual designs that would be used in Vanuatu. This is because the intention is to prepare local people for installation and maintenance, not design and procurement.</p> <ul style="list-style-type: none"> • modify existing courses from Australia and New Zealand for on-grid solar and wind adapted to Vanuatu needs • work with DoE and URA to be sure training will cover the areas appropriate to installation and maintenance of renewable energy systems in Vanuatu • access SEIAPI and other Pacific institutional and individual expertise on the types of renewable energy installations appropriate for Vanuatu • work with external experts to develop and implement a training for trainers course to prepare Vanuatu instructors to present the course • work with development partners to obtain necessary laboratory and classroom materials for the training • obtain funding to provide the training of trainers and to acquire the necessary materials for hands-on and classroom training

Activity 8

Finance for increasing private investment in renewable energy and energy efficiency

Sector(s)	On-grid and off-grid renewable energy and energy efficiency
Description	Investment in solar and wind energy and in energy efficiency improvements is heavily loaded at the front end. Once the investment is made, running costs are typically modest. It is therefore important to make finance available for the initial purchase to generate interest from potential investors. A commitment to low interest loan funds from international development banks is recommended. The fund should be channelled through a local financial institution specifically targeting qualified renewable energy investments in Vanuatu.
Actors	Local financial institutions, DoE, URA, multilateral development banks, external experts, development partners
Timeframe	60 months
Keys to success	<p>Establishing standards early on for renewable energy equipment to be installed by private investors will be important. They will need to be in place to determine whether proposed investments are qualified to obtain the loan funds.</p> <ul style="list-style-type: none"> • an agency is named to establish standards for renewable energy installations, and those standards are created • availability of low interest loan funds for renewable energy implementation • availability of funds or services from development partners to access the required external expertise

V. REFERENCES

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