ONSHORE RENEWABLE ENERGY POTENTIAL INTRODUCTORY BRIEF

VANUATU

JANUARY 2023

This brief highlights the **existing and potential electricity generation from different onshore renewable energy sources (onshore RES)** in Vanuatu given the geographic context of this South Pacific Ocean archipelago. Offshore renewable energy sources (offshore RES) are considered in passing, but do not form the primary focus of this brief.

The brief begins by sketching Vanuatu's geographic, demographic and economic context. Then, it highlights the archipelago's vulnerability profile, and the structure and governance of its electricity sector. Finally, the onshore potential for renewable electricity generation is presented, with **specific focus on solar, wind, hydropower, geothermal and biomass/biofuel sources**. The brief concludes with a cursory consideration of electricity generation potential from offshore RES.

*The **Islands, Nature & Renewable Energy Law Project (INRELP)** is a project of the IUCN World Commission on Environmental Law Climate Change Law Specialist Group. Working closely with island climate change and energy stakeholders INRELP develops policy recommendations with the goal of enhancing renewable energy, preserving nature, and engaging local island communities.*

VANUATU IN A NUTSHELL

Geography and Climate

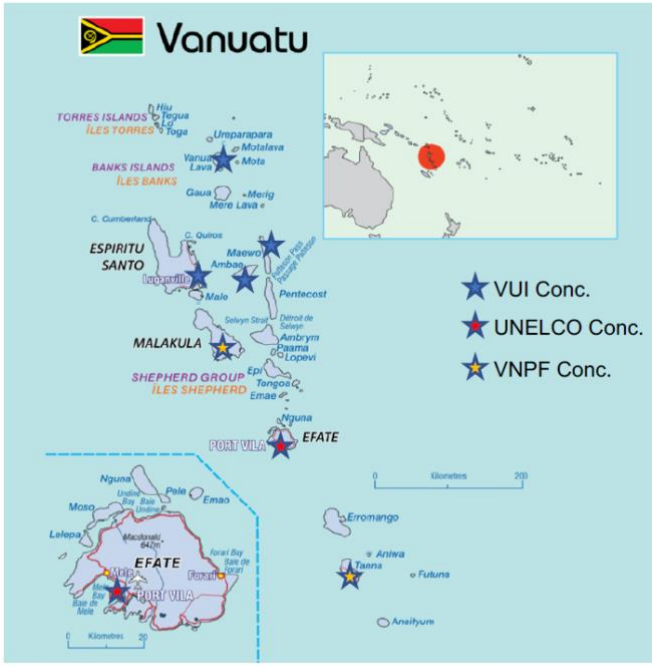
Vanuatu is a 1,200 km long, volcanic archipelago situated in the western part of the South Pacific Ocean, half-way between New Caledonia and Fiji and roughly 1800 km northeast of Australia.[1] Vanuatu's 84 islands are **mostly mountainous with narrow coastal plains**, offering 12,200 km^2 of total land area (162nd largest in the world). Of this, around 41% are suitable for habitation and cultivation. The archipelago boasts a rich on-land and underwater biodiversity, closely intertwined with the livelihoods of its urban and rural populations.[2]

The capital city of Vanuatu is Port Vila, located on Efate island. The archipelago is divided into six administrative provinces, corresponding to its 6 main island groups: Malampa (capital Lakatoro), Penama (capital Saratamata), Sanma (capital Luganville), Shefa (capital Port Vila), Tafea (capital Isangel) and Torba (capital Sola).[3]

Vanuatu's climate is generally **tropical with hot and humid winters and cooler, dryer summers**, with the centrally-located city of Port Vila experiencing an average temperature of 26 ^{o}C and 2300 mm of annual rainfall.[4]

Demography and Economy

Vanuatu has an ethnically and linguistically diverse, fast-growing population counting some 314,460 people in 2021.[5] Nearly **three quarters of the population reside in small settlements in rural areas.** Of the urban population, almost three quarters – some 51,500 people – reside in the capital city of Port Vila on Efate island. The other urban centre is Luganville, located on Espiritu Santo island.[6] Rural populations centre around community life and rely primarily on **subsistence**



Map Source: The Pacific Community, 2022, https://www.spc.int/our-members/vanuatu/details.

farming and the production of primary, plant-based raw materials and fishing.

Vanuatu's macroeconomic growth is driven by **tourism, international investment and public infrastructure spending**.[7] In 2021, Vanuatu had a slow but steadily improving human development index of 0.607 (140th best in the world), somewhat below the world and regional averages.[8] In 2020, Vanuatu graduated from 'Least Developed Country' to 'Developing Country' status.[9]

Vulnerability Profile

Vanuatu is consistently rated as **one of the most vulnerable countries on Earth**. Its isolation, status as a Small Island Developing State and dependence on fuel and commodity imports leave it exposed to price volatility on international markets. **In 2013, the value of imported goods exceeded the value of exported goods 5 to 1**.[10]

The archipelago, located in both the 'Ring of Fire' and the Pacific 'Cyclone Belt,' is prone and vulnerable to a range of natural disasters. Nearly 81% of Vanuatu's landmass is exposed to **(1) cyclonic risks** including high winds, storm surges and flooding, and **(2) geology-driven disasters** such as volcanic eruptions, earthquakes and tsunamis.[11]

Although Vanuatu is a net carbon sink and has pledged highly ambitious decarbonisation measures within its Nationally Determined Contributions to fulfilling the goals of the Paris Agreement, the **detrimental effects of climate change are likely to exacerbate Vanuatu's vulnerability** to cyclonic risks in particular.[12] The associated sea level rise threatens both urban and traditional livelihoods in narrow coastal plains, where the majority of Vanuatu's population centres are located.

Mamas Market, Port Vila shopkeepers retrieve their produce from shops destroyed by the 2015 Cyclone Pam. Source: Graham Crumb, CC BY-SA 3.0, https://commons.wikimedia.org/wiki/File:Mamas_market_14_March_2015.jpg.

Given this multifaceted vulnerability, Vanuatu began pursuing **measures at the intersection of climate change mitigation and adaptation** already before the mid-2000s, including within the country's electricity system. Notable examples of relevant policy include the 2007 National Adaptation Programme for Action,[13] the 2015 Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030,[14] and the 2018 National Policy on Climate Change and Disaster Induced Displacement.[15] Recognising the global character of climate change, in October 2022 Vanuatu launched a bid for an **Advisory Opinion of the International Court of Justice** on the obligations of States to protect the rights of present and future generations against the adverse effects of climate change.[16]

Characteristics of the Electricity Sector

Vanuatu's energy sector, particularly as regards electricity generation and distribution features **(1) electricity grids** on the archipelago's more populous islands, and **(2) off-grid self-generation and minigrid distribution facilities** on rural islands.

Island-wide electricity grids are located on the islands of Efate, Tanna and Malekula, and they are managed on concession by the Union Électrique du Vanuatu (UNELCO), a subsidiary of the French multinational energy company Engie. The map above shows the islands' concessions. **A grid is also present in Luganville** on Espiritu Santo island, managed on concession by Vanuatu Utilities and Infrastructure Ltd. (VUI), a subsidiary of the US-based construction company Pernix Group. This grid does not extend to rural areas of Espiritu Santo. **A smaller grid operates on the island of Maewo**, operated by the Talise Community. **Grid construction is planned on the islands of Ambae and Vanua Lava**, to be operated by the Penama and Torba provincial governments, respectively. Electricity generation in grid-connected areas relies on a **combination of biofuel and diesel**. On Efate, Espiritu Santo and Tanna islands, this is **complemented by a mix of renewable energy sources**. The Maewo grid relies exclusively on **hydropower**.[17]

Electricity access in off-grid areas and on rural islands is facilitated through self-generation and isolated minigrids. Off-grid generation relies primarily on **diesel generators**, although the use of **pico-solar systems** for low-voltage supply has been rising.[18] It is estimated that **in 2015, only 17% of rural households had access to electricity.**[19] Increasing rural electrification is a fundamental objective of the Updated Vanuatu

National Energy Road Map 2016-2030 (NERM 2016-2030), which emphasises the provision of accessible, affordable, secure, reliable and sustainable energy, and facilitating green growth.[20] **The number of electrified rural households has risen**, with a further USD 6.8 million in funding secured for additional rural electrification projects in 2022.[21]

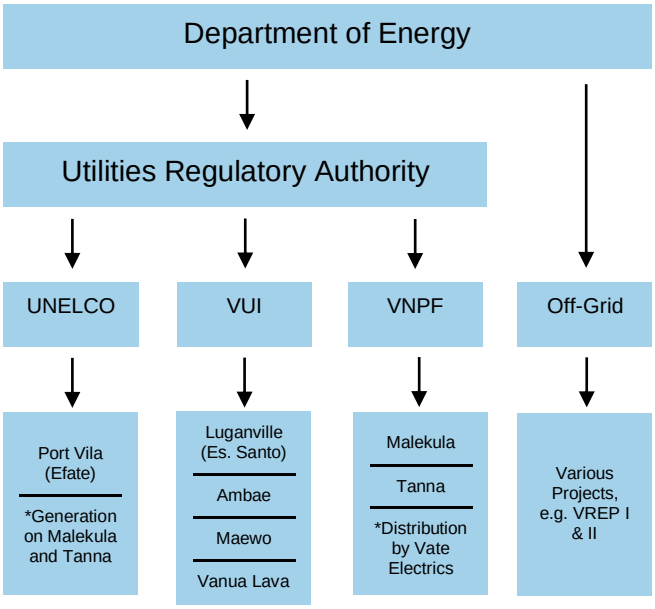
Governance of the Electricity Sector

Energy policy is primarily developed and executed by the **Department of Energy (DoE)** within the Vanuatu Ministry of Climate Change and Natural Hazards, alongside other government bodies active in the energy sector. Its missions include ensuring that households within grid-connected, concessional areas, households close to concessional areas, and off-grid households and public institutions gain **100% electricity access by 2030**. In developing energy policy, the DoE works closely with the **National Advisory Board (NAB)**, an expert planning and risk-assessment body in the area of disaster risk reduction and climate change. The government-established **Project Management Unit (PMU)** coordinates the delivery of projects in the electricity sector and beyond, ensuring alignment with Vanuatu's climate change mitigation and adaptation policy.

Broadly speaking, the **Utilities Regulatory Authority (URA)** is governed by the *Utilities Regulatory Authority Act,* which equips the URA with broad functions to **manage uniform electricity base tariffs within concessional areas** on an individual grid basis. For example, within the Port Villa Electricity Concession Contract between UNELCO and the Vanuatu Government, electricity tariffs are adjusted via a **monthly tariff-adjustment formula**, factoring in customs duties and regulatory surcharges. Other uniform tariff mechanisms allow the URA to **subsidise investments and operational costs for consumers**, typically in outer islands. The URA is currently exploring methods to ensure tariffs are affordable for consumers and is currently rolling out a **new customer category tariff structure** for VUI.

Last but not least, various private sector organisations, especially **social enterprises**, also participate in the governance process.[22]

In terms of legislation, Vanuatu's electricity transmission, distribution and supply are primarily regulated by the ***Electricity Supply Act 1972*** **(ESA),** applicable to entities both inside and outside concessional areas. Thus, it is directly relevant for both grid-connected and off-grid communities.



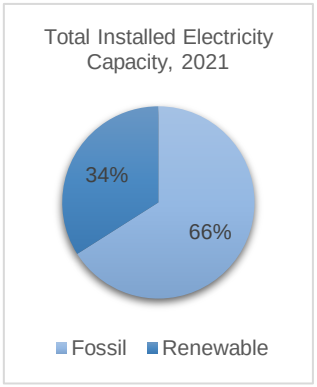
Structure of the governance of the Vanuatu electricity sector. Adapted from Taylor & Taylor 2022.[23]

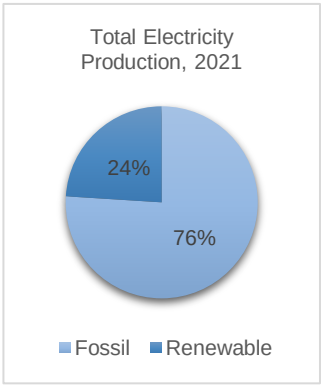
EXISTING AND POTENTIAL RES ELECTRICITY GENERATION

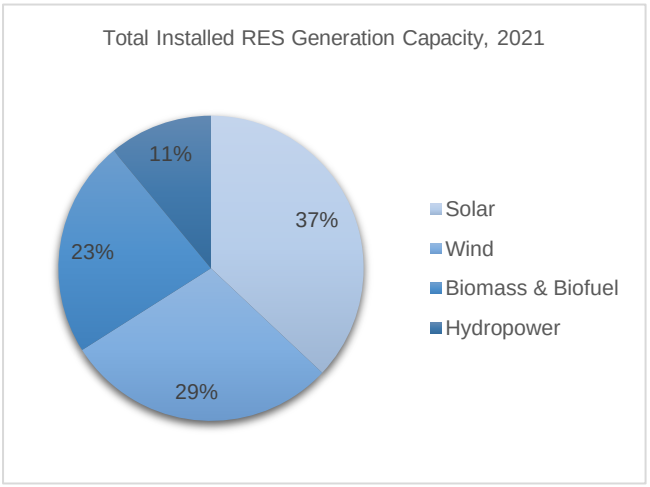
Vanuatu continuously progresses towards ensuring electricity access to an ever-greater proportion of its population and increasing the reliability of existing electricity supply. However, the country's complex vulnerability profile requires innovative solutions in order to **(1) further increase electricity access to rural households and (2) increase the resilience of the archipelago's electricity system**. This will aid in shielding the country from both import-dependence and natural hazards, while fulfilling long-term government policy. Exploitation of onshore RES to diversify the catalogue of fuels for electricity generation and gradually move away from dependence on fossil fuel imports offers significant contributions to this dual goal.

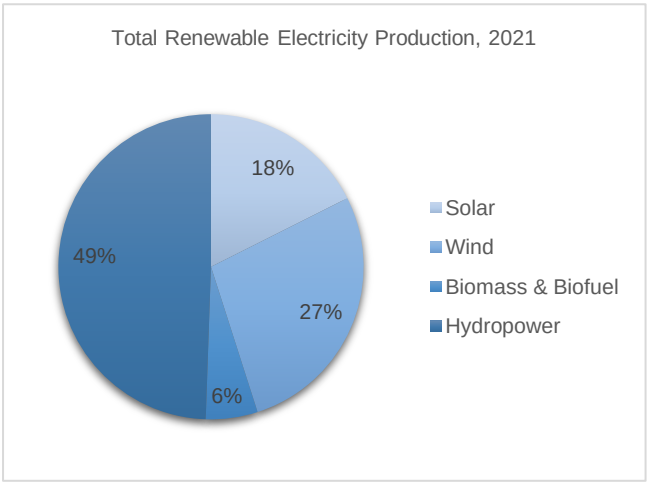
Recent values are hard to come by and are partially based on extrapolation and calculations. As of 2021, Vanuatu had approximately **34 MW of total installed electricity capacity**.[24] Of this, approximately **34% (11.6 MW) consists of onshore RES installations**.[25] In the same year,

total electricity production was around 76 GWh.[26] Of this, approximately **24% (18.2 GWh) were produced from renewable energy sources**.[27]







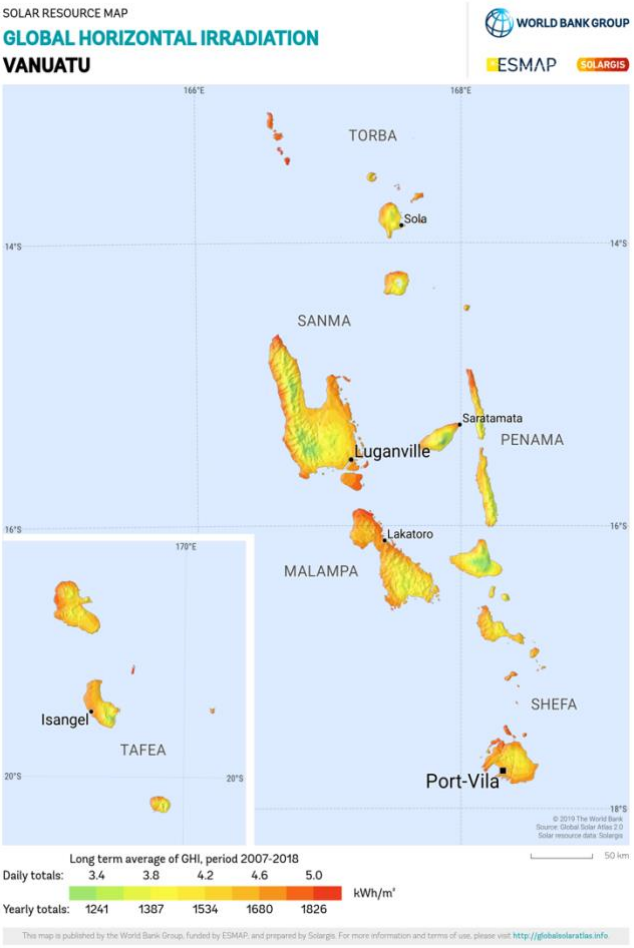


Graphs' source: The author.

Onshore RES: Solar Energy

In 2021, installed solar generation capacity was approximately **4.3 MW**, representing **37% of Vanuatu's total renewable electricity capacity**.[28] Approximately **3.2 GWh (18%)** of renewable electricity were produced by this solar generation capacity.[29] By 2030, the Vanuatu government expects an additional 7.6 MW of solar generation capacity to be installed.[30]

The archipelago's narrow coastal plains are **well irradiated by sunlight**, receiving on average between 3.2 and 4.0 KWh/m^3 of solar energy per day. While inland areas experience more intermittent cloud cover, they nevertheless retain good solar generation potential.[31] There are **good prospects for onshore solar generation to spearhead the electrification of rural, off-grid areas.** In fact, the NERM 2016-2030 singles out pico-solar lighting products, home solar systems and solar-powered minigrids as key ingredients for achieving electricity access in these areas.[32] Solar generation is also capable of **improving the reliability of electricity access in grid-connected areas,** as is already being done within UNELCO-managed grids on Efate, Espiritu Santo, Malekula and Tanna islands.[33]



Map Source: World Bank & The Global Solar Atlas 2.0, 2020, https://solargis.com/maps-and-gis-data/download/vanuatu.

Despite recent progress, solar generation is still rare compared to the combination of diesel and biofuel. Increasing the share of solar generation in grid-connected areas can decrease Vanuatu's reliance on a limited range of fossil fuels. However, the Vanuatu government estimates that **1 additional MW of solar electricity generation capacity requires 1.5 hectares of land**.[34] Therefore, installation of new generation capacity must prevent excess land use change and mitigate the impacts of new solar installations on biodiversity.

Onshore RES: Wind Energy

Second in line after solar energy, wind energy generation capacity counted approximately **3.4 MW** in 2021, **representing 29% of Vanuatu's total renewable electricity capacity**.[35] This capacity allowed to produce approximately **5 GWh (27%)** of renewable electricity in that year.[36]

Throughout the years, onshore wind generation capacity has stagnated, and no new investments in wind generation are planned for the time being.[37] **The 3 MW wind park near Port Vila remains the only large-scale wind generation installation**. Small-scale installations are present in off-grid areas on Futuna and Aneityum islands.

Wind monitoring stations located in all of Vanuatu's six provinces measure the archipelago's wind generation potential. An average wind speed of 7.2 m/s at 55 m above ground level, measured for the 2015 IRENA Renewable Readiness Assessment, signifies **very good potential for electricity generation by harnessing wind energy**.[38] The 2016-2030 NERM recognises the need for wind turbine design and location to account for natural hazards, especially cyclonic wind speeds.[39] The impact of new wind generation installations on the environment needs to be considered, such that the installation of new generation capacity does not unreasonably impact biodiversity at and around turbine sites.

Vanuatu's only large-scale onshore wind generation installation at Devil's Point near Port Vila, Efate island. Source: VERGNET, CC BY-SA 4.0, https://commons.wikimedia.org/wiki/File:Centrale_%C3%A9olienne_Vergnet_Vanuatu.jpg.

Onshore RES: Biomass and Biofuel

Biomass and biofuel accounted for about **2.7 MW**, or **23% of Vanuatu's renewable electricity capacity in 2021**.[40] Approximately **1 GWh (6%)** of renewable electricity was produced from biomass and biofuel in that year.[41]

Biomass and biofuels are the **RES of choice** to fulfil Vanuatu's green growth strategy, as elaborated in the 2016-2030 NERM.[42] Whereas burning biomass from climate resilient crops increases energy access for uses other than electricity generation (such as cooking on biomass-powered stoves), biofuels currently represent the main fuel for electricity generation next to diesel.

Boosting the use of biofuels **can contribute to rural electrification efforts and bolster generation capacity in rural minigrids**. The Biofuel Rural Electrification Project, connecting rural schools and public facilities on Penama and Torba islands to biofuel-driven minigrids, is exemplary in this regard.[43] Biofuel also has a demonstrated role in the **diversification of liquid fuels and the replacement of a part of the diesel to be consumed for electricity generation in grid-connected areas**. Although the use of climate resilient crops is a priority, the planting of these crops must not lead to deforestation. Land use change away from food production must also be prevented.

Onshore RES: Hydropower

Installed hydropower capacity was approximately **1.3 MW**, representing **11% of Vanuatu's total renewable electricity capacity in 2021**.[44] It produced approximately **9 GWh (49%)** of renewable electricity in the same year.[45]

In grid-connected areas, two hydropower installations stand out. The first consists of a **1.2 MW installation on the Sarakata river**, managed within the VUI concession on Espiritu Santo island. The second consists of a **75 KW, hydropower-driven minigrid on Maewo island** completed in 2019. Both point to the viability of deploying hydropower in Vanuatu.[46] As of 2021, **a 400 KW hydropower facility was under construction on Malekula island.**

Hydropower is also capable of driving Vanuatu's off-grid electrification ambitions. The **Loltong micro-hydropower project, completed in 2016 and supplying electricity to 70 households**, illustrates this potential.[47] Similar projects can assist in off-grid, rural area electrification due to their ease of replicability.[48]

Deployment of large-scale hydropower generation capacity in Vanuatu faces two challenges. First, the islands' **small watershed areas and seasonal precipitation variability** could make hydropower an unreliable source at certain times of the year, especially as the unpredictability of rainfall is likely to increase with climate change.[49] Second,

hydropower installations run the risk of **displacing local populations and causing irreversible damage to local biodiversity**.[50] Thus, any planned large-scale hydropower generation project must be accompanied by a thorough environmental and social impact assessment.

Onshore RES: Geothermal Energy

No geothermal generation facility was operational in Vanuatu as of December 2022.[51]

This is despite the fact that, by virtue of its volcanic geology, **certain parts of Vanuatu are well suited for electricity generation from geothermal energy**. Geothermal installations usually do not have a large footprint on surrounding biodiversity. Moreover, geothermal energy is especially suitable for delivering **stable, baseload generation potential**. Therefore, geothermal RES generation presents a viable option to both **facilitate rural electrification** and **decrease the share of fossil fuels** in Vanuatu's energy mix.[52] A 2016 research by the Vanuatu Ministry of Lands identified that certain islands are particularly well-suited for geothermal electricity generation. This concerns the islands of **Efate (21 potential sites), Vanua Lava (15 potential sites), Tanna (12 potential sites), and Gaua (10 potential sites)**.[53]

Future Options for Offshore RES Exploitation: Solar, Wind and Tidal Energy

Although **no offshore renewable energy installations have been implemented to date**, Vanuatu's geography is generally conducive to successful electricity generation from offshore RES. However, the **specific natural hazards** faced by offshore renewable energy facilities must be thoroughly considered during their planning and construction. Where applicable, the **development of near-shore renewable energy facilities must account for preserving Vanuatu's rich marine biodiversity.**

In the case of potential **floating solar generation capacity**, the same favourable insolation patterns as on land may be taken advantage of.

In the case of wind generation, **offshore floating turbines** as opposed to fixed-foundation turbines have been assessed favourably by the World Bank due to near-shore marine biodiversity preservation concerns. According to this assessment, a maximum capacity of **91 GW** of electricity is estimated to be technically obtainable from offshore wind generation across the entire archipelago.[54]

Finally, although **tidal generation potential** has been identified in parts of nearby Fiji,[55] no studies have identified or investigated renewable electricity generation potential through harnessing tidal and wave forces in Vanuatu to date.

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