Vanuatu Energy Demand Projections: Business As Usual Scenario

Global Green Growth Institute
19F Jeongdong Building, 21-15 Jeongdong-gil, Jung-gu, Seoul, 100-784, Korea

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Abbreviations and Acronyms

AAGR	Average Annual Growth Rate
AVGAS	Aviation Gasoline
BAU	Business as Usual
CAGR	Compound Annual Growth Rate
CFL	Compact Florescent Lamp
DoE	Department of Energy (Vanuatu)
GDP	Gross Domestic Product
GoV	Government of Vanuatu
GPOBA	Global Partnership on Output Based Aid
HIES	Household Income and Expenditure Survey
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IRENA	International Renewable Energy Agency
JETA1	Jet Fuel
kWh	Kilowatt Hour
L	Liters
LPG	Liquefied Petroleum Gas
MW	Megawatt
MWh	Megawatt-Hours
NAMA	Nationally Appropriate Mitigation Action
NERM	National Energy Roadmap
PEEP	Promoting Energy Efficiency in the Pacific (Asian Development Bank)
PV	Photovoltaic
SHS	Solar Home Systems
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SREP	Scaling Up Renewable Energy in Low Income Countries
TOE	Tons of Oil Equivalent
UNELCO	Union Electrique du Vanuatu Limited
URA	Utilities Regulatory Authority
USD	United States Dollar
VNSO	Vanuatu National Statistics Office
VREP	Vanuatu Rural Electrification Project
VUI	Vanuatu Utilities and Infrastructure Limited
VUV	Vanuatu Vatu
W	Watt

Exchange Rate

Local currency to United States Dollar (USD) in November 2015[1]

Table 1. Exchange rate

Country	Local Currency	USD
Vanuatu	Vatu (VUV)	0.0089

Unit Conversion Table

Table 2. Unit conversion table

	Toe	Grid Electricity (kWh)	LPG (L)	Diesel (L)	Wood 20% (tons)
Toe	1	11,630	1,744	1,151	2.85

1 http://www.exchangerate.com.

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Executive Summary

The Council of Ministers of Vanuatu endorsed the Vanuatu National Energy Roadmap (NERM) in 2013 as the overarching policy framework for developing Vanuatu's energy sector. The Government of Vanuatu (GoV) undertook the first revision of the NERM between October 2015 and May 2016 to update the roadmap's goals and targets. Recognizing the importance of energy efficiency initiatives, and their centrality to meeting the GoV's vision for the energy sector, energy efficiency was a key element in the revision of the NERM, alongside the need to increase implementation of renewable energy technologies.

Within this framework, the Vanuatu Energy Demand Projections: Business as Usual (BAU) Scenario report was prepared to give an analysis of energy efficiency in the key sectors of Vanuatu. The BAU report estimates energy consumption for key sectors in Vanuatu between 2015 and 2030 under a BAU scenario in order to establish a baseline and enable identification of the impacts of activities recommended in the NERM.

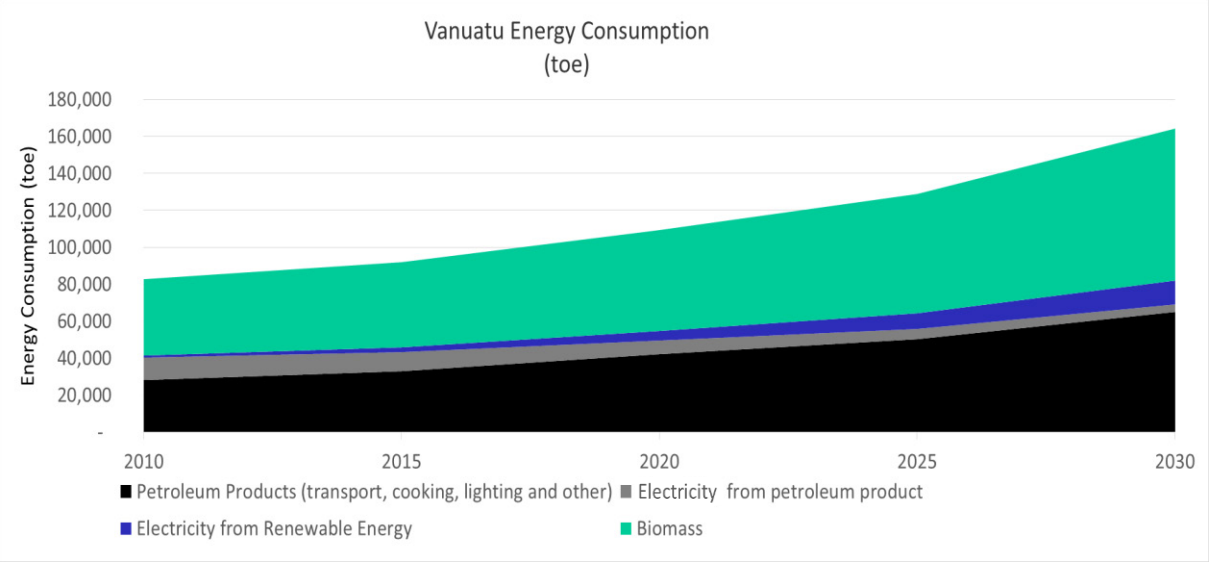
The objectives of this report are to:

- Collect up-to-date data on energy consumption by end use;
- Identify energy usage data gaps;
- Analyze baseline data;
- Review the status of ongoing, planned and/or financed energy projects;
- Based on relevant assumptions, develop models and estimate energy demand projections between 2015 and 2030 for the three main forms of energy (petroleum, biomass and electricity); and
- Analyze the potential impacts of non-achievement of the NERM 2013–2020 targets on projected energy consumption.

The BAU for each energy form (petroleum, biomass and electricity) was established taking into consideration the expected behavior and demand from the main end-user groups—the residential sector, public sector and private sector (commercial and industrial). This approach is useful to: (1) better understand the contribution from each end-user segment; (2) estimate the potential savings for an intervention targeting only one end-user group; and (3) establish roles and responsibilities for implementation.

Overall, energy consumption in Vanuatu is expected to double in the coming 15 years. Commercially-produced energy, i.e., petroleum and electricity, is projected to represent a combined 56% of the consumption growth; while biomass, most of which is not traded in the economy, makes up the balance (see Figure 1). Although the increase in commercial energy consumption will drive and be driven by gross domestic product (GDP) growth, the demand for biomass for cooking and drying crops, which is expected to increase by 78% during the same 15-year period, will potentially increase pressure on limited natural resources.

Figure 1. Projection of total energy consumption in Vanuatu



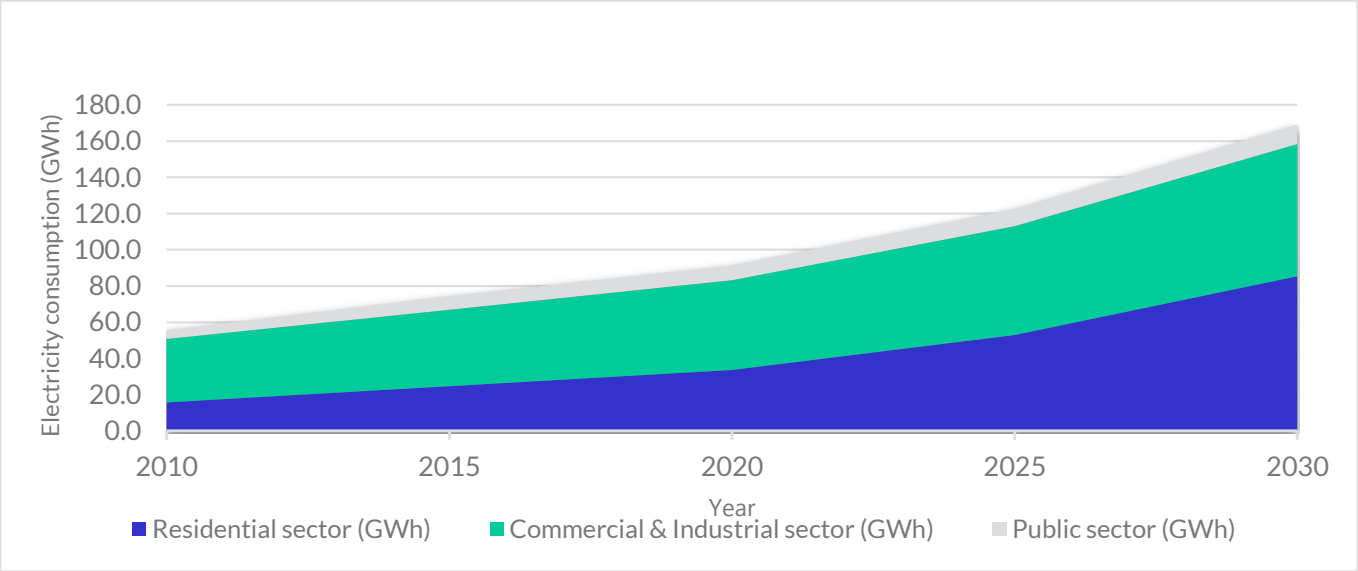
Livelihoods will improve with increased rural electrification; and health, education and transport services will benefit from improved energy access. However, dependence on imported petroleum products is expected to increase in absolute (volume) terms between 2015 and 2030. Greenhouse gas emissions, as well as emissions of other primary pollutants from the combustion of petroleum products and biomass, will continue to increase over this period.

Petroleum product consumption is expected to increase by about half during the period 2015 to 2030. Land vehicles will continue to be the dominant contributor with an increasing share from 50% of petroleum fuel use in 2010 to 71% in 2030. This projected trend for land transport is based on the growing number of registered vehicles, expected development of road infrastructure, and greater need for ground transportation for commercial and industrial activities. The second driver for petroleum consumption is air transport with an expected 10% increase by 2030. Fuel consumption for international flights is not considered in this BAU projection. Petroleum product consumption related to cooking, sea transport and other uses are expected to continue to grow, but the share in the overall volume should stagnate at around 5% for each usage. The quantity of kerosene for lighting will continue to decrease, and be replaced over time by grid electricity or stand-alone renewable energy systems. Assuming that NERM goals for use of renewables are met, the higher usage of renewable energy in grid electricity generation and rural electrification through renewable energy projects will mean a reduction of imported fuel volume for electricity from 29% in 2010 to 6% in 2030.

If no measures are taken to manage growth, the demand for biomass energy will almost double in the next 15 years, driven by the need of rural populations for cooking and crop drying. This could potentially increase localized deforestation currently experienced in Vanuatu. Biomass sources in Vanuatu are 50% mixed fuelwood (5% moisture content) and 50% coconut residues (air dry – 0% moisture content). These types of biomass are locally available to the rural population at no, or very low cost. Biomass-based charcoal is also used but no data is available on quantities. With an annual increase between 3% and 4%, the required volume of fuelwood and coconut residues being burnt aligns with the assumptions used for population and GDP growth, respectively 3.1% and 3.6%.

Overall, electricity consumption could more than double between 2015 and 2030. This growth is expected to be driven initially by the commercial and industrial sector, followed by residential uptake (see Figure 2).

Figure 2. Projection of national electricity consumption



This analysis assumes a 41% electrification rate for off-grid households by 2020 via grid-extension and micro-grids, which corresponds to the pipeline of projects with confirmed financing up to 2020.[2] Progressively, the share of residential consumption will increase, from an initial 30% in 2010 to 50% of total electricity consumption in 2030, pushed first by the increase in the electrification rate, and then by a progressive increase in the number and size of household electrical appliances.

The electrification rate targets in the NERM 2013–2020 are ambitious. Currently, the number of projects planned and financed up to 2020 will only be able to partially achieve the set targets. New projects will have to be identified and funded if the targets are to be fully met by 2020. Even if the NERM electrification targets are only partially achieved, however, there will be some impact on the overall projected electricity consumption.

Overall, only achieving 50% household electrification would represent a decrease of 14% of the BAU projection for total electricity consumption. In this scenario, the total electricity consumption would still increase by approximately 110% between 2015 and 2030, compared to an increase of approximately 180% under the scenario where the NERM electrification targets are fully achieved.

If Vanuatu does not achieve the targets for renewable electricity generation set in the NERM or the Intended Nationally Determined Contribution submitted to the United Nations Framework Convention on Climate Change, petroleum consumption projections will increase compared to the BAU scenario mentioned above. In the case where only two-thirds of the targets are achieved (i.e., 26.6% renewable energy in 2015,[3] 40% in 2020 and 60% in 2030), the result would be an increase by 90% in the BAU projection of cumulative petroleum consumption for electricity generation by 2030. In summary, the annual petroleum consumption for electricity would increase by 24% between 2015 and 2030, instead of the 62% decrease currently projected under the BAU.

2 The pipeline of projects with confirmed financing is based on the November 2015 rural electrification projects list from the DoE.

3 The electricity generation from renewables was reported to be 29% at the end of 2015 (communication with DoE).

1. Introduction

The Council of Ministers of Vanuatu endorsed the Vanuatu National Energy Roadmap (NERM) in 2013 as the overarching policy framework for developing Vanuatu's energy sector. The Government of Vanuatu (GoV) undertook the first revision of the NERM between October 2015 and May 2016 to update its goals and targets, based on a review and analysis of the achieved results to date, resources available and potential revised priorities.

Recognizing the importance of energy efficiency initiatives, and their centrality to meeting the GoV's vision for the energy sector, the examination of options to improve energy efficiency was a key element in the revision of the NERM, alongside the need to increase implementation of renewable energy technologies.

Within this framework, the Vanuatu Energy Demand Projections: Business as Usual (BAU) Scenario report is intended to estimate energy consumption for key sectors in Vanuatu between 2015 and 2030 under a BAU scenario. This analysis will in turn serve as a basis for: (1) the establishment of energy efficiency targets; (2) development of alternative energy efficiency scenarios; and (3) development of effective energy efficiency policies, strategies and action plans.

The objectives of this report are to:

- Collect up-to-date data on energy consumption by end-use;
- Identify energy usage data gaps;
- Analyze baseline data;
- Review the status of on-going, planned and/or financed energy projects;
- Based on relevant assumptions, develop models and estimate energy demand projections between 2015 and 2030 for the three main forms of energy (petroleum, biomass and electricity); and
- Analyze the potential impacts of non-achievement of the NERM 2013 – 2020 on projected energy consumption.

2. Methodology and Data Availability

The BAU scenario describes the expected changes in Vanuatu's energy consumption in the absence of any specific measures taken. This scenario therefore assumes a continuation of the existing policy framework and the most likely future trends in energy consumption, energy efficiency and energy project development.

The BAU for each energy form (petroleum, biomass and electricity) was established taking into consideration the expected behavior and demand from the main end-user groups—the residential sector, public sector and private sector (commercial and industrial). This approach is useful to: (1) better understand the contribution from each end-user segment; (2) estimate the potential savings from an intervention targeting only one end-user group; and (3) establish roles and responsibilities for implementation.

The methodology adopted to develop projections for energy demand under the BAU scenario comprised a spreadsheet tool to input and analyze historical energy data, the development of relevant assumptions based on evidence gathered, and the development of models to validate the assumptions and calculate differing energy demands.

A reasonably accurate overview of energy consumption in Vanuatu to date has been obtained by analyzing historical data on biomass, petroleum and electricity usage in the country. However, in the case of biomass, there was very little up-to-date data available and this limited the accuracy of the biomass analysis. As biomass is expected to continue to meet at least half of the gross national energy demand through to 2030, further research (for example, household and farm biomass usage surveys) should be conducted to measure biomass consumption and develop more precise BAU projections. Biomass survey results available for the present BAU demand study dated back to the 1980s (no new surveys were carried out as part of this report). Key stakeholders for data collection for the biomass sector would be the Vanuatu National Statistics Office (VNSO), the Department of Energy (DoE), the Department of Agriculture and the Department of Forestry, amongst others.

Accurate petroleum data was partially available for this report. The imported volume for each petroleum product was obtained from the Department of Customs and Inland Revenue. These figures were verified with sales figures from local companies supplying and distributing petroleum products—Origin Energy for Liquefied Petroleum Gas (LPG), and Société des Services Pétroliers, also known as Pacific Petroleum, for all other petroleum products. The nature of data available for petroleum products did not allow accurate categorization of petroleum usage within the same "energy user" sectors as electricity usage (i.e., residential, public sector, and commercial and industrial). In addition, although petroleum product distributors and different government bodies (VNSO, Utilities Regulatory Authority (URA) and Customs) provided some information on petroleum consumption from a product or functional perspective, detailed data for energy usage in the transport sector was scarce, and further research on energy usage in the transport sector is recommended.

Finally, there was good coverage of electricity generation and consumption data provided by the URA, which is responsible for the economic regulation of water and electricity in the concession areas of Vanuatu. The utility companies operating in the four concessions, i.e., UNELCO (in Port Vila, Lakatoro and Lenakel) and VUI (in Luganville) kept detailed records of the operation of their power plants and distribution networks. However, newly established rural mini- and micro-grids lacked verifiable information.

In order to estimate BAU scenarios for the electricity sector, an analysis of historical electricity consumption patterns was carried out at both the national and provincial levels. The main indicators examined were the number of clients, their average annual consumption and their total consumption. BAU projections were then developed based on assumptions, which were made through observation of major trends, and specific province or end-user group behavior. Current and planned projects in the electricity sector were also taken into account.

In analyzing electricity consumption reports for the concession areas, tariff categories of technical reports from 2013 for both the Union Electrique du Vanuatu Limited (UNELCO) and Vanuatu Utilities and Infrastructure Limited (VUI) were aggregated into three end-user groups (residential, public sector, and commercial and industrial) as follows:

These end-user groups are important, as they will determine the structure of the BAU scenarios, as well as inform future energy efficiency policies, strategies and targets.

The BAU projections are based on market development and end-user consumption profile assumptions. Two main factors influence the overall national energy consumption:

1. A growing population at an estimated rate of 2.3% per year based on the 2009 national census;[6] and
2. A developing economy with a gross domestic product (GDP) which, according to the International Monetary Fund (IMF), grew at an average annual growth rate (AAGR) of 1.8% between 2010 and 2014. Although GDP decreased by 2% in 2015 due to Cyclone Pam, it is expected to grow again at an AAGR of 3.6% between 2016 and 2020. [7]

The evolution of specific demand per end-user is also reflected in the BAU projections. The NERM target to provide electricity access to all rural households would translate into increased electricity consumption per capita in rural areas, while electricity consumption per capita in urban areas is also expected to increase and remain higher than in rural areas.

UNELCO	VUI[4]
Residential	Residential
Private Domestic Private Prepaid Private Others	Private Domestic Private Prepaid Private Others
Public Sector	Public Sector
Admin Other Admin High Voltage Admin Street Lighting Not Invoiced	Admin Other Admin High Voltage Admin Street Lighting Internal Not Invoiced
Commercial & Industrial	Commercial & Industrial
Private High Voltage Private Patent Internal (Water & Energy Utility)[5]	Private High Voltage Private Patent

4 With the transition in 2011 of the Luganville concession from UNELCO to VUI, it is assumed that both the number of Admin Other and Admin High Voltage remained constant.

5 Commercial and industrial customers have been grouped as a single end-user group as the tariff structure does not enable a clear identification of each end-user consumption.

6 VNSO, "2009 National Population and Housing Census," July 2, 2011.

7 IMF, "Vanuatu: 2015 Country Report No. 15/149; May 20, 2015," June 9, 2015.

3 Petroleum BAU Projections

3.1 Petroleum for Electricity Generation

3.1.1 Access to Grid Electricity and Demand

Based on the 2013-2020 NERM, it was assumed that by 2030, 100% of households within grid concession areas and 100% of households close to concession areas would be electrified through grid extensions.[8] For off-grid households, some will be electrified through micro-grid projects and the remainder through solar home systems (SHS) and solar lanterns.[9] Projections for electricity consumption for 2015-2030[10] are therefore based on the assumption that 100% of the urban and 41% of the rural population will be connected to grid electricity.

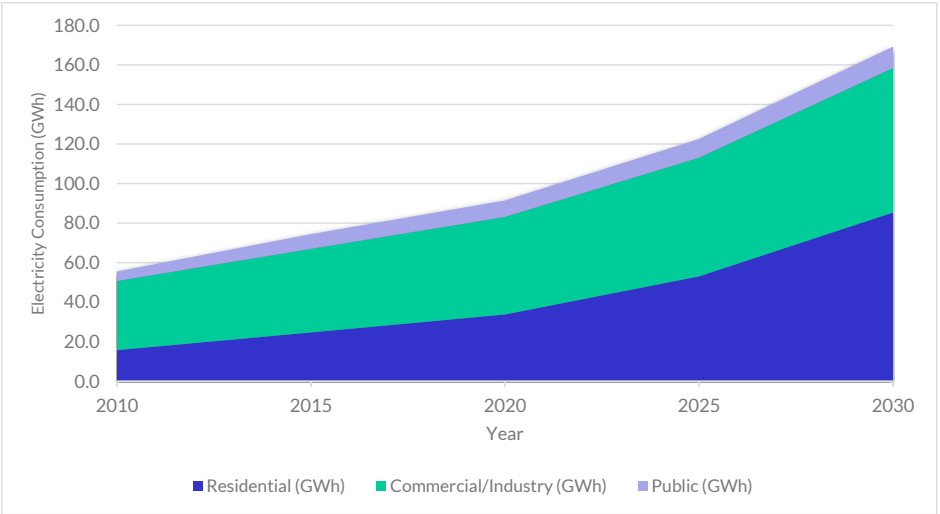
As household connections increase, energy consumption per capita will also slowly increase over time. In combination with a growing demand from the public, commercial and industrial sectors, the total grid electricity consumption is expected to grow by 124% between 2015 and 2030, or 6% per year (for further information see section 5.1 of this report).

3.1.2 Renewable Energy

The Government of Vanuatu GoV and the two private sector utilities (UNELCO and VUI) have clearly established their commitment to include more renewable energy in the electricity generation mix, both in the concession areas and in rural mini-grid projects. The targeted contribution of renewable energy in the NERM 2013-2020 was 40% renewable energy electricity generation by 2015 and 65% by 2020.[11]

The average share of renewable energy in utility grid generation was about 25% during the period 2012 to 2014. At the end of 2015, the share of renewables in the four utility grids (concession areas) had risen to an average of 29% throughout the year. While the annual share of renewable energy was below the target for 2015, encouraging efforts have been made in past years by the utilities and the GoV to increase the share of coconut oil, hydro, wind and solar in the generation mix. In August 2015, the monthly share of renewable energy in electricity generation represented 50% of the total generation in the four concession areas,[12] well above the target of 40%. During the best month, i.e. when natural resources patterns are favorable, the Sarataka hydropower plant has met 88.8% of Luganville's monthly demand while Devil's Point wind farm has provided up to 26.7% of Port Vila's electricity. A mix of grid-connected solar and local coconut oil-based biofuel also complements the share of renewable energy in the concessions on Efate, Malekula and Tanna.

Figure 3. Projection of national electricity consumption



8 GoV, "Vanuatu National Energy Road Map 2013–2020," July 19, 2013.

9 Although solar lanterns are a source of a small amount of good quality light (and can often also charge mobile phones), they are not always considered as full "electrification" due to the small amount of electricity they can provide, which limits their usefulness as a source of electricity.

10 GGGI, "Vanuatu Energy Efficiency – BAU Projections for Electricity," 2015.

11 ibid.

12 URA, "Monthly Energy Market Report – September 2015," October 31, 2015.

Existing micro and mini-grids in rural areas already rely on hydropower and solar-powered mini-grids will be implemented from 2016 onwards. The technical feasibility for coconut oil usage has been demonstrated in concession areas, although management costs of such installations remain significant. There is potential for replication of coconut oil electricity generation projects[13] and these projects represent a unique opportunity to re-invest revenue from electricity into the rural economy and boost production of copra rather than importing petroleum products. However, apart from within the UNELCO concession areas; the risks to sustainable operation of coconut oil projects remain high, and considerable financial and technical support (covering issues such as land availability, technical operations, financial management, socio-economic analysis and gender impacts) would be needed to establish more projects, particularly in rural areas.

While the details and timing of commissioning for new grid connected renewable energy systems are not readily available at present, the number of projects in the pipeline as indicated by key stakeholders during the compilation of this report strongly indicates that the share of renewable energy will increase in the coming 15 years.

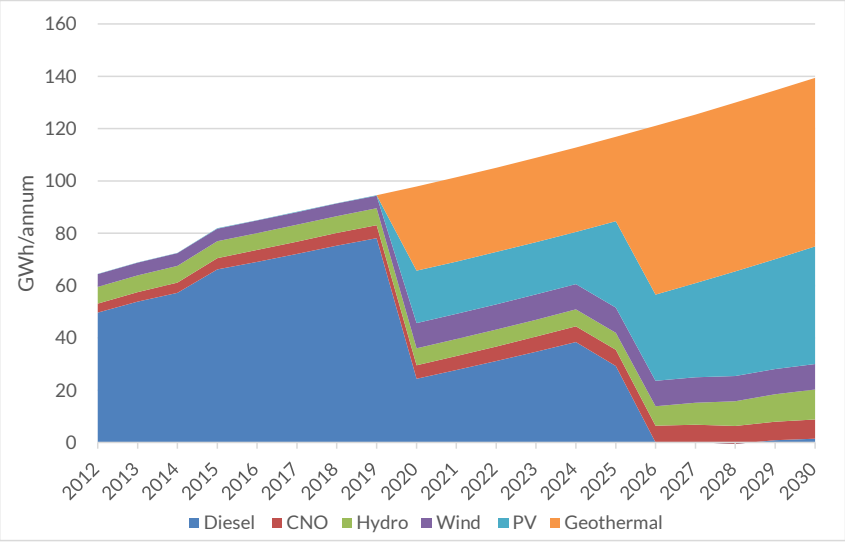
However, it is important to keep in mind that most of these projects are still awaiting funding confirmation and/or technical capacity for implementation. The proposed Intended Nationally Determined Contribution (INDC)[14] submitted by the GoV to the United Nations Framework Convention on Climate Change presents a detailed scenario for investments, which, if implemented, could provide 100% renewable energy in the concession areas during the 2020-2030 period.

The INDC includes the following projects:

- Doubling of the wind installed capacity to 5.5 MW by 2025;
- Installing 10 MW grid connected solar PV by 2025;
- Commissioning the proposed first stage 4 MW geothermal plant by 2025;
- Adding 10 MW grid connected solar PV by 2030
- Commissioning the second stage 4 MW geothermal plant by 2030;
- Substituting and/or replacing fossil fuels with coconut oil based electricity generation .

However, the INDC is an intended contribution and there is currently no legal obligation to implement the projects outlined within it. Furthermore, the implementation of the INDC is conditional on the availability of funding from external sources. The proposed interventions in the INDC would need external funding of around US$180 million[15] to complete implementation within the 2030 timeframe. In addition, substantial technology transfer would be required including institutional support and training.

Figure 4. Projection of electricity generation mix



Source: GoV, "Republic of Vanuatu: Intended Nationally Determined Contribution (INDC)," September 21, 2015.

13 National Advisory Board, GoV, "National Advisory Board on Climate Change and Disaster Risk Reduction – NAMA," October 15, 2015.

14 GoV, "Republic of Vanuatu: Intended Nationally Determined Contribution (INDC)," September 21, 2015, http://www4.unfccc.int/submissions/INDC/Published%20Documents/Vanuatu/1/VANUATU%20%20INDC%20UNFCCC%20Submission.pdf.

15 Ibid

In addition, SHS and solar lanterns, already widely adopted in the rural areas, will continue to be implemented and complement the solutions above for remote households and villages, and are expected to provide basic lighting and mobile phone charging solutions to up to 50% of rural population in 2030.[16]

3.1.3 Projected Fuel Demand for Electricity Generation

Based on data provided by the utilities and URA, the distributed electricity, the share of petroleum in electricity generation and the consumption of petroleum products, the petroleum consumption for generation per distributed kWh was calculated. This was found to be equal to 0.274 liters/kWh for the period 2010-2013.

Using the BAU projections for distributed electricity within the four concessions and additional micro-grids (see section 5.1), combined with targets for renewable energy share from the NERM 2013-2020 (40% in 2015, 65% in 2020) and the INDC (estimated as 80% in 2025 and 90% in 2030), the projected fuel demand for electricity generation was established (see Table 3). In the calculations a simplification has been made to use the same share of renewable energy for all the concession grids and it is assumed that transmission and distribution losses will also be similar across the grids and remain the same over time (approximately 15%). It should be noted that in reality this is not currently the case and the four grids are increasing their renewable energy penetration at a different pace. Therefore, some grids will continue to use more petroleum products than others.

16 GoV, "Vanuatu National Energy Road Map 2013–2020," July 19, 2013

Table 3. Projected national electricity consumption and associated petroleum consumption for generation[17]

End-User Sector	CAGR 2010-2014	Growth 2015-2020	Growth 2020-2030	2010	2015	2020	2025	2030
Residential (MWh)	3.9%	6.4%	9.7%	18,420	24,657	33,696	53,047	85,276
Commercial / Industry (MWh)	1.3%	3.2%	4.0%	39,566	42,292	49,428	60,026	73,149
Public & Street Lighting (MWh)	1.9%	2.1%	2.6%	6,228	7,262	8,074	9,166	10,468
Total Electricity Consumption (MWh)				64,214	74,241	91,198	122,240	168,893
Share of Renewable Energy (%)				18.6%	40%	65%	80%	90%
Renewable Energy Consumption (MWh)				11,969	29,697	59,279	97,792	152,004
Petroleum Consumption per Distributed Energy (L/MWh)				271	274	274	274	274
Residential (L)	-2.5%	-4.5%	-3.2%	1,064,063	4,058,578	3,231,438	2,906,992	2,336,552
Commercial / Industry (L)	-5.0%	-7.4%	-8.2%	8,729,833	6,952,782	4,740,163	3,289,442	2,004,281
Public & Street Lighting (L)	-4.4%	-8.3%	-9.5%	1,374,211	1,193,908	774,266	502,312	286,836
Petroleum Consumption for Eelectricity Generation (L)	-1%	-7%	-7%	14,168,107	12,205,268	8,745,867	6,698,747	4,627,668

Key for table (same throughout the report): Green = Hypothesis calculated, Black = Raw data; Blue = Projections

17 The compound annual growth rate (CAGR) is the mean annual growth calculated as follows: $CAGR = \left(\frac{\text{Ending Value}}{\text{Beginning Value}}\right)^{\left(\frac{1}{\#\text{ of years}}\right)} - 1$

If the NERM 2013–2020 targets are met, then national electricity consumption is expected to double in the coming 15 years. The main contributing factors being increased rural electrification, higher consumption per capita over time, and increased number of connections from the public sector and the commercial and industrial sector. [18]

In addition, if renewable energy projects are commissioned according to the INDC plan, the increased share of renewable energy in the overall mix for electricity generation is expected to result in a significant reduction of petroleum consumption for electricity. As shown in Figure 5, the volume of petroleum fuel used for electricity generation is expected to drop to about one-third (33%) of 2015 consumption by 2030.

3.1.4 Kerosene for Lighting

Kerosene lamps were until recently used by 42% of rural households for lighting. [19] These are now steadily being replaced by solar lanterns and other solar PV products such as SHS. The rapid adoption of solar technologies over the last few years has drastically reduced the use of kerosene, which in 2014 had dropped to 25% of the 2010 consumption level. [20] The Independent Completion Review of the Lighting Vanuatu Project estimated that over 55,000 solar lanterns were distributed between 2010 and 2013. [21]

Based on NERM 2013–2020 targets for rural electrification, the consumption of kerosene is expected to continue to drop and become insignificant compared to other petroleum products. Figure 6 illustrates this trend with an assumed annual decrease of 20% between 2015 and 2020, and 10% between 2020 and 2030.

Figure 5. Projection of petroleum consumption for electricity generation

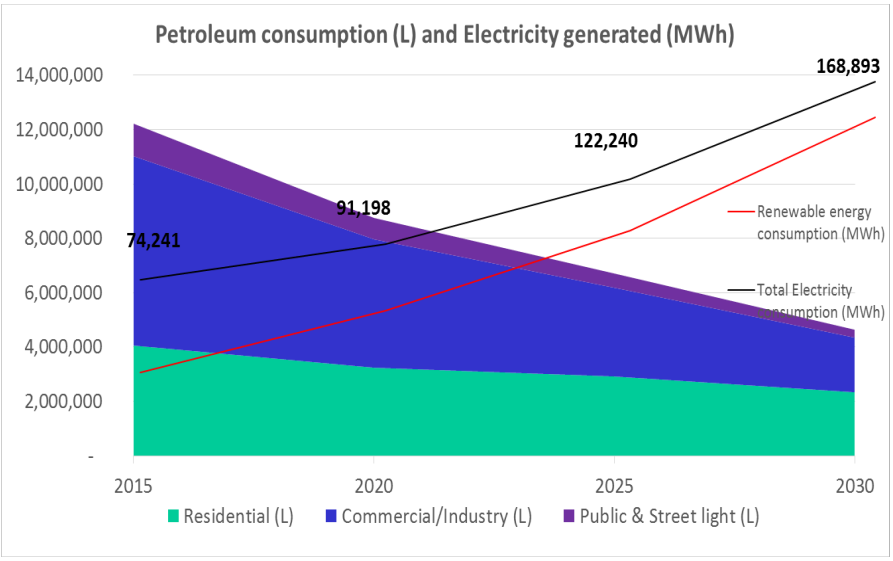
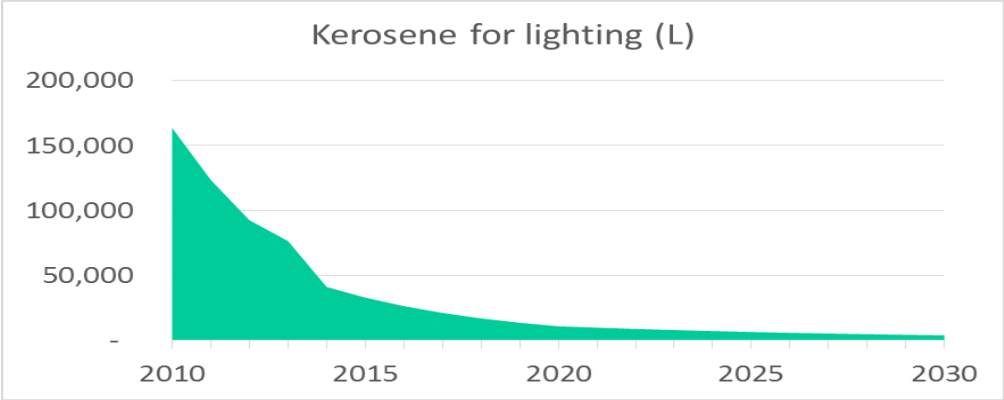


Figure 6. Projection of kerosene consumption for lighting



18 Commerce and industry are considered as one sector in this report.

19 VNSO, "Vanuatu Household Income and Expenditure Survey 2010," January 28, 2013.

20 Department of Customs and Inland Revenue, GoV, "Petroleum product import 2010–2015," 2015.

21 Australian Aid, "Lighting Vanuatu: Independent Completion Report," October 14, 2015.

3.2 Petroleum for Transportation

The development of the Vanuatu economy is largely dependent on transport-related activities. Within each island, land vehicles offer mobility for goods and persons (including tourists) and the means for construction and maintenance of key infrastructure.

Interconnection between islands within the archipelago will always depend on domestic aviation and marine transport. Inter-island transport demand is already increasing based on higher local population mobility, tourism and growing exports of local production (cattle, copra, coconut oil, cocoa and kava).

3.2.1 Land Vehicles

Land transport represents the majority of petroleum fuel consumption with 50% by volume in 2011.[22] Every year, about 1,000 additional vehicles are registered in Port Vila and Luganville, [23] resulting in a growing number of total land vehicles. The number of newly registered vehicles is likely to grow in line with Vanuatu's GDP growth, at a rate of 2% per year. [24]

Most of the newly registered vehicles are expected to last seven years. The analysis also assumes that each year, 20% of Port Vila and Luganville vehicles that reach seven years old are sent to rural areas where they are used for another four years. Far away from urban areas, they are most likely not registered anymore. As a result, the number of registered vehicles tends to be significantly less than the number of vehicles actually on the road, at least for private cars and trucks.

Registered vehicles are highly concentrated in the Port Vila area. In 2010, 71% of motor vehicles were found in Shefa province (mostly Efate) and 17% in Sanma province (mainly Santo). [25] This trend is expected to continue over time with registered vehicles being mostly located in urban areas. Tables 4 and 5 show the number of newly registered vehicles and the total number of vehicles in use, respectively.

Table 4. Actual and projected number of newly registered land vehicles

Newly Registered Land Vehicles in Port Vila and Luganville	CAGR 2010-2014	Growth 2015-2020	Growth 2020-2030	2010-2014	2015-2020	2021-2025	2026-2030
Motorcars	8.5%	2%	2%	2,159	3,848	3,575	3,947
Pick-Ups	-11.5%	2%	2%	1,690	1,332	1,237	1,366
Trucks	-4.7%	2%	2%	266	283	263	290
Buses	-3.0%	2%	2%	1,120	1,274	1,184	1,307
Motorcycles	-0.4%	2%	2%	478	605	562	620
Total New (Port Vila & Luganville)				5,713	7,342	6,821	7,531

Note: Green = Hypothesis calculated, Black = Raw data; Blue = Projections

Table 5. Actual and projected number of land vehicles in use (registered and non-registered)

Vehicle Type	CAGR 2010-2014	Growth 2015-2020	Growth 2020-2030	2010	2015	2020	2025	2031
Registered = Port Vila & Luganville	6.4%	3.3%	2.3%	4,956	6,618	7,737	8,742	9,744
					4%	3%	2%	2%
Non-Registered = Rural Areas [Estimated]	2.8%	4.0%	2.7%	552	645	781	905	1,021
					4%	3%	3%	2%
Total	6.1%	3.4%	2.4%	5,508	7,263	8,518	9,647	10,765

Note: Green = Hypothesis calculated, Black = Raw data; Blue = Projections

22 David Butcher and Associates, "Final Report: Options for Increasing the Efficiency of Vanuatu's Oil and Gas Supply Chain," April 24, 2013.

23 VNSO, "Quarterly Statistical Indicators: Republic of Vanuatu – January–March 2015," June 26, 2015, http://www.vnso.gov.vu/index.php/document-library?view=download&fileId=4257.

24 VNSO, 2014

25 VNSO, "Vanuatu Household Income and Expenditure Survey 2010," January 28, 2013.

The total number of land vehicles in use in Vanuatu 15 years from now, including both registered and non-registered vehicles, will be 50% higher than present levels (see Figure 7), and will create an increased demand for petroleum products for land transportation. The mix of newly registered vehicles is shown in Figure 8.

Figure 7. Number of land vehicles

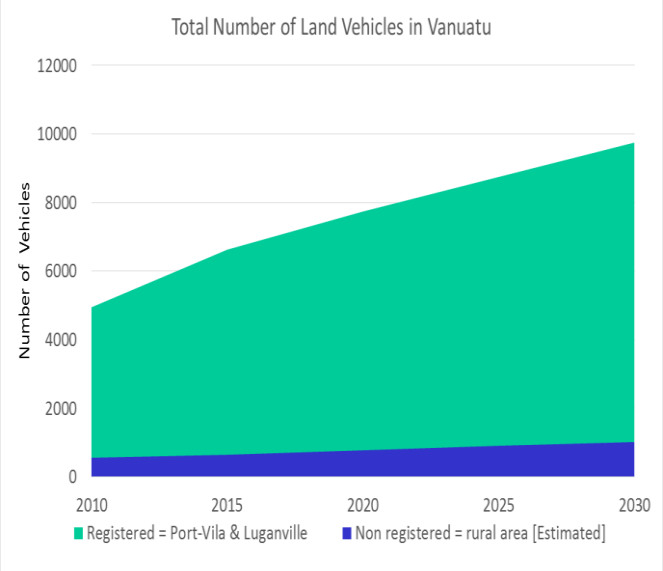
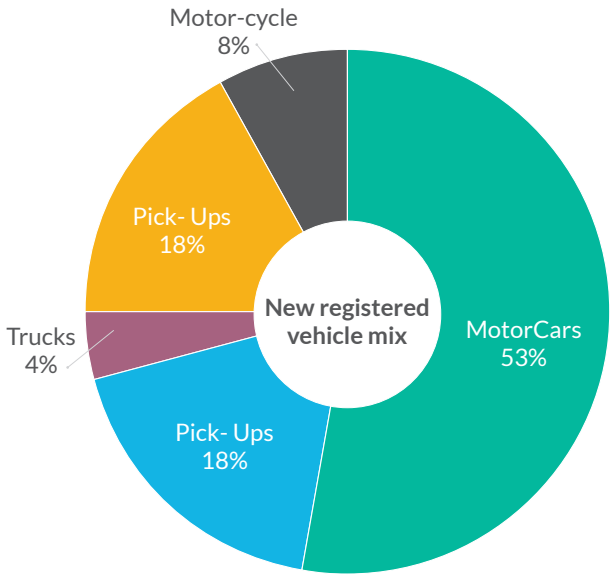


Figure 8. Newly registered vehicle mix



In May 2015, 645 vehicles were registered with a government license plate, [26] representing almost 10% of the national fleet. This share is not expected to change significantly by 2030. It is estimated that 50% of the vehicles will be owned by households in 2030 (with 22% of households in Port Vila and Luganville owning a car, and around 1% of households elsewhere). Based on GGGI's analysis, it is estimated that the commercial and industrial sector will represent 40% of registered ground vehicles by 2030.

Expected future fuel consumption for ground transportation is linked to the growing number of vehicles registered in the country, at an annual increase of between 2% and 3%. In addition, the planned development of road infrastructure in each island is expected to increase the amount of travel and thus, the average fuel consumption per vehicle. The combination of population mobility, tourism and transportation of locally-produced goods or imported products are all assumed to push petroleum consumption for land transport to a growth rate of more than 4% per year.

In 2010, over three-quarters of household heads in Vanuatu (85%) stated that the main means of transport used by members of the household was public transport, compared to private transport, which only accounted for 7%. [27] Thus, vehicles from the commercial and industrial sector (e.g., company vehicle fleets, and public transport such as trucks, buses and taxis) are expected to remain the main drivers for fuel consumption. Vehicle growth rates up until 2030 in the public sector (governmental vehicles) and the residential sector will represent a similar trend in fuel volume demand.

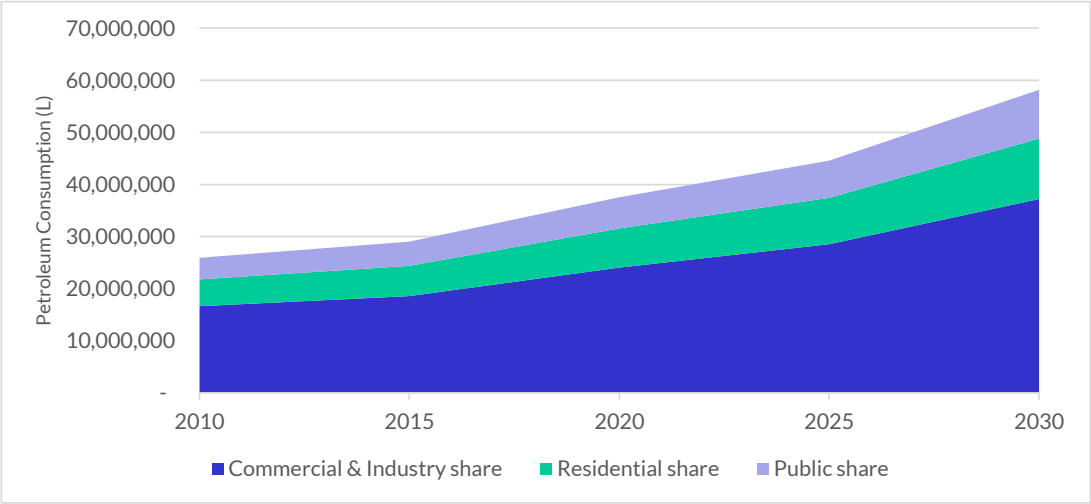
Based on BAU projections by end-user sector in Figure 9, it is estimated that the average petroleum consumption per vehicle per year is 64% growth for the commercial and industrial sector, and 16% growth for the public sector. The average petroleum consumption per vehicle for the residential sector represents only one-quarter of use (CAGR of 16%) in the commercial and industrial sector.

Improvements in data collection regarding land vehicles by the GoV would enable an improved analysis of land transportation trends, for example, data collection by category of end-user (residential, public, commercial/industrial). Data collection by fuel type (diesel, gasoline or other) and engine sizes/cylinder capacity sizes would also enable further and more in-depth analysis of transport sector energy usage.

26 Department of Customs and Inland Revenue, "Total number of G plated vehicles ranging from cars to road construction equipment," in Rates and Taxes, May 2015.

27 Ibid.

Figure 9 Petroleum consumption for land transportation, by end-user sector



3.2.2 Marine Transportation

The total number of marine vessels includes: about 30 marine vessels operating for cargo and passenger services; 25 large fishing boats; 49 registered charter-game fishing boats; 43 pleasure yachts; and 8 dive boats.[28] In addition to this total of 155 registered sea vessels, the Vanuatu coasts are filled with countless fiberglass boats used by local communities for fishing and transport of goods, Ni-Vanuatu people and tourists. There is no data available on the number of these small, usually privately-owned vessels. Therefore, the total number of vessels in Vanuatu, and their usage patterns are not well known, and the number of registered vessels is an underestimate of the total vessels in use.

There is very limited data available on petroleum consumption for marine transport. In 2010, it represented only 2% of the domestic demand for petroleum products. [29] However, based on a growing domestic cargo freight sector, and increased number of registered and non-registered boats for small-scale fishing, leisure activities and tourism, the volume of fuel dedicated to sea vessels is expected to grow at the same rate as land transport (4%).

As there is no data available on usage of petroleum in the marine transport sector that is broken down by end user, a simplified set of assumptions has been made as follows. The projected share of petroleum use for sea transport for residential and commercial/ industrial sectors is assumed to be equal (50% each), while the public sector contribution is assumed to be insignificant[30] (see Figure 10).

Sales data from Société des Services Pétroliers (Pacific Petroleum) has enabled the calculation of the consumption of fuel related to the air industry (AVGAS and JETA1). While Aviation Gasoline (AVGAS) is used exclusively for the domestic market, Jet Fuel (JETA1) is required for both international and domestic flights (connections made with an ATR plane for Efate-Santo and Efate-Tanna). The share of domestic demand for JETA1 is estimated to be 30% [31] which, combined with AVGAS, recorded an annual growth of over 25% per year between 2010 and 2014 for domestic aviation. [32] Fuel consumption for international flights is not considered in these BAU projections.

Inter-island mobility, partially relying on domestic flights, is expected to continue growing at a rapid rate to support the pressing demand from all sectors in the country. It is therefore assumed that fuel consumption will increase at a rate of 5% per year, resulting in a doubling of petroleum volume consumed annually for domestic air transport between 2015 and 2030.

The trend in the residential sector is increasing air travel for personal reasons (work, holidays and medical needs). It is therefore estimated that domestic air travel for the residential sector would represent 50% of the overall demand of domestic aviation fuel use (see Figure 11). Business trips, tourism and air freight (commercial/ industrial sector) would contribute up to 40%, while the remaining 10% would be used by the public sector (government representatives and civil servants).

28Vanuatu sea vessel registry, 2015.

29 David Butcher and Associates, "Final Report: Options for Increasing the Efficiency of Vanuatu's Oil and Gas Supply Chain," April 24, 2013.

30 The GoV currently owns only six vessels. The largest is on lease to the private sector and is therefore counted as commercial and industrial consumption. The other five are small vessels.

31 Société des Services Pétroliers.

32 Department of Customs and Inland Revenue, GoV, "Petroleum product import 2010–2015," 2015.

Figure 10. Petroleum consumption for sea transportation, by end-user sector

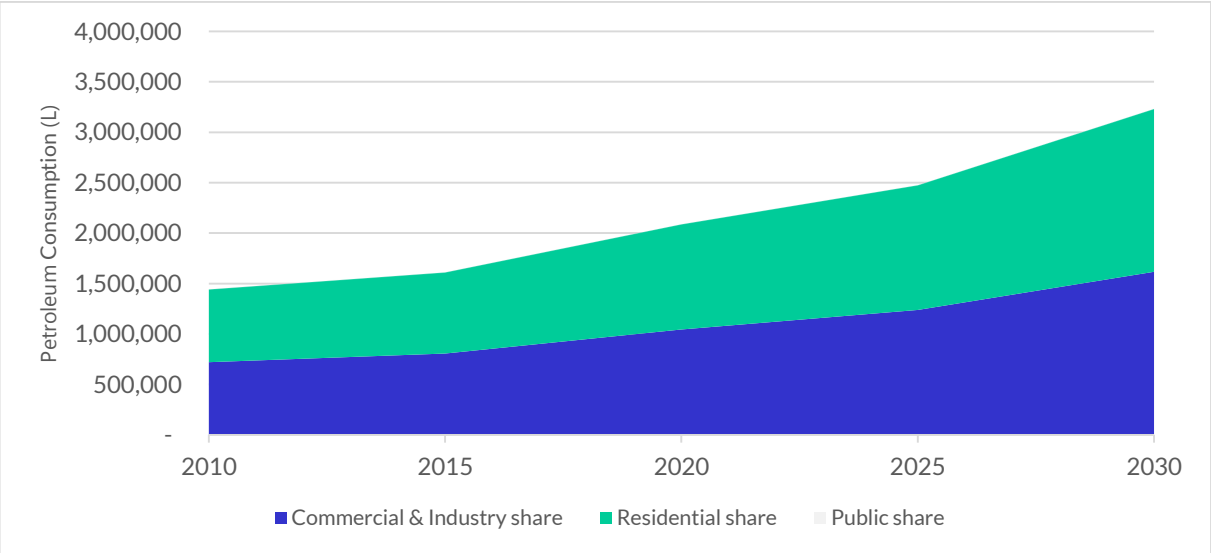


Figure 11. Petroleum consumption for air transportation, by end-user sector

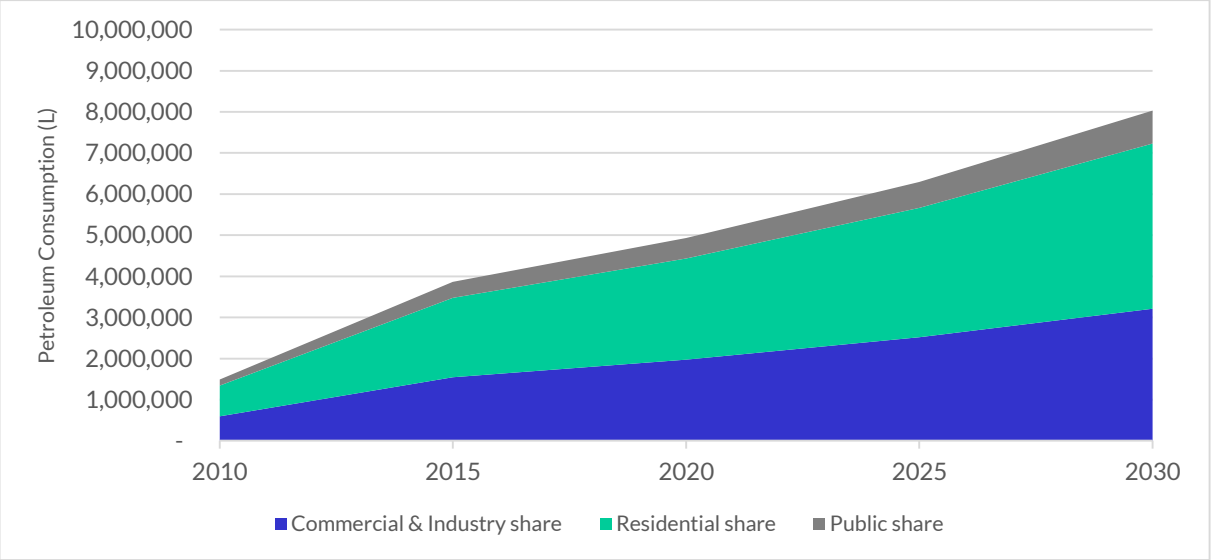
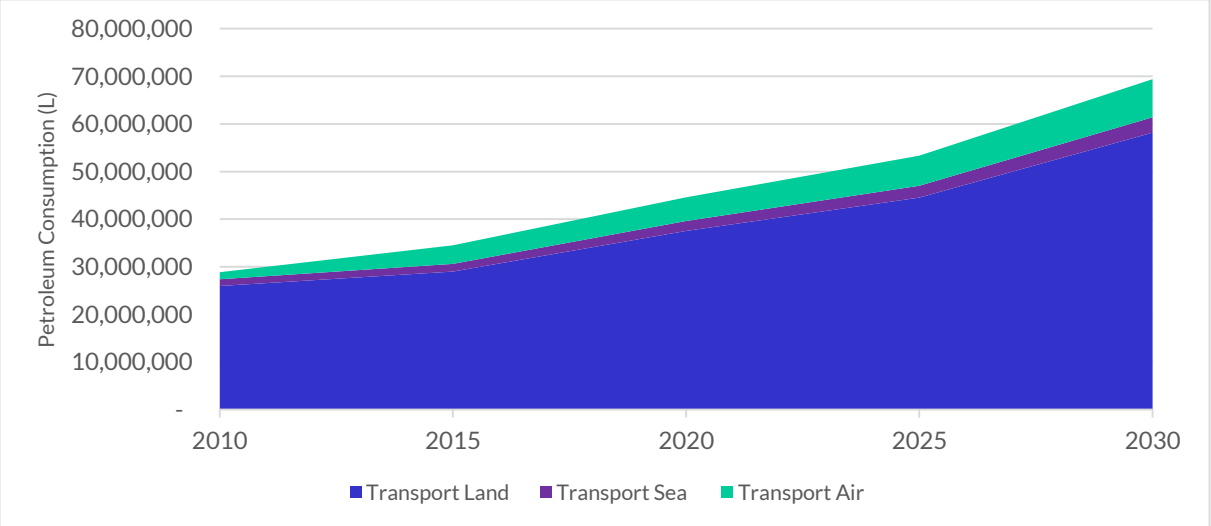


Figure 12. Petroleum consumption for the transportation sector



3.2.4 Overall Projected Fuel Consumption for Transportation

As shown in Figure 12, the annual demand for petroleum products combining all means of transport is expected to double between 2015 and 2030 to reach a volume of over 69 million liters for the year 2030 alone.

In 2030, it is projected that ground transport will continue to be the main contributor to transport energy demand at 83.3%, followed by air travel at 11.6%, and marine transport at 4.7%. In light of the limited data available for marine transport, the share of petroleum use for the maritime transport sector should be viewed with caution and further data collection is recommended to enable more detailed analysis of the current situation and future trends for this sector.

The commercial/industrial, residential and public end-user sectors are expected to be responsible for 60.6%, 24.9% and 14.6% of the petroleum demand for transport, respectively.

3.3 Petroleum for Cooking

As shown in Figure 13, 40% of LPG consumption was used for cooking in the residential sector (mostly urban areas) in 2014. The remaining 60% was used in the public and commercial/industrial sectors [33] where 50% is assumed to be used for cooking in restaurants and hotels, and 10% for cooking in boarding schools and institutions (e.g., hospitals). A small percentage may also be used for LPG-powered air conditioners in a few large buildings. As a result, over 90% of the total LPG sold is assumed to be used for cooking purposes (see also Table 6).

Figure 13. LPG consumption, by end-user sector

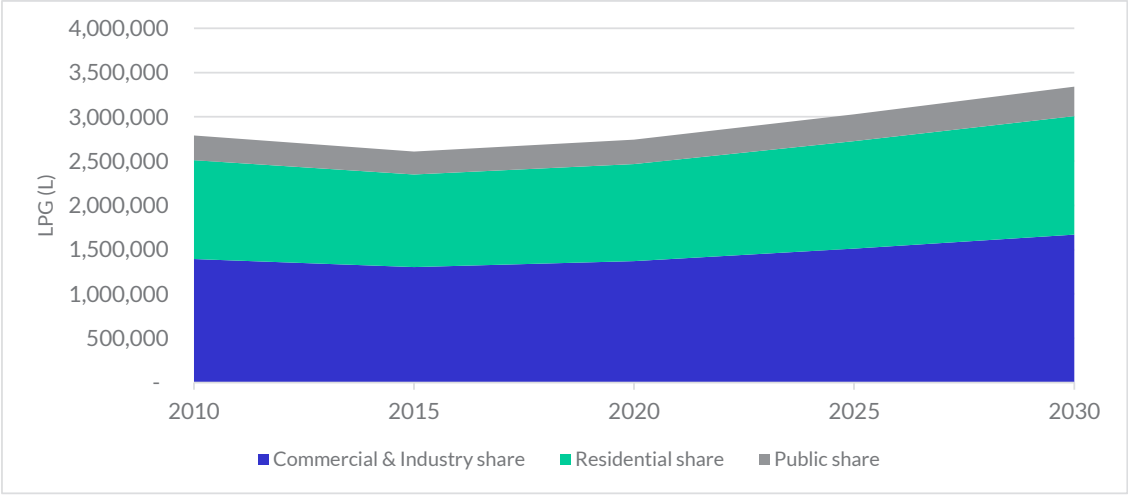
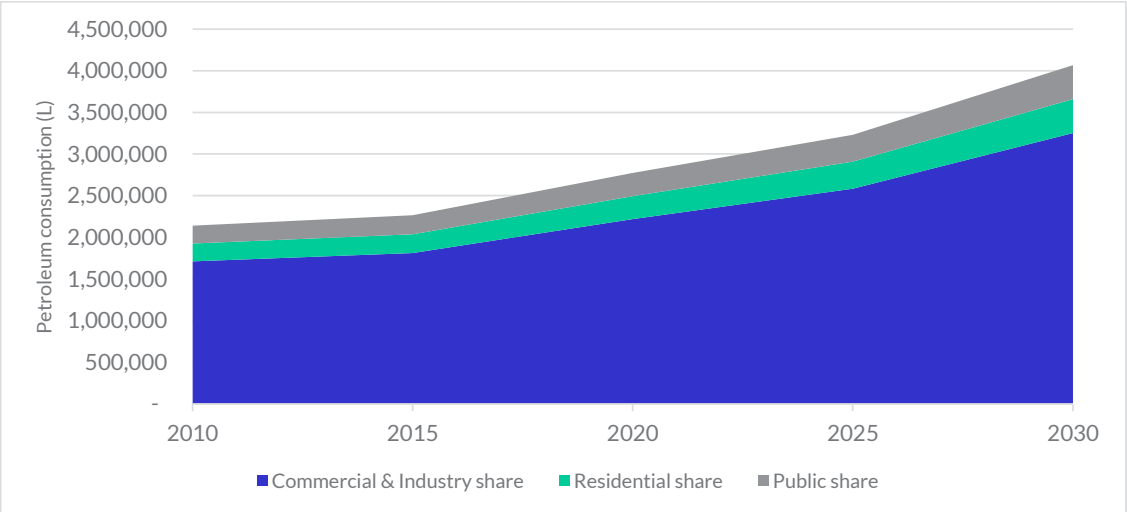


Figure 14. Other petroleum usage, by end-user sector



33 Origin Energy Imports & Sales Volume 2010–2014.

LPG consumption has remained relatively steady for the last 5 years (see Table 6), but it is still expected to grow based on an increased demand from the tourism sector (hotels and restaurants), and growing use of LPG as the first fuel of choice for cooking in the urban areas (slowly replacing wood fuel and kerosene). However, LPG price and logistics related constraints are important barriers to increased consumption (it is unlikely that the use of LPG will expand in rural areas for these reasons). Therefore, a limited annual growth of 1% until 2020 and 2% beyond is assumed (2020–2030).

3.4 Other Petroleum Usage

A significant portion of the national petroleum consumption (between 5% and 7%) could not be included in the functional usage detailed above (i.e., grid electricity, transport and cooking). This outstanding balance of fuel comprises petroleum products used for domestic gensets, back-up generators in buildings, construction sites, factories or others, LPG air conditioners in large buildings, and other fuel-powered equipment. The commercial and industrial sector represents an estimated 80% of this consumption, while the residential and public sectors are estimated to account for 10% each (see Figure 14).

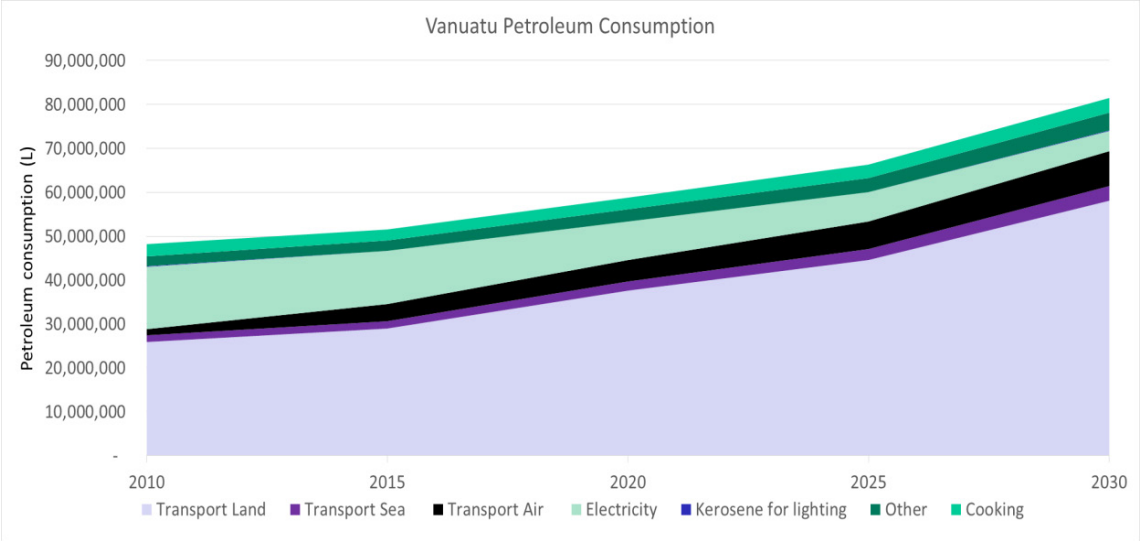
3.5 National Petroleum Consumption Projections Under the BAU Scenario

The breakdown per functional energy usage presented in the analysis above enables an estimation of the type of activities that will be the highest contributors to the overall national petroleum products demand in 2030. The projection of national petroleum consumption, by type of functional end use from 2015 to 2030 is shown in Figure 15.

Land vehicles will continue to be the dominant contributor with an increasing share from 50% in 2010 to an expected 71% in 2030. The second driver for petroleum consumption is air transport with an expected 10% increase by 2030. The increasing share of renewable energy in grid electricity generation targeted in the NERM 2013–2020 will result in a reduction of the imported fuel volume for electricity generation from 29% of the total in 2010 to 6% in 2030. Consumption related to cooking, sea transport and other usage will continue to grow, although their share of the overall volume will stagnate by around 5% each. The quantity of kerosene used for lighting, while already insignificant compared to other activities, will continue to decline.

Taking into account that the market penetration of more efficient vehicles or equipment is relatively slow and that limited energy efficiency measures have been implemented so far in Vanuatu [34] to reduce dependency on imported fossil fuels, the potential for energy efficiency interventions remains very high. Energy efficiency measures should address land transport as a priority if petroleum imports are to be managed. Further investigation into maritime transport petroleum use is also required in order to better understand energy demand for inter-island transport.

Figure 15. Past trends and BAU projections for petroleum consumption, by type of functional end use



34 The few energy efficiency projects that have been implemented to date have focused only on the electricity sector.

Table 6. Past trends and BAU projections for petroleum products demand

Sector	CAGR 2010-2014	Growth 2014-2020	Growth 2020-2030	2010	2015	2020	2025	2030
Land Transport (L)	3.4%	4.0%	4.5%	25,952,613	29,003,840	37,553,259	44,538,981	58,150,560
Sea Transport (L)	3.4%	4.0%	4.5%	1,441,812	1,611,324	2,086,292	2,474,388	3,230,587
Air Transport (L)	25.3%	5.0%	5.0%	1,490,559	3,863,055	4,930,346	6,292,510	8,031,014
Electricity (L)	-4.2%	-5.0%	-6.2%	14,168,107	12,205,268	8,745,867	6,698,747	4,627,668
Cooking (L)	-1.9%	1.0%	2.0%	2,789,724	2,608,536	2,741,598	3,026,945	3,341,992
Kerosene for Lighting (L)	-29.2%	-20.0%	-10.0%	163,499	32,800	10,748	6,347	3,748
Other (L)	1.8%	3.2%	3.9%	2,139,243	2,263,458	2,771,692	3,231,124	4,066,085
TOTAL				48,145,556	51,588,283	58,839,802	66,269,041	81,451,654

Note: Green = Hypothesis calculated, Black = Raw data; Blue = Projections

Figure 16. Contribution in overall petroleum consumption, by end-user sector

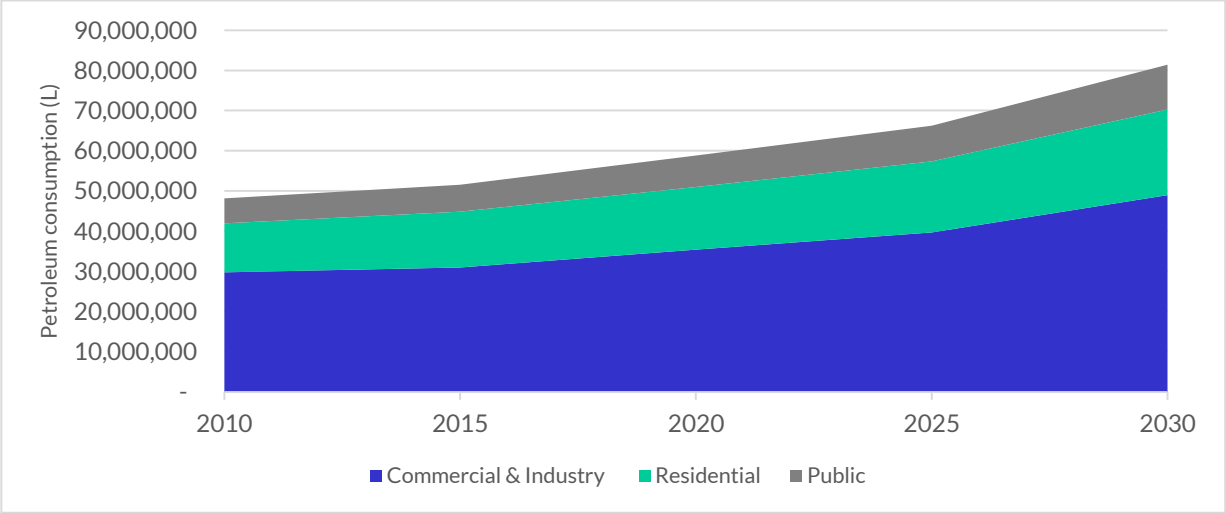


Table 7. Past and projected petroleum consumption, by end-user sector

Sector	CAGR 2010-2014	Growth 2015-2020	Growth 2020-2030	2010	2015	2020	2025	2030
Residential (L)	2.6%	2.0%	3.2%	12,214,084	13,899,096	15,634,965	17,738,474	21,344,617
Commercial & Industry (L)	0.8%	2.2%	3.3%	29,762,891	30,981,159	35,377,686	39,646,960	48,972,202
Public (L)	1.7%	2.6%	3.6%	6,168,582	6,708,028	7,827,151	8,883,607	11,134,834
TOTAL				48,145,556	51,588,283	58,839,802	66,269,041	81,451,654

Note: Green = Hypothesis calculated, Black = Raw data; Blue = Projections

The BAU scenario for petroleum products is based on information and past historical trends for which data was only available from a functional usage perspective. The contribution by end-user sectors to projected demand for petroleum has been estimated for each type of activity (i.e., transport, cooking, others) in the sections above. This information is combined in Figure 16 and Table 7 to show the projection of national petroleum consumption by end-user type from 2015 to 2030.

The commercial and industrial sector remains the main petroleum consumer with an expected share of 60% of petroleum demand in 2030. Therefore, the private sector should be a strong focus for any energy efficiency initiatives.

Vanuatu households (residential sector) will be responsible for 26% of petroleum demand, and public bodies under the GoV account for 14%. While the contribution of the GoV to the overall demand of petroleum products is relatively small, the leadership role of government in incorporating energy efficiency into its own processes and infrastructure should not be underestimated. It is important to show that the GoV itself is making energy efficiency a priority through energy efficiency projects in the public sector.

It should be noted that various petroleum consumption projections for Vanuatu have been established over the last 20 years, mostly using a functional usage approach but based on a slightly different hypothesis. [35] Table 8 summarizes the assumptions of the various reports.

3.6 Impact of the Non-Achievement of NERM 2013–2020 Targets

The NERM 2013–2020 targets for the share of renewable energy in electricity generation are ambitious with 40% targeted in 2015 and 60% in 2020, while the Vanuatu INDC proposes an increase to 90% by 2030. These renewable energy targets have implications for the consumption of petroleum. If Vanuatu does not achieve the NERM targets or the INDC target, petroleum consumption projections will increase compared to the BAU scenario presented above. In the case where only two-thirds of each target is achieved, i.e., 26.6% in 2015, [39] 40% in 2020 and 60% in 2030, the result would be an increase by 90% in the BAU projection of cumulative petroleum consumption for electricity generation by 2030. With only two-thirds of the renewable energy for electricity generation targets achieved, the annual petroleum consumption for electricity would increase by 24% between 2015 and 2030, instead of the 62% decrease currently projected under the BAU.

Table 8. Petroleum growth projections from various sources

Growth Rate	1992 World Bank Report[36]	2004 SREP Report[37]	H&T[38] 2012-2022	GGGI 2015 - 2020	GGGI 2020 -2030
GDP	2 - 2.5%	2.8%	4.0%	4%	4%
Population		3.5%	2.5%	3.1%	3.1%
Petroleum Products	Transport sector @ 5% Jet fuel @ 3% Remaining fuel @ 2 - 2.5%	3.5% per annum	Petrol @ 8% declining to 4% Jet fuel @ 1% Diesel: Transport @ 4% Electricity @ 2% Outer island @ 8% LPG @ 4%	Petrol @ 3% LPG @ 1% Kerosene @ -20% Jet fuel @ 5% Diesel @ 1.7% with: Transport land & sea @ 4% Electricity @ -5%	Petrol @ 3% LPG @2% Kerosene @ -10% Jet fuel @ 5% Diesel @ 3.3% with: Transport land & sea @ 4.5% Electricity @ -6.2%

35 A comparison of these scenarios was presented in Hale and Twomey, and David Butcher and Associates, "Draft Final Report: Options for Increasing the Efficiency of Vanuatu's Oil and Gas Supply Chain," November 2012.

36 World Bank, "Pacific Regional Energy Assessment," August 25, 1992.

37 Peter Johnston, "SPREP – Pacific Regional Energy Assessment 2004," November 5, 2005.

38 Hale and Twomey, and David Butcher and Associates, "Draft Final Report: Options for Increasing the Efficiency of Vanuatu's Oil and Gas Supply Chain," November 2012.

39 In reality, 29% renewable energy electricity was achieved on average in 2015.

4 Biomass BAU Projections

4.1 Sectoral Assumptions and BAU Projections

Biomass sources in Vanuatu are 50% mixed fuelwood (5% moisture content) and 50% coconut residues (air dry – 0% moisture content). These types of biomass are locally available to the rural population at no, or very low cost. In 2012, 79% of Vanuatu's population was wholly or partially dependent on traditional fuels, which almost exclusively was fuelwood and other agricultural wastes such as coconut husk. Currently, there is no commercial use of biogas or biomass resources for energy apart from coconut oil. [40] There is a small market for biomass-based charcoal but no data is available on charcoal production quantities. Non-energy related biomass production (such as timber) is not included in this analysis.

In 2004, the Secretariat of the Pacific Regional Environment Programme (SPREP) estimated that biomass provides over 50% of gross national energy production. About 106 kilotons of fuelwood were estimated to be consumed per annum for cooking, as 95% of the rural population and 47% of the urban population still cooked with biomass fuel. [41] It is worth noting that cooking with biomass in Vanuatu is predominantly via open fire cooking and other inefficient cooking methods. In addition, a large portion of biomass is used for drying purposes in agriculture with copra as one of the main commodities. The International Renewable Energy Agency (IRENA) estimated that in 2012 around 43,600 toe of fuelwood is burned each year for cooking and crop drying. [42]

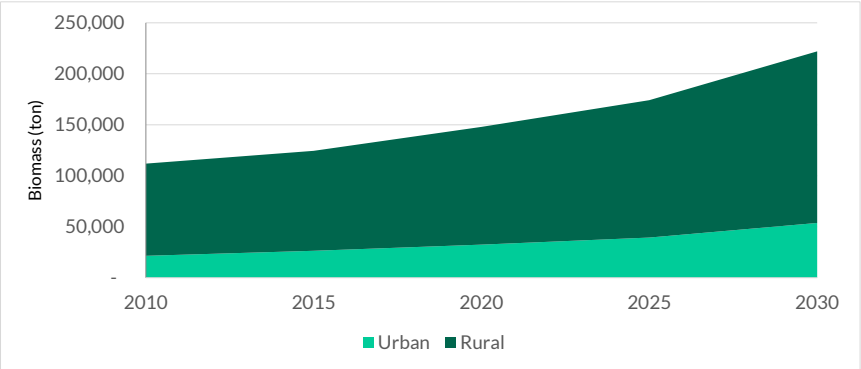
A five-day survey conducted by the Department of Forestry at the Port Vila market [43] concluded that the main species used as fuelwood in urban areas are *Leucaena leucosephala* followed by *Macaranga* and *Accasia spirobis*. Based on interviews, traders of fuelwood are spending more time to find and collect fuelwood (some of which is converted into charcoal). The majority of those interviewed have indicated that fuelwood resources are in decline, and there is a need for replanting and sustainable harvesting. Based on the crude estimates of biomass consumption currently available and national population data, it is estimated that the current daily consumption of a household relying on biomass for cooking is about 8 kg fuelwood.

In the absence of changes in household behavior and technologies used for cooking and drying, the national biomass consumption is likely to increase in line with population (3.1% growth) and GDP (4% growth) over the coming 15 years.

4.2 National Biomass Consumption Projections Under the BAU Scenario

Acknowledging that the baseline data available for biomass consumption is limited, the following projections are rough estimates only and would need to be updated when the next national survey on biomass usage for energy is conducted.

Figure 17. Estimated national biomass consumption in urban and rural areas



40 DoE and United Nations Development Programme, "NAMA on Rural Electrification in Vanuatu," 2015, http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/MDG%20Carbon%20Facility/NAMA%20Final%20Vanuatu.pdf.

41 Peter Johnston, "SPREP – Pacific Regional Energy Assessment 2004," November 5, 2005.

42 IRENA, "Vanuatu: Renewables Readiness Assessment," June 2015, http://www.irena.org/DocumentDownloads/Publications/IRENA_RRA_Vanuatu_2015.pdf. Note: There is an inconsistency on the data information from IRENA and SPREP/GEF estimates on biomass – this is due to limited information available on biomass usage in Vanuatu.

43 Tate Hanington, "Wood Energy a Reliant Energy Source for Vanuatu," SPC Newsletter, December 1, 2012.

The demand for biomass is driven by cooking and crop drying in rural households and businesses. With an expected annual growth in biomass usage of 3% in the next 5 years, and 4% between 2020–2030, the required volume of fuelwood and coconut residues being burnt is estimated to increase by 78% between now and 2030. If this scenario does eventuate, it could lead to the following impacts: (1) increased deforestation around areas with high population density; (2) increased time spent collecting biomass; and (3) continued negative impacts on health, caused by exposure to smoke. These impacts will have a disproportionate impact on women, who are largely responsible for cooking tasks.

The biomass sector is open to a wide range of potential energy efficiency interventions. These can slow the rate of demand growth and result in benefits to consumers and businesses in terms of reduction in overall costs (time spent or monetary), as well as positive impacts on the environment, including management of deforestation and reduction of carbon emissions.

5 Electricity BAU Projections

5.1 Residential Sector Assumptions and BAU Projections

5.1.1 Projected Number of Households

Based on the urban and rural households figures available for the years 1999 and 2010 from two reports the "Energy Efficiency Targets Report – Vanuatu" of the Promoting Energy Efficiency in the Pacific Phase 2 (PEEP2) Project of the Asian Development Bank [44] and VNSO's "Household Income and Expenditure Survey 2010" [45]—the number of urban and rural households up to 2030 are estimated:

- The CAGRs for the number of urban and rural households for the period 1999 and 2010 were 3.9% for urban households and 2.8% for rural households.
- The distribution of rural households among provinces are based on data from the Vanuatu Household Income and Expenditure Survey 2010.

Table 9. Projected number of households

Year	1999	2010	Share	CAGR	2013	2015	2020	2025	2030
Source	PEEP2	HIES 2010							
No. of Urban Households	8,218	12,460		3.9%	13,615	14,445	16,745	19,412	22,504
Port Vila		9,760	78%		10,665	11,315	13,117	15,206	17,628
Luganville		2,700	22%		2,950	3,130	3,629	4,207	4,877
No. of Rural Households	28,197	38,280		2.8%	40,623	42,264	46,663	51,520	56,882
Torba		1,790	5%		1,900	1,976	2,182	2,409	2,660
Sanma Rural		7,040	18%		7,471	7,773	8,582	9,475	10,461
Penama		6,930	18%		7,354	7,651	8,448	9,327	10,298
Malampa		8,680	23%		9,211	9,583	10,581	11,682	12,898
Shefa Rural		6,960	18%		7,386	7,684	8,484	9,367	10,342
Tafea		6,880	18%		7,301	7,596	8,387	9,260	10,223
Total No. of Households	36,415	50,740		2.2%	54,238	56,709	63,408	70,932	79,386

Notes: PEEP2 = Data from Asian Development Bank's PEEP2 Project
HIES 2010 = VNSO's Household Income and Expenditure Survey 2010
Green = Hypothesis calculated, Black = Raw data; Blue = Projections

Source: VNSO, "Vanuatu Household Income and Expenditure Survey 2010," January 28, 2013.

44 International Institute for Energy Conservation, "Appendix 2.5: Energy Efficiency Targets Report – Vanuatu," in Promoting Energy Efficiency in the Pacific (Phase 2): Final Report (Mandaluyong: Asian Development Bank, 2015)

45 VNSO, "Vanuatu Household Income and Expenditure Survey 2010," January 28, 2013.

By assuming that the share of each province of the total population remains the same between 2010 and 2030, [46] the following projected numbers of households for the years 2015, 2020, 2025 and 2030 are obtained as shown in Table 9.

5.1.1.1 Projection of Electrification Rates

In 2013, the electrification rate in Vanuatu was 27% [47] (this data was heavily skewed toward major urban centers). In 2010, 80% of the urban households and 11% of the rural households, where more than 75% of the population resided, were electrified. [48]

Electricity supply is mainly provided by two utilities (UNELCO and VUI) operating grids on the main islands of Vanuatu: Efate (Port Vila), Santo (Luganville), Malekula (Lakatoro) and Tanna (Lenakel). There are smaller distribution networks on the islands of Sola, Ambae and Maewo, which are operated by provincial governments

In the NERM 2013–2020 projections, it is assumed that by 2030, 100% of households within grid concession areas and 100% of households close to concession areas would be electrified through grid extensions. For off-grid households, according to the Vanuatu Rural Electrification Project, [49] 25% of the households are expected to be electrified through micro-grid projects, and the remaining 75% through SHS [50] and solar lanterns. [51]

According to the 2013-2020 NERM electrification status by 2030 should therefore be:

- 100% of urban households electrified through connections in existing concessions areas,[52]
- 50% of rural households electrified either by grid extensions (9%) or by micro-grids (91%), and
- the remaining 50% rural households not connected to grid electricity using solar lanterns or solar home systems.

It should be noted that the BAU scenarios presented here do not consider the households electrified by SHS or solar lanterns.

Table 11 shows the estimated access to national electricity in 2015. These estimates, by concession areas, are calculated based on the 2013 number of customers (from utilities' data) to which 2010–2013 CAGR was applied, and the electricity access assumptions presented in the report, "Nationally Appropriate Mitigation Action (NAMA) on Rural Electrification in Vanuatu" were used. [53]

Table 10. Electricity access: Baseline and roadmap targets

	Current	2015	2020	2030
Households Within Grid Concession Areas ~ 18,500	68% (12,500 Households)	75%	90%	100%
Households Close to Concession Areas – Grid Extensions ~ 3,000	0%	33%	90%	100%
Off-Grid Households ~ 31,500	<10%	TBD	100%	100%
Public Institutions (Grid and Off-Grid)	50%	90%	100%	100%

Source: GoV, "Vanuatu National Energy Road Map 2013–2020," July 19, 2013.

Note: Total number of households ~53,000 based on the 2010 Census Update and national average of 4.5% persons per household.

46 According to the Vanuatu Household Income and Expenditure Survey 2010, no major rural exodus has been observed in recent years

47 DoE, "Update on the Energy Sector in Vanuatu," 2015.

48 GoV, "Vanuatu National Energy Road Map 2013–2020," July 19, 2013.

49 DoE, "Vanuatu Rural Electrification Project," July 28, 2015.

50 Solar home systems (SHS) refer to solar panel installations and basic internal wiring that can supply several lights and charging facilities for phone, TV, radio, etc.

51 Solar lanterns refer to the cash-and-carry pico lighting and charging products sold through retail shops and other establishments.

52 According to the DoE, connection rates have only started increasing since the Global Partnership on Output Based Aid (GPOBA) Improved Electricity Access Project that started in October 2014.

53 DoE and United Nations Development Programme, "NAMA on Rural Electrification in Vanuatu," 2015, 25, http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/MDG%20Carbon%20Facility/NAMA%20Final%20Vanuatu.pdf.

Table 11. Electricity access in 2015

Island	Efate	Espirito Santo	Tanna	Malekula	Ambae	Banks Group (Vanua Lava)	Maewo
Operator	UNELCO	VUI	UNELCO	UNELCO	PENAMA Provincial GoVernment	TORBA Provincial GoVernment	Talise Community
Customers	10,338	2339	682	526	125	75	80
Installed capacity (MW)	2635	4.1	0.5	0.5	0.1	0.07	0.0075
Annual sales (MWH)	52,243	7,742	509	620	NA	NA	Commissioned in late 2014
Energy sources	Diesel, Wind, Biofuel & Solar	Hydro + Diesel	Diesel + Solar	Biofuel + Diesel	Biofuel + Diesel	Biofuel + Diesel	Hydro

Sources: Utilities; and DoE and United Nations Development Programme, "NAMA on Rural Electrification in Vanuatu," 2015.

Province-wise electrification rates were estimated for the period between 2015 and 2020, based on electrification projects planned (grid extension)[54] and on already financed rural electrification projects (see Table 12 below):[55]

Urban Areas:

Port Vila and Luganville: Due to the Global Partnership on Output Based Aid (GPOBA) Improved Electricity Access Project, it is expected that the electrification growth rate of Luganville will grow between 2015 and 2020.

Rural Areas:

Shefa rural: There are 1,058 households to be connected around the ring road as part of the Efate grid extension completion. [56] This would represent on average 30% of all households outside of concession areas, but implementation depends on the progress of the geothermal power project. The grid extension should be completed by 2020.

Samna rural: According to the grid extension plan presented in the NERM, the east coast of Santo and the south will be electrified through grid extension. This should enable the connection of 1,000 households by 2020.

Malampa rural: On the island of Malekula, the concession grid is to be extended up to Vao reaching 100% households within this area. Then micro-grid projects are planned for electrification of another 630 households by 2020.

Tafea rural: Grid extension in the Tanna concession area is expected to reach 200 households. However, only 91% of the existing concession area can be electrified through grid extension. Construction of one micro-grid in Whitesand Tanna is underway reaching 88 households. An additional micro-grid is expected to be built in the island of Aniwa electrifying 29 households.

Penama rural: On Maewo, the grid is expected to be extended and connect an additional 20 households, and an off-grid hydro project is expected to bring electricity to around 300 households. The same mix (off-grid hydro and grid extension) is planned for the island of Ambae, reaching 45 households. One micro-grid is planned in Pentecost Island electrifying 51 households. A European Union financed biofuel rural electrification project should electrify an additional 350 households in off-grid areas of Penama.

Torba rural: Extension of the grid in Sola is expected to electrify 100 households, and projects financed by the European Union are targeting 300 households.

54 National Advisory Board, GoV, "National Advisory Board on Climate Change and Disaster Risk Reduction – NAMA," October 15, 2015.

55 Ibid.

56 Castlerock Consultants, Vanuatu: Efate Geothermal Power and Island-Ring Grid Development Framework (Washington, D.C.: World Bank, 2011).

Table 12. Ongoing electrification projects

	GPOBA	World Bank	EU	IUCN	M3P	SREP
Full name of initiative	GPOBA Grid Based Electricity Access Project	Vanuatu Rural Electrification Project (VREP) – Phase 1 and 2	Biofuel Rural Electrification Project	Talise Hydro Project	Melanesia's Million Miracle Programme	Scaling Up Renewable Energy in Low Income Countries Program
Short description	Project aims to increase sustainable access to formal grid-based electricity services within Vanuatu's electricity concession services areas for low-income customers through targeted subsidies. The project aims to cover 80% of the cost of connecting 4,375 households to the national grid through post-paid and pre-paid (where available) metered connections.	Project aims to provide access to electricity services for 17,500 rural households, 230 aid posts and 2,000 community halls located in dispersed off-grid areas. The project will reach 85% of the off-grid households. The project will subsidize the retail cost of eligible solar "plug & play" PV systems by 50%.	Project aims to increase access to electricity services for rural households of Penama, Torba and Malampa provinces. It targets 300 households in Torba, 350 households in Penama and 500 households in Malampa. Additionally, it also targets 2 hospitals, 4 dispensaries, 10 schools, business houses and government facilities.	Project aims to increase access to electricity services in Maewo. It targets 300 households, 1 health center, 3 schools and small shops.	Program aims to provide electric lighting through solar lanterns for 200 households in 2 communities, with further scaling up envisaged if additional funds are available.	Program aims to pilot and demonstrate the economic, social and environmental viability of development pathways in the energy sector by creating new economic opportunities and increasing energy access through the use of renewable energy.
Target area	UNELCO and VUI concession areas	All off-grid areas in Vanuatu	Off-grid areas of Penama, Torba and Malampa provinces	Off-grid areas in Maewo	2 communities in Tanna (White Sands and Port Resolution)	All off-grid areas in Vanuatu
Financing	USD 4.85 million GPOBA (financed through Australian Aid); and USD 0.51 user contributions	USD 4.7 million (financed by New Zealand through the World Bank)	~USD 3.5 million (financed by the European Union and GoV)	USD 1 million (financed by IUCN and GoV)	USD 110,000	USD 14 million (Financed through Climate Investment Funds, ADB & WB group)
Total budget	USD 5.36 million	USD 4.7 million	~USD 3.5 million	> USD 1 million	n.a.	USD 34.2 million*
Financing institution	Australian Aid and World Bank	New Zealand and World Bank	European Union	IUCN	Secretariat of the Pacific Community (SPC)	Asian Development Bank and World Bank Group
Timeline	Start of roll out – March 2014	Officially launched in September 2015. The revised closing date is December 31, 2019 [57]	Ongoing	Ongoing	Implementation started Q4/2014	Approval of Project Preparatory Technical Assistance – June 2015
Project implementing unit	DoE	DoE	DoE	DoE	DoE	DoE
Involved private parties	UNELCO, VUI	Equipment suppliers	Not currently. There may be in future.	n.a.	Equipment suppliers, Alternative Commodities Trade in Vanuatu (ACTIV)	Private sector vendors and renewable energy service companies

Source: DoE
**This includes USD 4.7 million for the VREP - Phase 1*

57. World Bank, "Rural Electrification Project: Implementation Status & Results Report," 10 December 2015, http://documents.worldbank.org/curated/en/221461468318266762/pdf/ISR-Disclosable-P150908-12-10-2015-1449724124185.pdf.

In order to fulfill the ambitious rural electrification targets set by the GoV in the NERM 2013–2020, during 2020–2030 it is assumed that at least the same number of electrification projects as during 2015–2020 will be maintained between each subsequent five year periods (i.e., between 2020 and 2025 and then between 2025 and 2030). Even with all these projects, it is estimated that Vanuatu will likely only reach 41% of rural electrification through grid extensions and micro-grids, below the 50% target set by the NERM (see Table 13).

5.1.2 Households Electrified

Based on the assumptions regarding household numbers and electrification rates discussed above, the number of electrified households up to 2030 is estimated in Table 14.

As shown in Table 14, because of the relatively high projected population growth rate as well as the ambitious electrification targets set by the GoV, even if NERM targets are not fully met, the number of electrified households is expected to triple in the coming 15 years, with electrified rural households outnumbering urban electrified households by 2030. The evolution of electrified households by location is shown in Figure 18.

Table 13. Electrification rates in Vanuatu

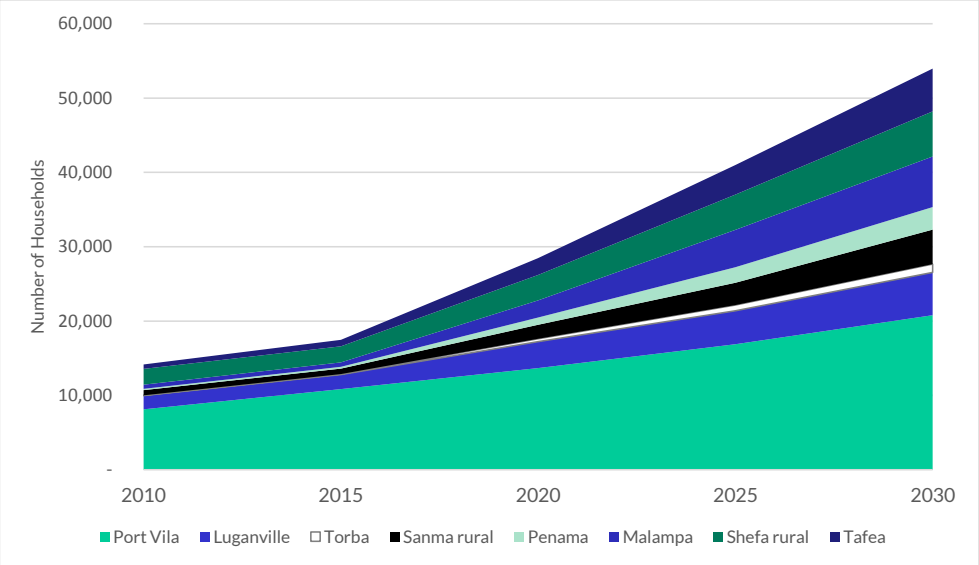
Year	2010 Source: HIE 2009	2013 Sources: UNELCO & VUI	2015	2020	2025	2030
% of Urban Households Electrified	80%	84%	86%	95%	97%	100%
Port Vila	83%	88%	92%	96%	98%	100%
Luganville	68%	67%	66%	90%	95%	100%
% of Rural Households Electrified	11%	11%	11%	22%	34%	41%
Torba	1%		4%	17%	28%	35%
Sanma	10%		9%	20%	28%	38%
Penama	3%		3%	11%	20%	25%
Malampa	7%	5%	6%	20%	38%	45%
Shefa	30%		27%	37%	45%	50%
Tafea	8%	11%	11%	25%	38%	48%
% of Total Households Electrified	28%		30%	41%	51%	58%

Note: Green=calculated / Black=hypothesis and historical data

Table 14. Number of electrified households

	2015	2020	2025	2030	Annual Growth Rate 2010–2020	Annual Growth Rate 2020–2030
Urban	13,002	17,226	21,396	26,556	6%	4%
Port Vila	10,849	13,679	16,872	20,801	5%	4%
Luganville	2,153	3,548	4,524	5,754	7%	5%
Rural	4,677	11,229	19,577	27,411	10%	9%
Torba	82	400	760	1,092	33%	11%
Sanma	728	1,859	2,991	4,664	10%	10%
Penama	239	1,007	2,103	3,020	19%	12%
Malampa	598	2,292	5,004	6,810	15%	12%
Shefa	2,159	3,400	4,752	6,067	5%	6%
Tafea	870	2,271	3,967	5,757	15%	10%
	17,473	28,455	40,973	53,967	7%	7%

Figure 18. Evolution of the number of households electrified



5.1.3 Distribution of Existing and New Customers

The analysis of UNELCO and VUI technical reports of 2013 shows that new residential customers have a much lower average household electricity consumption than existing customers. However, average electricity consumption of new customers grows at a much faster rate than that of existing customers. Therefore, prior to estimating future average electricity consumption, the analysis first estimates the number of existing customers and new customers.

As shown in Table 15, based on the analysis of average consumption of residential customers in UNELCO and VUI technical reports, it is assumed that a new customer takes on average 10 years to reach the consumption level of existing customers.

5.1.4 Average Residential Electricity Consumption

For the estimation of future average residential electricity consumption, it is assumed that the annual growth rates will be lower in 2015–2020 than in 2020–2030. This is because of programs such as the GPOBA Improved Electricity Access Project that is running between 2014 and 2018 and will enable low-income households to connect to the main grid. Based on previous experience [58] low-income households joining the grid have low initial electricity consumption, thus lowering the overall average growth rate for the 2015–2020 period.

Overall, based on the analysis of past trends, [59] residential electricity consumption is expected to evolve as follows:

- For urban areas connected to the utility grid (Port Vila and Luganville), the average household electricity consumption will remain almost constant, the growth in number and size of appliances being compensated by the gain in energy efficiency of newer appliances available on the market. [60]

- For rural areas connected to utility grids in Malekula and Tanna, the average electricity consumption will tend toward Luganville customers' average. The average electricity consumption of these two concessions should thus increase toward the Luganville level.

- For rural areas connected to mini-grids in the provinces of Torba and Penama, it is estimated that the average electricity consumption will follow that of Tanna.

It is expected that once older inefficient appliances have been replaced in urban areas with more efficient ones, the older appliances will be recycled and reused in rural areas. This should increase per capita consumption in rural areas.

Based on these assumptions, the growth rates for future evolution of per capita residential consumption are estimated as shown in Table 16.

58 Utilities reports from UNELCO and VUI, 2013

59 Ibid.

60 Note that this gain in energy efficiency is already slowly happening even without any specific energy efficiency measures.

Table 15. Number of existing and new customers

	2010	2015	2020	2025	2030
Urban	9,976	12,797	17,226	21,396	26,556
Port Vila	8,140	10,849	13,679	16,872	20,801
Existing Customer	8,140	8,140	9,495	13,618	18,383
New Customer	-	2,709	4,184	3,253	2,418
Luganville	1,836	2,153	3,548	4,524	5,754
Existing Customer	1,836	1,836	1,995	3,009	4,931
New Customer	-	317	1,553	1,516	823
Rural	4,174	4,677	11,229	19,577	27,411
Torba	23	82	400	760	1,092
Existing Customer	23	23	53	271	776
New Customer	-	59	347	490	316
Sanma	708	728	1,859	2,991	4,664
Existing Customer	708	708	718	1,303	3,003
New Customer	-	20	1,141	1,687	1,661
Penama	174	239	1,007	2,103	3,020
Existing Customer	174	174	206	655	1,979
New Customer	-	65	800	1,448	1,041
Malampa	568	598	2,292	5,004	6,810
Existing Customer	568	568	583	1,460	4,514
New Customer	-	30	1,709	3,544	2,296
Shefa	2,120	2,159	3,400	4,752	6,067
Existing Customer	2,120	2,120	2,140	2,770	3,761
New Customer	-	39	1,261	1,982	2,306
Tafea	581	870	2,271	3,967	5,757
Existing Customer	581	581	725	1,498	2,732
New Customer	-	289	1,546	2,469	3,025

Table 16. CAGRs of household electricity consumption per capita in different areas

		CAGR (Historical)	Growth Rate 2010 - 2020	Growth Rate 2020 - 2030
New Customers	CAGR of New Customers' Electricity Consumption in Rural Areas		3.0%	5.0%
	CAGR New Customers' Electricity Consumption in Urban Areas		8.0%	8.0%
Existing Customers	CAGR of Per Capita Electricity Consumption in Malekula – Malampa	8.2%	3.0%	2.0%
	CAGR of Per Capita Electricity Consumption in Tanna – Tafea	-0.2%	2.0%	4.0%
	CAGR of Per Capita Electricity Consumption in Port Vila – Shefa	-2.8%	-1.0%	0.5%
	CAGR of Per Capita Electricity Consumption in Luganville – Samna	0.2%	0.0%	0.5%

For existing customers in concession areas, average electricity consumption is directly taken from UNELCO and VUI reports of 2013:

- Port Vila: 134 kWh/month;
- Luganville: 88 kWh/month;
- Malekula: 44.5 kWh/month; and
- Tanna: 31.3 kWh/month.

For new customers in micro-grids area, average electricity consumption is evaluated according to their estimated level of equipment as defined in the NERM 2013–2020 (see Table 17).

For new customers in and outside concession areas, per capita consumption is defined based on the consumption of pre-paid customers in 2013 in UNELCO concessions. [61] It should be noted that based on previously mentioned assumptions, per capita electricity consumption patterns [62] are calculated in Table 18 and graphically represented in Figure 19.

Table 17. Level of equipment of micro-grids customers

Newly Connected Household Appliances	Watts	Hours / Day	kWh / Day	KWh / Month
Lighting CFL * 2@11W	22	8	0.2	5.3
Phone Charging	5	2	0.0	0.3
TV	65	0	0.0	0.0
Radio	35	12	0.4	12.6
Total	127	22	0.6	18.2

Source: GoV, "Vanuatu National Energy Road Map 2013–2020," July 19, 2013.

Table 18. Average annual electricity consumption in rural and urban households

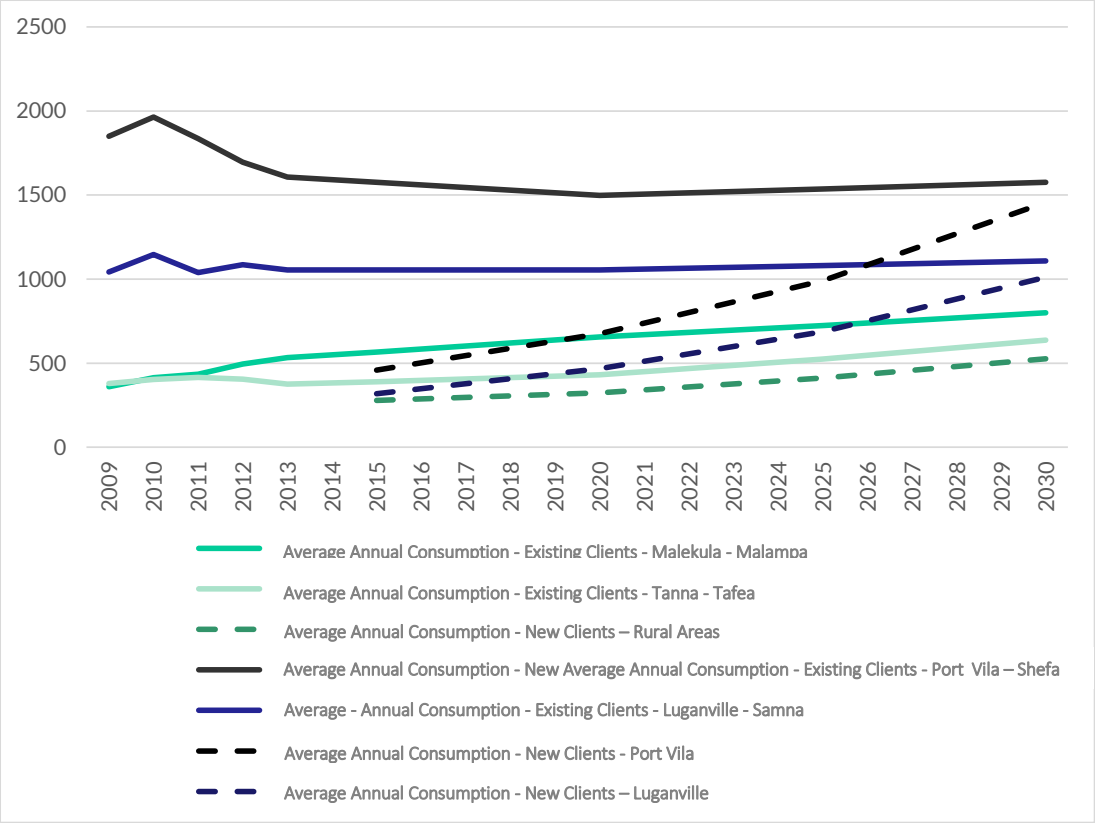
	2009	2010	2011	2012	2013	2020	2025	2030
Average Annual Electricity Consumption in Rural Households (kWh/Year)	371	408	424	444	435	576	704	860
Average Annual Consumption - Existing Clients - Malekula - Malampa	360	414	434	495	534	656	725	800
Average Annual Consumption - Existing Clients - Tanna - Tafe	379	404	415	406	375	431	524	638
Average Annual Consumption - New Clients – Rural Areas						323	413	526
Average Annual Electricity Consumption in Urban Households (kWh/Year)	1,696	1,805	1,686	1,585	1,512			
Average Annual Consumption - Existing Clients - Port Vila – Shefa	1,850	1,964	1,836	1,696	1,608	1,499	1,537	1,576
Average - Annual Consumption - Existing Clients - Luganville - Samna	1,043	1,146	1,038	1,086	1,054	1,054	1,081	1,108
Average Annual Consumption - New Clients - Port Vila						675	991	1,457
Average Annual Consumption - New Clients – Luganville						453	666	979
Ratio Urban/Rural	4.6	4.4	4.0	3.6	3.5			

Note: Blue = Projections

61 The UNELCO pre-paid tariff is a highly subsidized connection for those that consume less than 60 kWh/month. The subsidy to low-energy users is provided by charging higher prices to high-demand customers. The 60 kWh/month tariff was set at VUV16.22/kWh or 15.59 US cents in May 2015 compared to over VUV50/kWh (over 45 US cents) for customers consuming over 60 kWh/month.

62 For simplification and as data on electricity consumption in existing micro-grids were not available, per capita consumption in rural areas outside of concessions started to be computed only for after 2013.

Figure 19. Average annual electricity consumption of households



Note: The decline observed between 2010 and 2011 in the graph above is due to the increase of new customers in 2011 impacting the overall level of residential average electricity consumption.

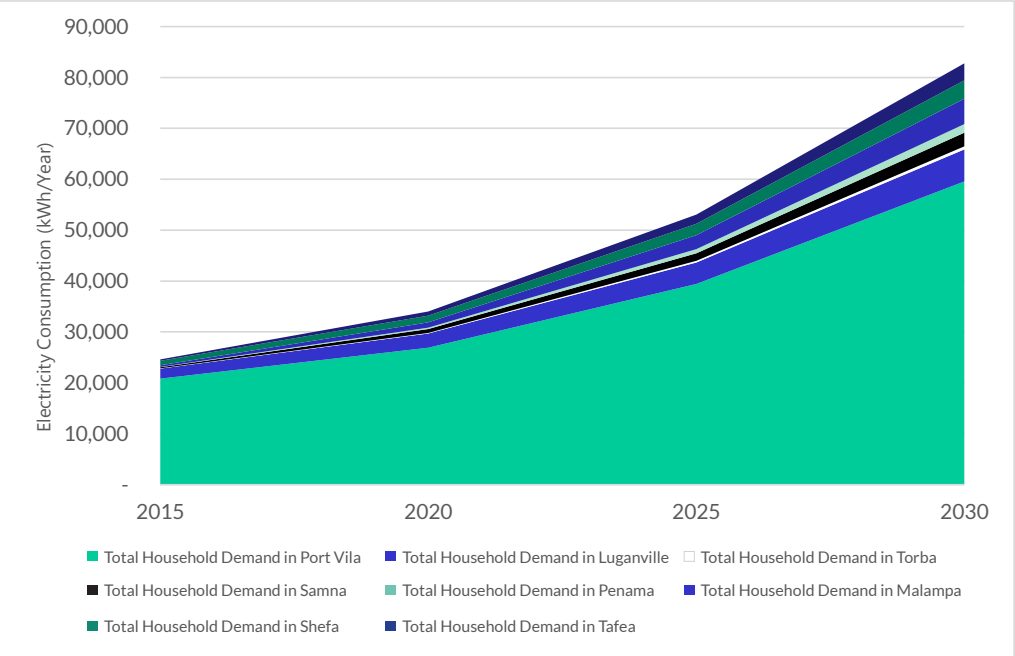
5.1.5 Projected Electricity Sales for the Residential Sector

Calculating the number of existing and new customers with their average annual electricity consumption, projections of electricity sales are estimated in Table 19.

Table 19. Projected electricity sales

	2015	2020	2025	2030
Projected Electricity Demand in Urban Areas (MWh/Year)	22,874	29,738	43,722	65,845
Total Household Demand in Port Vila	20,837	26,908	39,427	59,548
Total Household Demand in Luganville	2,037	2,830	4,295	6,297
Projected Electricity Demand in Rural Areas (MWh/Year)	1,808	4,324	9,439	16,947
Total Household Demand in Torba	26	135	344	661
Total Household Demand in Samna	282	678	1,379	2,790
Total Household Demand in Penama	86	348	941	1,811
Total Household Demand in Malampa	330	935	2,520	4,821
Total Household Demand in Shefa	838	1,329	2,270	3,613
Total Household Demand in Tafea	307	812	1,804	3,335
Total Household Electricity Consumption (MWh/Year)	24,743	33,976	52,979	82,876

Figure 20. Evolution of total residential electricity consumption



These BAU projections for the residential sector can be used as the baseline to prepare energy efficiency targets for Vanuatu.

Overall, residential electricity consumption is expected to more than triple in the coming 15 years, and residential demand is expected to remain highly concentrated in Port Vila.

5.2 Commercial and Industrial Sector Assumptions and BAU Projections

5.2.1 Number of Commercial and Industrial Customers

Growth rates used in the projections for commercial and industrial customer numbers are estimated, based on the CAGRs, which were obtained from the number of commercial and industrial customers (from 2009–2013) in UNELCO and VUI technical reports of 2013, and on the analysis of past trends.

Using the previously estimated annual growth rate and the number of customers in 2013 from VUI and UNELCO reports, the evolution of the commercial and industrial customer numbers shown in Figure 21 is calculated. For off-grid areas, a conservative assumption that the initial number of customers will be around half the number of customers in Malekula (therefore 14 customers) is used. [63]

Taking into consideration the above assumptions, the total number of consumers is therefore predicted to grow by 156% (2,293 consumers) in 15 years, with the number of commercial and industrial customers in Port Vila experiencing the greatest increase.

Table 20. CAGRs for customer numbers in the industrial and commercial sector

	CAGR (Historical)	Growth Rate 2015 - 2020	Growth Rate 2020 - 2030
No. of Commercial & Industrial Customers in Port Vila	2.2%	2.2%	2.5%
No. of Commercial & Industrial Customers in Luganville	1.2%	1.2%	3.0%
No. of Commercial & Industrial Customers in Tanna	8.9%	4.0%	6.0%
No. of Commercial & Industrial Customers in Malekula	0.8%	2.0%	3.0%
No. of Commercial & Industrial Customers in Off-Grid Areas		2.0%	4.0%

Figure 21. Number of industrial and commercial customers

63 Based on the UNELCO utility report of 2013, the number of commercial and industrial customers in Malekula is 28 and it is assumed that half of these customers are in off-grid areas i.e., 14 customers.

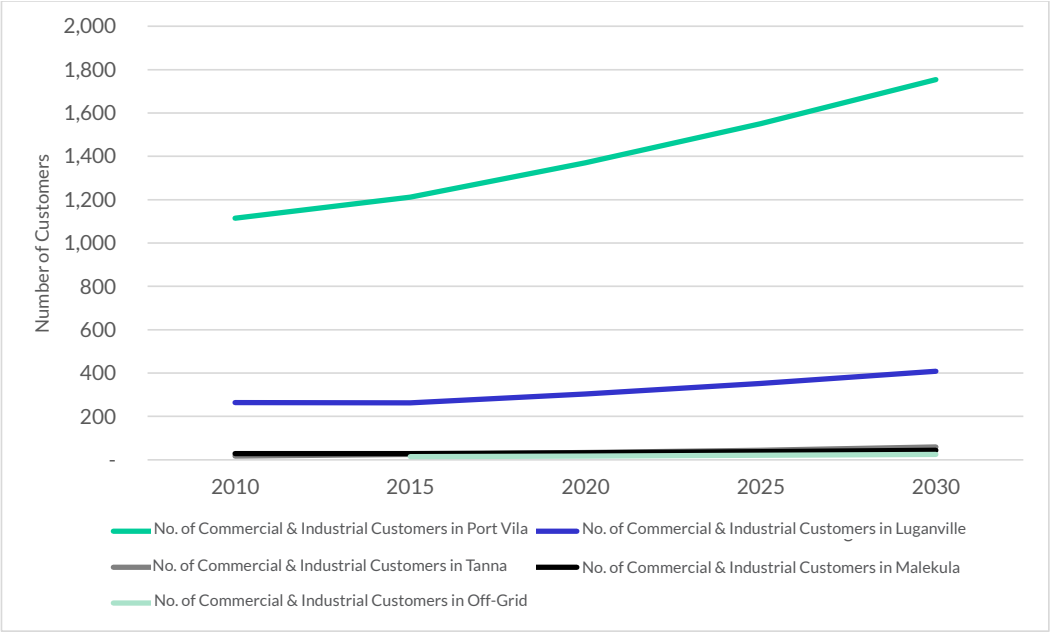
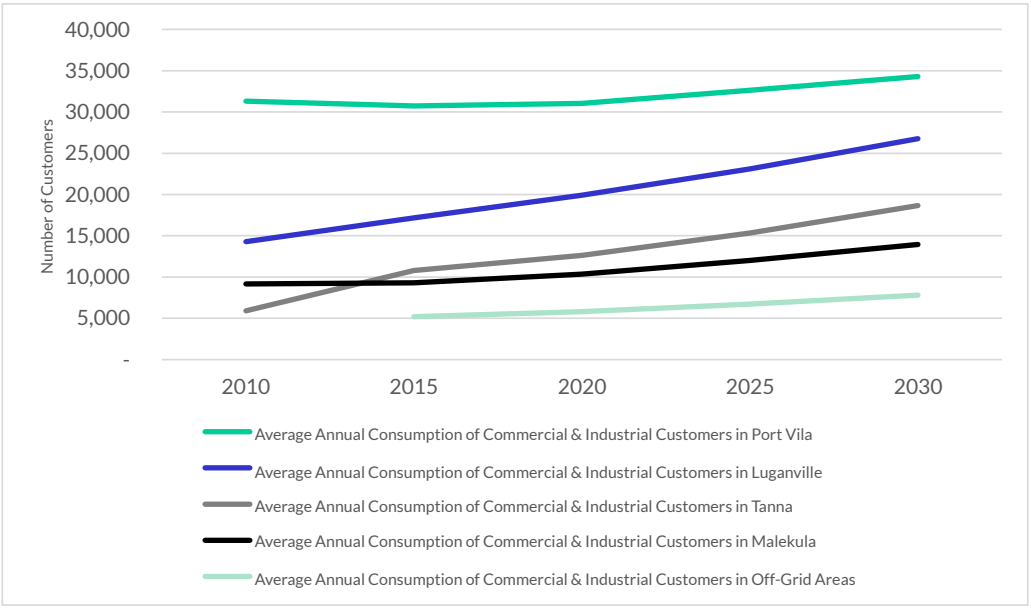


Table 21. Average electricity consumption of industrial and commercial customers

	CAGR (Historical)	Growth Rate 2015 - 2020	Growth Rate 2020 - 2030
Average Annual Consumption of Commercial & Industrial Customers in Port Vila	-0.7%	0.0%	1.0%
Average Annual Consumption of Commercial & Industrial Customers in Luganville	3.6%	3.0%	3.0%
Average Annual Consumption of Commercial & Industrial Customers in Tanna	13.7%	4.0%	5.0%
Average Annual Consumption of Commercial & Industrial Customers in Malekula	1.5%	3.0%	4.0%
Average annual consumption of Com & Ind Customers in off-grid areas (kWh/year)		3.0%	3.0%

Figure 22. Average annual electricity consumption of the commercial and industrial sector



5.2.2 Average Commercial and Industrial Electricity Consumption

Based on the analysis of UNELCO and VUI technical reports, and the assumption that average consumption in off-grid areas will be similar to Malekula, annual growth rates for per capita consumption of commercial and industrial customers is estimated in Table 21. Based on these growth rates, the projected average consumption of commercial and industrial customers over time is estimated in Figure 22.

Over the next 15 years, due to the current low development of both commerce and industries in the country, it is expected that the average electricity consumption of commercial and industrial customers across the nation will grow 3% to 4% annually with the exception of Port Vila where growth will be lower. As the majority of commercial and industrial customers are based in Port Vila, the overall average electricity consumption of commercial and industrial customers are therefore only likely to grow 1% annually.

5.2.3 Projected Electricity Sales in the Commercial and Industrial Sector

Taking into account the number of existing customers with their average annual electricity consumption, and the projected increases in numbers and growth in consumption estimated above, the projections of electricity sales are shown in Figure 23.

As with the results for the residential sector, the commercial and industrial customer demand will remain strong in urban areas (mainly in Port Vila but also, to a lesser extent, in Luganville), and electricity consumption in the sector is likely to nearly double in the coming 15 years.

These BAU projections for the commercial and industrial sector can be used to prepare energy efficiency targets for Vanuatu, which targets this group of consumers.

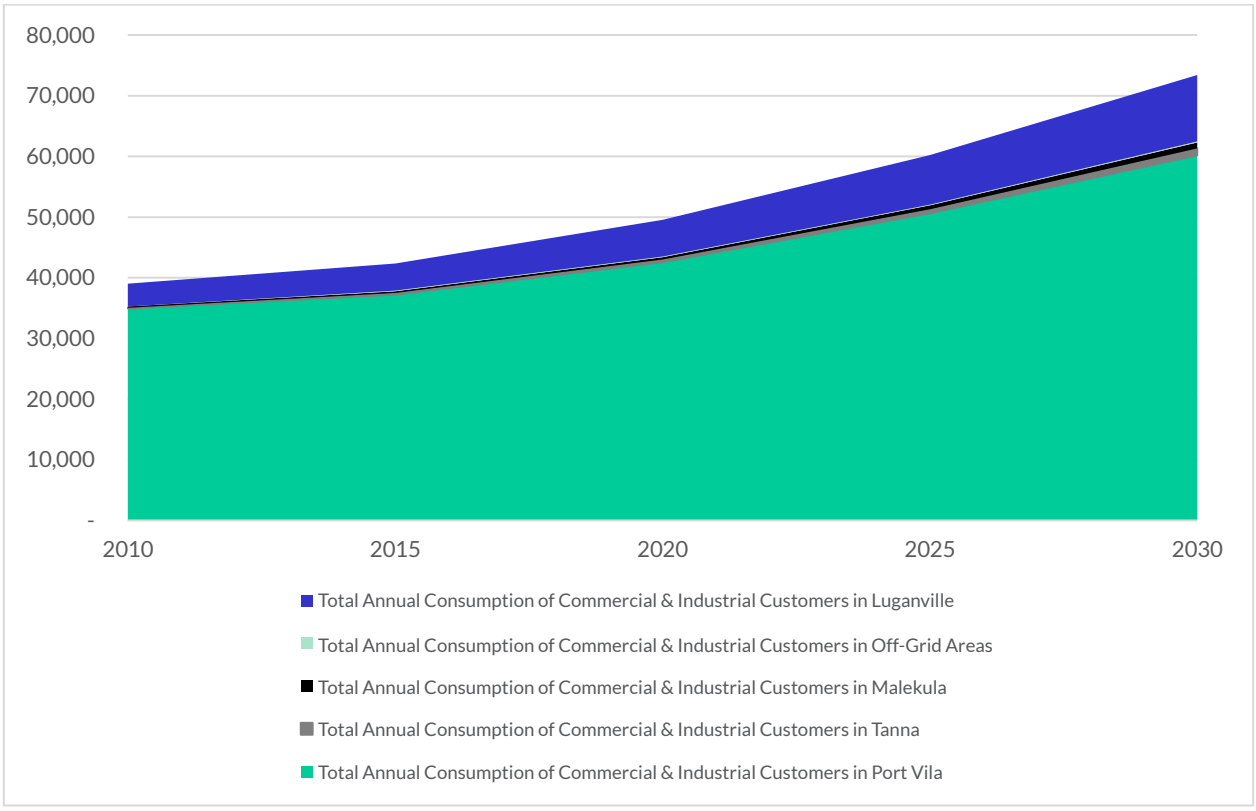
5.3 Public Sector and Street Lighting Assumptions and BAU Projections

5.3.1 Number of Public Sector Customers

Based on the growth of public sector customers between 2009 and 2013 (from UNELCO and VUI technical reports of 2013), and assuming that the number of public sector customers in off-grid area will follow the same growth pattern as Malekula, growth rates are estimated in Table 22. [64]

Based on historical trends from UNELCO and VUI technical reports, it is assumed that the number of public sector customers in off-grid areas will be similar to Malekula.

Figure 23. Projected electricity sales in the commercial and industrial sector



64 For further information on the evolution of public sector customer numbers, see the Appendix.

Table 22. CAGRs and growth rates of the number of public sector customers

	CAGR (Historical)	Growth Rate 2015 - 2020	Growth Rate 2020 - 2030
No. of Public Sector Customers in Port Vila	1.6%	1.6%	1.6%
No. of Public Sector Customers in Luganville	1.5%	1.5%	1.5%
No. of Public Sector Customers in Tanna	-0.8%	7.0%	4.0%
No. of Public Sector Customers in Malekula	6.2%	7.0%	4.0%
No. of Public Sector Customers in Off-Grid Areas		7.0%	4.0%

Table 23. Projections of public sector customer volume

	2010	2015	2020	2025	2030
Total No. of Public Customers	317	364	403	452	505
No. of Public Sector Customers in Port Vila	187	212	229	248	269
No. of Public Sector Customers in Luganville	83	86	92	99	107
No. of Public Sector Customers in Malekula	28	24	25	30	37
No. of Public Sector Customers in Off-Grid Areas	19	23	32	39	47
No. of Public Customers in Off-grid Areas		20	25	35	45

With the growth rates and the number of public sector customers in 2013, indicated in UNELCO and VUI technical reports, projections of public sector customer volume are shown in Table 23.

In 15 years, it is therefore expected that the number of public sector customers will grow overall by more than 150%. The majority of new customers will come from rural areas reflecting the increase in rural electrification.

5.3.2 Average Public Sector Electricity Consumption

The average electricity consumption of public sector customers is taken from UNELCO and VUI technical reports of 2013. In off-grid areas, it is estimated that average consumption of public sector customers is below the lowest consumption in rural concession areas.

The average annual electricity consumption growth rates estimated are based on the calculated CAGRs, and the historical trends of average electricity consumption of public sector customers between 2009 and 2013 from UNELCO and VUI technical reports.

Table 24. CAGRs of average annual electricity consumption in the public sector

	CAGR (Historical)	Growth Rate 2015 - 2020	Growth Rate 2020 - 2030
Average Annual Consumption of Public Sector Customers in Port Vila	0.4%	1.0%	0.5%
Average Annual Consumption of Public Sector Customers in Luganville	1.4%	1.5%	0.0%
Average Annual Consumption of Public Sector Customers in Tanna	7.3%	2.0%	4.0%
Average Annual Consumption of Public Sector Customers in Malekula	-4.5%	1.0%	4.0%
Average Annual Consumption of Public Sector Customers in Off-Grid Areas		4.0%	4.0%

To calculate the projected average electricity consumption, each concession's 2013 values, taken from UNELCO and VUI technical reports, were used. For all off-grid areas, it is estimated that average consumption will be lower than the lowest average consumption in all concession areas (3,000kWh/year). This, combined with the previously estimated CAGRs, give the projections for the public sector's per capita electricity consumption (Figure 24).

It is therefore expected that public sector average annual consumption will grow slowly, with the increase in demand being mitigated by ongoing improvements in energy efficiency of appliances and lighting used by the government.

5.3.3 Projected Electricity Sales for the Public Sector

By calculating the number of existing customers with their average annual electricity consumption, the projections for electricity sales are obtained (Figure 25).

Figure 24. Per capita annual electricity consumption for the public sector

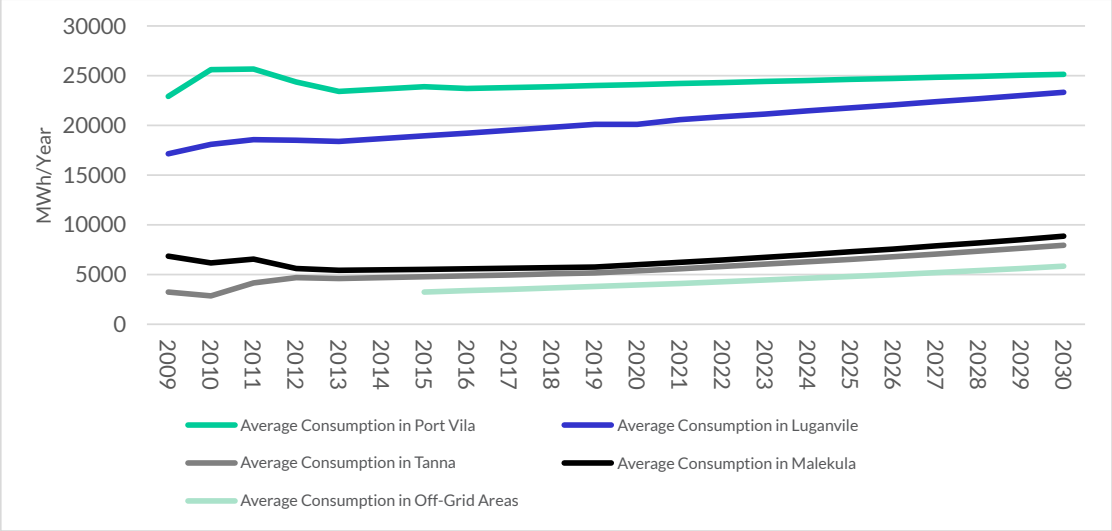
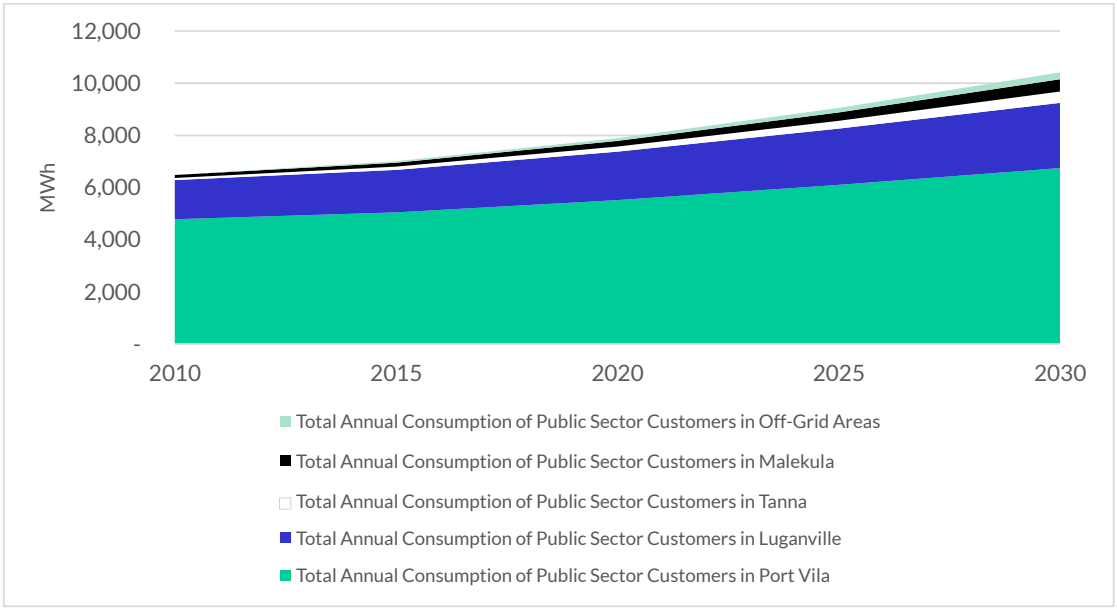


Figure 25. Projected public sector electricity sales



5.3.4 Assumptions Regarding Street Lights

According to a PEEP1 report on Vanuatu, [65] in 2009, the street lighting network of Vanuatu was composed of 984 lamps and consisted of different types of lamps—high-pressure sodium and mercury vapor—with an average power ranging from 80W to 400W per fitting. Most street lighting network lamps were inefficient, decaying, costly to maintain, and 35% of them needed to be replaced as they were no longer functioning. Since municipalities were not paying their electricity bill regularly, daily street lighting operating hours were reduced to about five hours.

Based on data from December 2012, the Energy Efficiency Street Lighting Project proposal published in June 2013 for Port Vila and Luganville from PEEP2, [66] reported 238 street lights in Luganville, among which 215 were grid connected and 23 were off-grid solar PV powered.

UNELCO reported having the following number of street lights:

- 26 street lights in Malekula (2010–2015);
- 25 street lights in Tanna (2010–2015); and
- 163 street lights in Port Vila under maintenance contract (2010–2014), and from March 2014, 712 street lights.

Based on these pieces of information as well as on UNELCO's report of total street light electricity consumption, the average operating hours are calculated (see Table 26).

Table 25. Street lighting network in Vanuatu, 2009

Number (Lamps)	Current Power (W)	Share of Lamps Functioning	Number of Lamps Functioning	Total Power (KW)	Annual Energy Consumption (MWh/Year)
24	80	100%	24	2	4
862	125	60%	517	67	122
75	250	100%	75	21	38
23	400	100%	23	10	18

Source: Econoler International, "PEEP1: Promoting Energy Efficiency in the Pacific (Phase 1)," November 16, 2012.

Table 26. Street light operating hours in UNELCO's concessions

Street Light Operating Hours	2010	2011	2012	2013	2014	Average
Port Vila	4	3	4	4	5	4.0
Malekula	5	5	5	5	4	4.6
Tanna	2	2	2	2	2	1.8

Source: UNELCO

Table 27. Street lighting network in Vanuatu before March 2014

	Average Street Light Operating Hours	Current Power (W)							Total Number Installed	Power Installed (kW)	Average Annual Consumption (kWh/Year)	Annual Energy Consumption (MWh/Year)
		42	60	70	75	125	250	400				
Port Villa	4.0					576	73	21	670	99	215	144.2
Luganville	8				115	100			215	21	287	61.7
Malekula	4.6					26			26	3	212	5.5
Tanna	1.8					25			25	3	83	2.1
Total	5					727	73	21	936	126	228	213

Sources: UNELCO; and International Institute for Energy Conservation, Promoting Energy Efficiency in the Pacific (Phase 2): Final Report (Mandaluyong: Asian Development Bank, 2015).

65 Econoler International, "PEEP1: Promoting Energy Efficiency in the Pacific (Phase 1)," November 16, 2012.

66 Felix Gooneratne, "Promoting Energy Efficiency in the Pacific: Project Proposal – Phase 2," June 24, 2013.

The state of street lights in Vanuatu between 2010 and 2014 is shown in Table 27.

In March 2015, PEEP2 reported having replaced 75% of all Luganville's street lights (based on 2013 total lighting) and 25% of Port Vila's street lights with 70W LED lights, improving lighting quality and reducing electricity consumption by up to 50% for lights replaced.

Combining PEEP2 report and data from UNELCO, the state of street lighting in Vanuatu in 2015 is shown in Table 28.

By analyzing Tables 27 and 28, and assuming that over the period the number of street lights in Vanuatu will increase, the evolution of the number of street lights is estimated (see Table 29).

5.3.5 Average Annual Consumption of Street Lights

The PEEP2 final report, [67] stated that in the near future in Port Vila, the operating hours of street lights might change from 4–6 hours to 11 hours per day due to the reduction of the electricity bill after the first energy efficiency projects are implemented. This should have a significant impact on Port Vila street lights' electricity consumption.

For Malekula, it is expected that future street light installations will lower the average street light electricity consumption as the street lights currently used are very inefficient. This phase should be followed by an increase of the average electricity consumption of street lights mainly because of a progressive increase in operating hours. Since Tanna street lights' average electricity consumption is far below Malekula's consumption, an overall increase is expected even if new street lights installed are more efficient.

Table 28. Street lighting network in Vanuatu in 2015

	Average Street Light Operating Hours	Current Power (W)							Total Number Installed	Power Installed (kW)	Average Annual Consumption (kWh/Year)	Annual Energy Consumption (MWh/Year)
		42	60	70	75	125	250	400				
Port Vila	4	39	163	30	0	410	49	21	712	85	175	124.7
Luganville	8			264	56	0			320	23	207	66.2
Malekula	4.6					26			26	3	210	5.5
Tanna	1.8					25			25	3	82	2.1
Total	5		163			461	49	21	1083	114	183	198

Sources: UNELCO; and International Institute for Energy Conservation, Promoting Energy Efficiency in the Pacific (Phase 2): Final Report (Mandaluyong: Asian Development Bank, 2015).

Table 29. CAGRs of the number of street lights in different areas

	CAGR 2010 - 2015	CAGR 2015 - 2020	CAGR 2020 - 2030
No. of Street Lights in Port Vila	1.2%	1.0%	1.0%
No. of Street Lights in Luganville	8.3%	2.0%	1.0%
No. of Street Lights in Tanna	0.0%	2.0%	2.0%
No. of Street Lights in Malekula	0.0%	2.0%	2.0%
No. of Street Lights in Off-Grid Areas		5.0%	5.0%

Sources: UNELCO; and International Institute for Energy Conservation, Promoting Energy Efficiency in the Pacific (Phase 2): Final Report (Mandaluyong: Asian Development Bank, 2015).

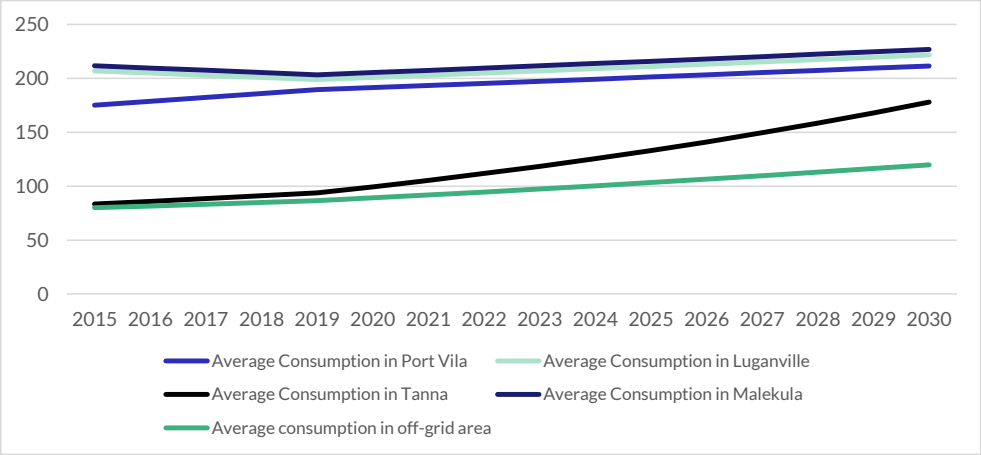
67 International Institute for Energy Conservation, Promoting Energy Efficiency in the Pacific (Phase 2): Final Report (Mandaluyong: Asian Development Bank, 2015).

Table 30. CAGRs and annual growth rates of average annual consumption of street lights

	CAGR (Historical)	Annual Growth Rate 2013 - 2020	Annual growth rate 2020 - 2030
Average Annual Consumption of Street Lights in Port Vila	-4.0%	2.0%	1.0%
Average Annual Consumption of Street Lights in Luganville	-6.3%	-1.0%	1.0%
Average Annual Consumption of Street Lights in Tanna	0.0%	3.0%	6.0%
Average Annual Consumption of Street Lights in Malekula	0.0%	-1.0%	1.0%
Average Annual Consumption of Street Lights in Off-Grid Areas		2.0%	3.0%

Source: UNELCO and VUI Technical reports and PEEP 2 Reports

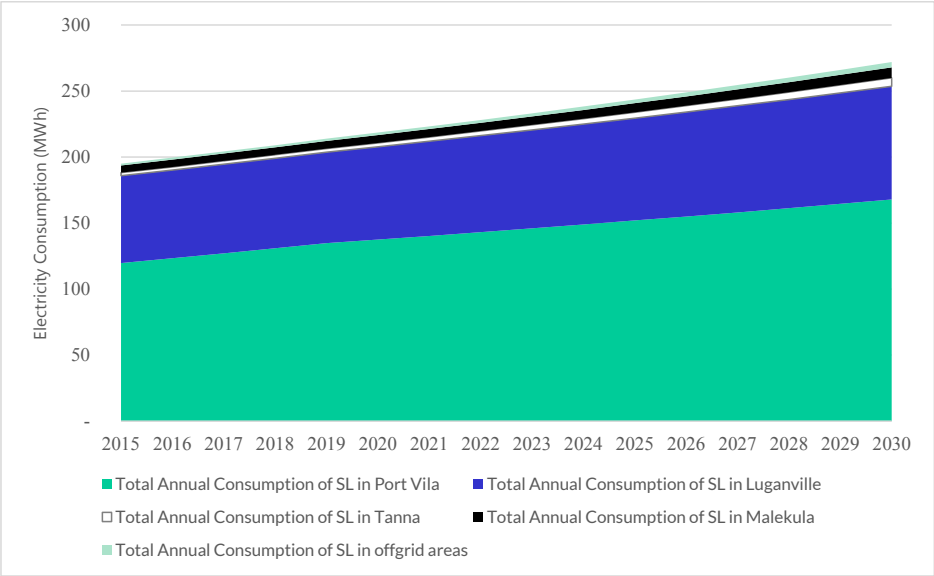
Figure 26. Average electricity consumption of street lights



5.3.6 Projection of Street Lights' Total Electricity Consumption

By computing the previously mentioned estimations, the total electricity consumption of street lights is calculated (see Figure 27).

Figure 27. Electricity consumption of street lights



5.3.7 Projected Electricity Sales for the Public Sector and Street Lighting

By adding both the annual consumption of public sector customers and that of street lights, the public sector's total electricity consumption is calculated (see Figure 28).

These BAU projections for the public sector can be used to prepare energy efficiency targets for Vanuatu.

Similar to both the residential sector and the commercial and industrial sector, public sector demand for electricity should remain at the same level in Port Vila. In the coming 15 years, overall public sector demand should grow annually by 3% representing a total increase of almost 60%.

5.4 National Electricity Consumption Projections Under the BAU Scenario

According to the previously described sectoral projections, the projected national-level electricity consumption under the BAU scenario for the years 2015, 2020, 2025 and 2030 is shown in Table 31 and Figures 29 and 30.

Figure 28. Electricity consumption of public sector consumers and street lights

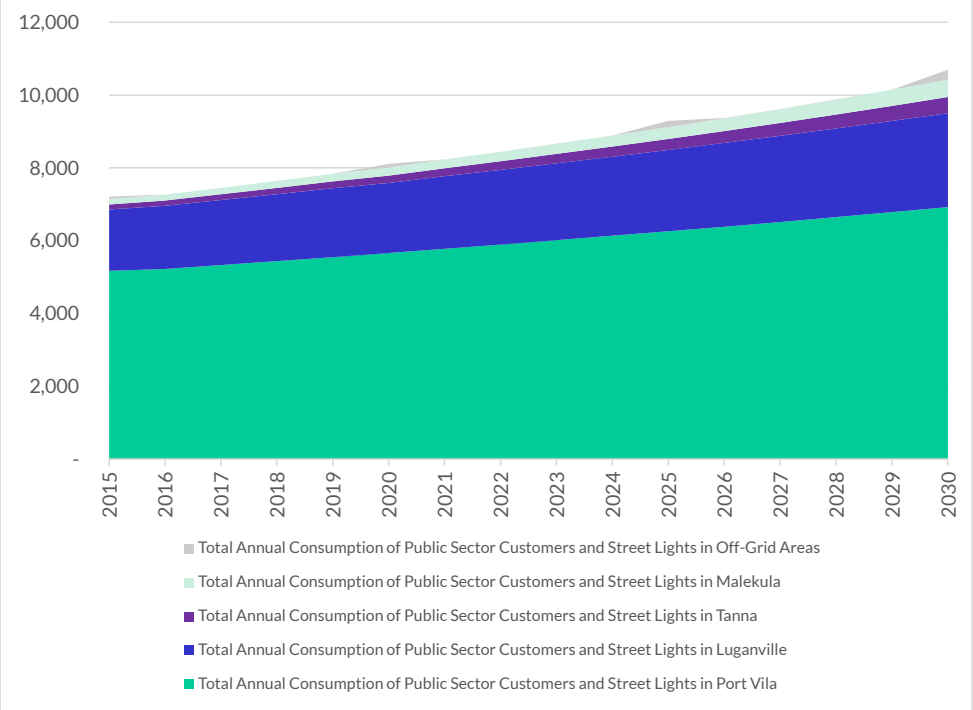
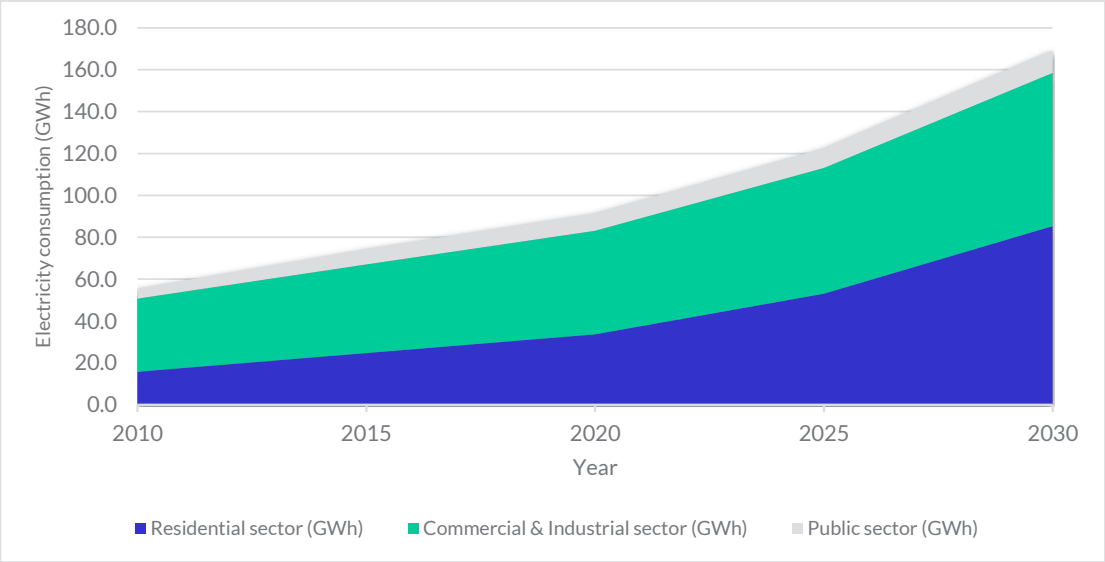


Table 31. National electricity consumption

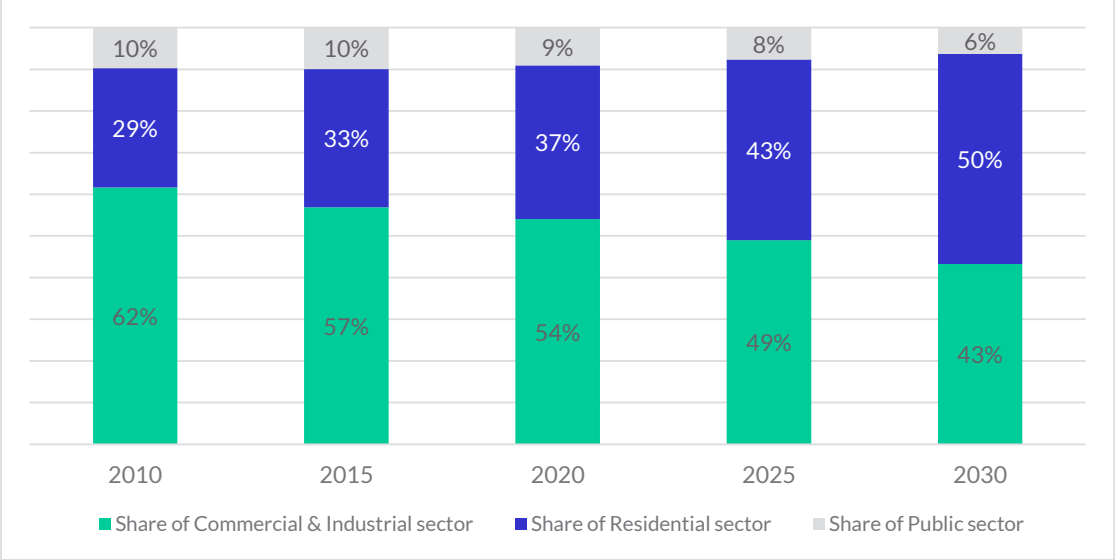
Year	2010	2015	2020	2025	2030	CAGR 2009 - 2013	Growth 2015 - 2020	Growth 2020 - 2030
Residential Sector (GWh)	18,420	24,743	33,976	52,979	82,876	1.3%	7%	9%
Commercial and Industrial Sector (GWh)	39,566	42,292	49,428	60,026	73,149	1.6%	3%	4%
Public Sector (GWh)	6,228	7,211	8,109	9,294	10,693	2.3%	2%	3%
National Electricity Consumption (GWh)	64,214	74,245	91,513	122,300	166,719	1.3%	4%	6%

Figure 29. Projection of national electricity consumption, by end-user sector



Given the ambitious electrification targets in the NERM 2013–2020, and taking into account the pipeline of projects financed until 2020, [68] it is expected that overall electricity consumption will more than double between 2015 and 2030. This will be led initially by commercial and industrial growth, and later by residential uptake. The share of residential consumption will rise progressively, from an initial 30% in 2010 to 50% of total electricity consumption in 2030.

Figure 30. Projected share of national electricity consumption, by end-user sector



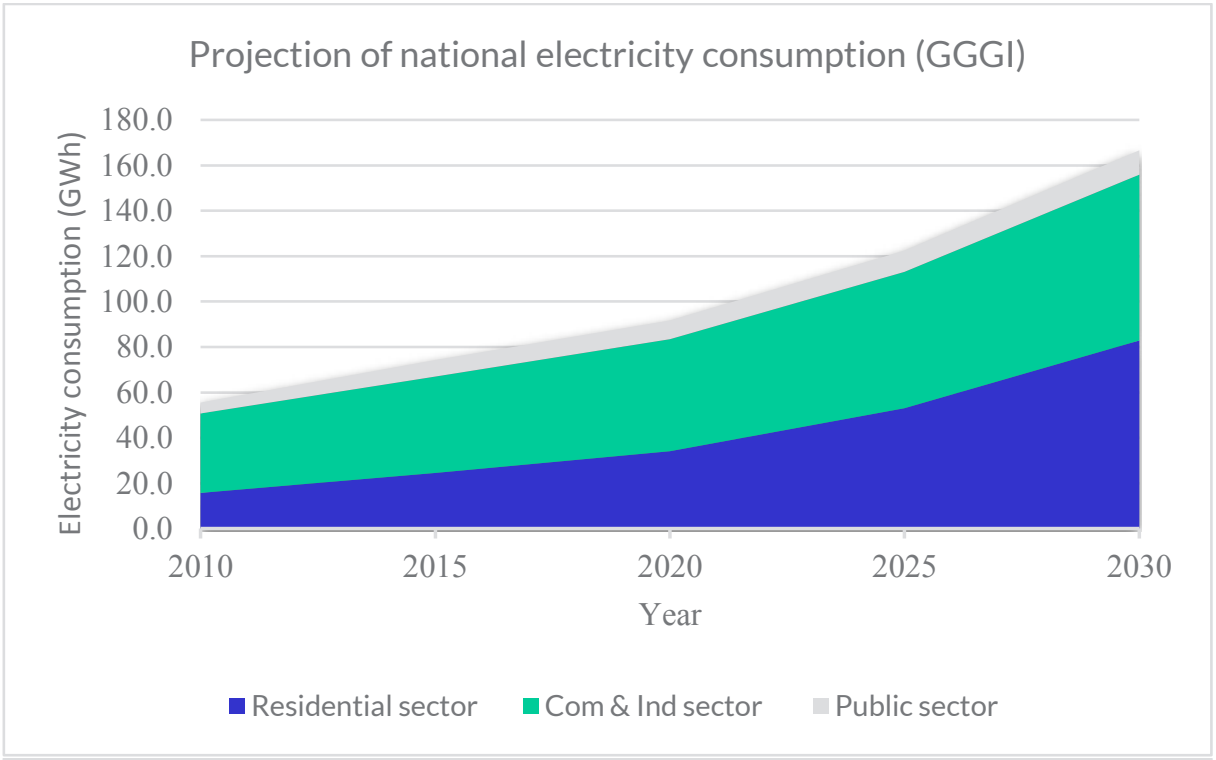
68 Especially in terms of rural electrification rate.

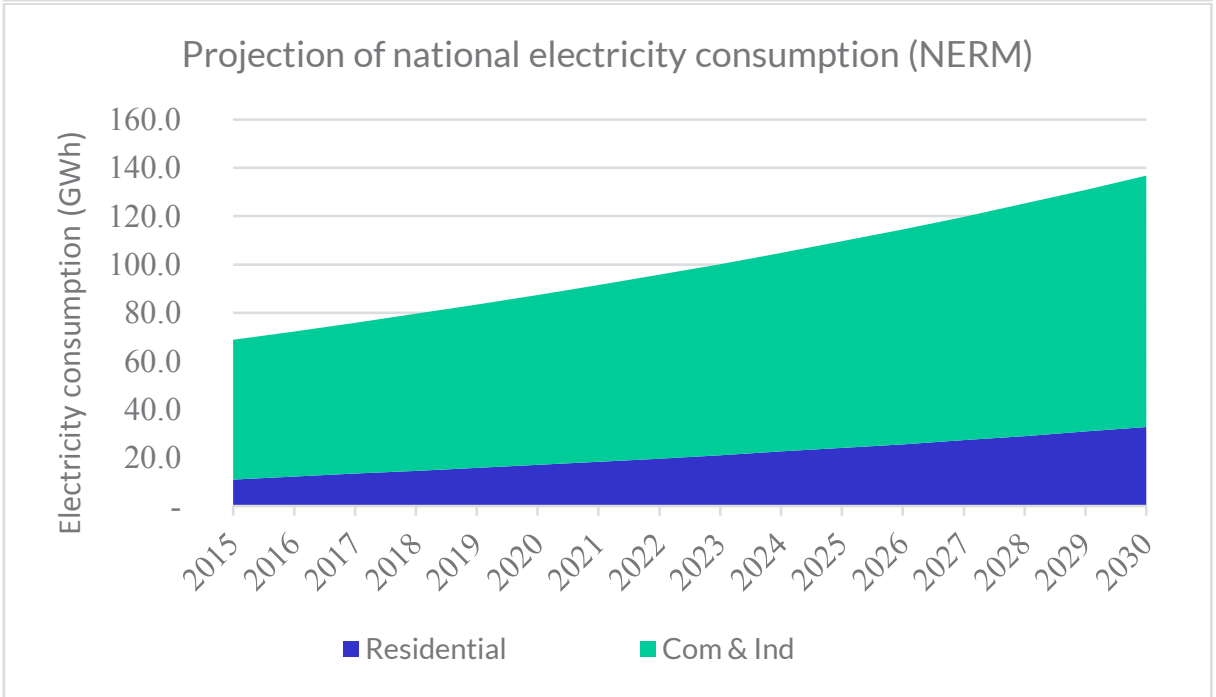
5.5 Comparison and Analysis of Electricity Projections under Different BAU Scenarios

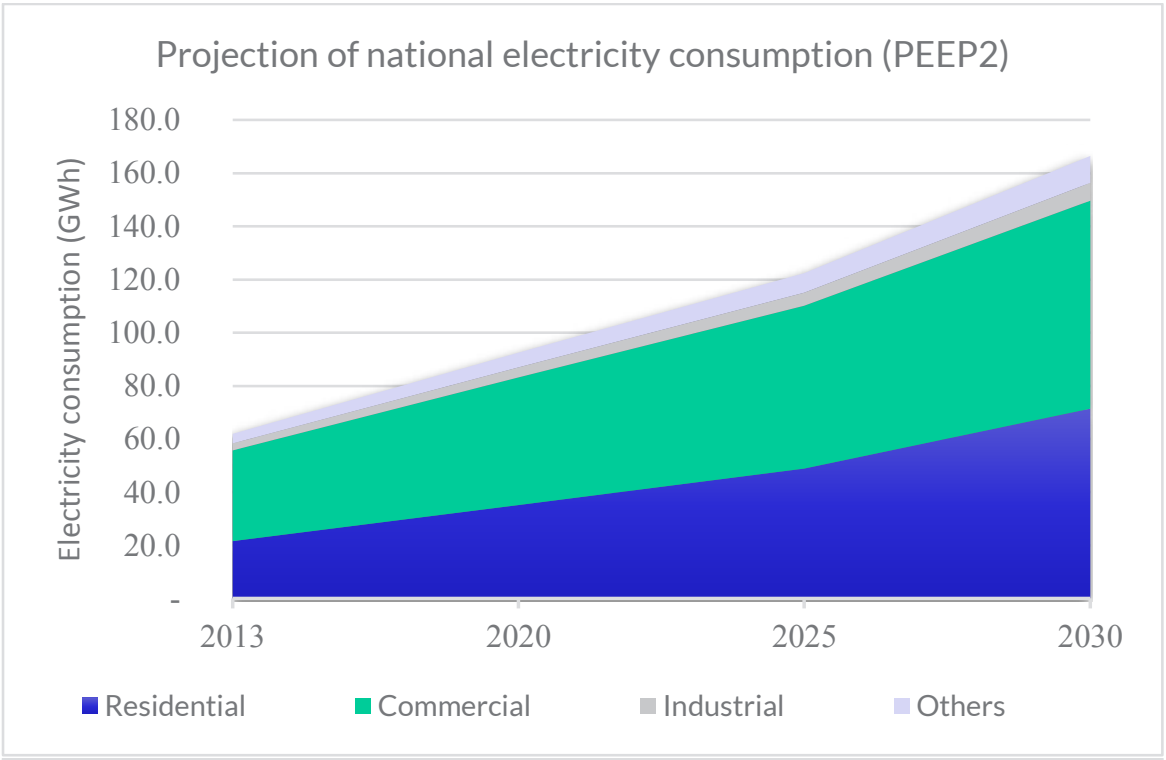
In order to validate the electricity BAU scenario presented in this report, the following comparisons have been carried out:

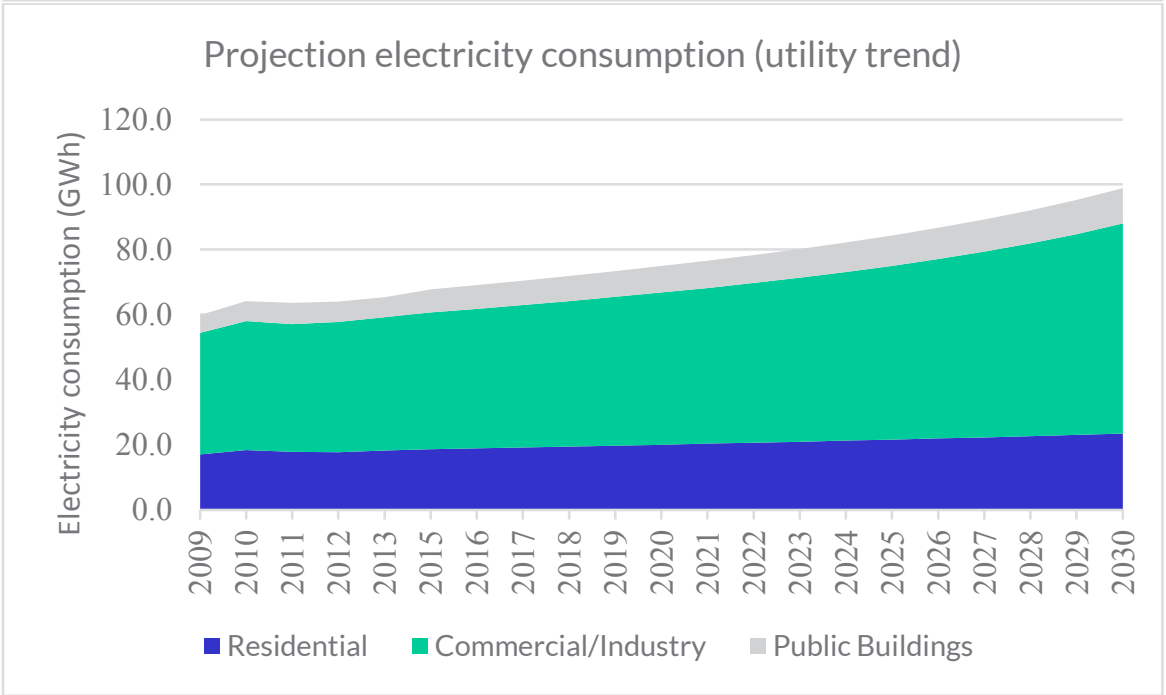
- Comparison of the GGGI BAU scenario with other BAU scenarios (PEEP2, NERM as well as a BAU scenario arising directly from past trends observed in the utilities' technical reports) and a brief review of their respective assumptions and results; and
- Comparison of the GGGI BAU scenario with the projected GDP for Vanuatu.

Figure 31. BAU scenarios of GGGI, PEEP2, NERM and utilities






Projection of national electricity consumption (PEEP2)
Electricity consumption (GWh)
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
-
2013
2020
2025
2030
Residential
Commercial
Industrial
Others


Projection electricity consumption (utility trend)
Electricity consumption (GWh)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
2009
2010
2011
2012
2013
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Residential
Commercial/Industry
Public Buildings

5.5.1 PEEP2:

Below are the main assumptions of the PEEP2 BAU scenario for electricity consumption, as stated in its report. [69]

1. Residential:

- As of 2009, 80% of the urban households were electrified and 11% of the rural households were electrified. For the year 2013, it is assumed that the electrification rate for urban (80%) and rural (11%) households remain the same. By 2030, it is assumed that 100% of the urban households and 50% of the rural households would be electrified. For the years 2020 and 2025, electrification rate of 25% is assumed.
- Households are considered to be the "domestic", "pre-paid", "5A" and "10A" customers in the UNELCO technical reports.
- No data is available on per capita consumption of urban and rural households, hence it is assumed that an urban household consumes three times as much as rural households.
- A growth rate of 5% for a five-year period is considered for projecting electricity consumption per household for both urban and rural households.

2. Commercial & Industrial:

- No data is available on the share of commercial electricity consumption to the total electricity consumption, hence it is assumed that about 10% electricity consumption (4% industrial and 6% others) is in the industrial and others categories, and the remaining 55% electricity consumption is in the commercial category. The proportion of sales to commercial category is assumed to remain the same until 2013.
- The built-up area of offices and hotels is assumed to be 150,000 square meters (sq.m) for the year 2013, and so the specific electricity consumption works out to be about 205 kWh/sq.m. To project the electricity consumption in the commercial sector for the horizon period, a year-on-year growth rate of 5% is assumed for the built-up area, while specific electricity consumption is assumed to remain at the same level of 205 kWh/sq.m.
- For the financial year 2013, the share of sales to the industrial category and others category is assumed to be 4% and 6%, respectively. For the horizon period, the share of sales to both these categories is assumed to remain at the same level.

5.5.1.1 PEEP2 and GGGI Energy Efficiency BAU Scenarios Comparison

The overall level of electricity consumption reached in 2030 projected in the PEEP2 BAU scenarios is very similar to the ones presented in this document.

The main differences are due to the hypothesis taken for residential consumption in rural areas (per capita consumption), and the growth rates of household electrified. Moreover, commercial and industrial growth would occur only after a certain level of electrification and development was achieved. This will certainly also be linked to the price of electricity, which should eventually start lowering slowly [70] by 2020 with the commissioning of renewable energy power plants.

5.5.2 NERM

Below are the main assumptions of the NERM BAU scenario for electricity consumption:

- Households are the "domestic" and "pre-paid" accounts as recorded, i.e., far lower growth than in the other projections in UNELCO's annual technical report.
- Household growth rate is estimated at 2.5% annually.
- There are two new connections per month in each concession.
- Existing households consume an average of 35 kWh/month in Port Vila; 24.5 kWh/month in Malekula; 44kWh/month in Luganville; and 33 kWh/month in Tanna.
- Newly connected households consume 18 kWh/month, but increase consumption faster than existing households.
- The annual increase in demand for existing households is 4%, and for new households it starts in 2011 at 11% and decreases until 4% in 2030.
- Commercial customers and public administration demands are taken from the UNELCO 2010 technical report.
- The annual demand growth for commercial customers and public administration is 4%.

5.5.2.1 NERM Projections' Comparison with Utility Data Between 2010 and 2013

The projections in the NERM 2013–2020 underestimated the growth rate of the number of new residential clients. According to UNELCO and VUI technical report of 2013, the annual number of residential client experienced 5% growth rate during the period 2010–2013.

69 International Institute for Energy Conservation, Promoting Energy Efficiency in the Pacific (Phase 2): Final Report (Mandaluyong: Asian Development Bank, 2015).

70 Note that the magnitude of any decline in tariffs is difficult to predict as future petroleum fuel prices are unknown.

Table 32. Comparison between the NERM 2013–2020 projections for the growth in the number of residential clients and the actual growth reflected by utility data

	CAGR between 2010 & 2013	
Annual Number of Residential Clients' Growth	NERM	Utility Data
Port Vila	2%	6%
Tanna	8%	11%
Malekula	6%	1%
Luganville	5%	1%
National	3%	5%

Sources: GoV, "Vanuatu National Energy Road Map 2013–2020," July 19, 2013; UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

The NERM also largely overestimated the projection of annual demand growth rates (see Table 33). The NERM's projection for the growth of annual demand among households was 8.4%, while the actual growth rate between 2010 and 2013 was -0.4%. Similarly, for the public, commercial and industrial sectors, NERM's projection for the growth of annual demand was 4%, while the actual growth rate between 2010 and 2013 was 1%.

Table 33. Comparison between the NERM 2013–2020 projections for the growth in demand and the actual growth reflected by utility data

		CAGR between 2010 & 2013	
	Growth of Annual Demand	NERM	Utility Data
Port Vila	Just Households	7.2%	-0.5%
	Public & Commercial/Industrial Sectors	4.0%	0.6%
	Total	4.3%	0.3%
Tanna	Just Households	16.5%	8.2%
	Public & Commercial/Industrial Sectors	4.1%	23.8%
	Total	9.9%	15.4%
Malekula	Just Households	17.2%	10.1%
	Public & Commercial/Industrial Sectors	3.9%	-0.9%
	Total	7.2%	3.2%
Luganville	Just Households	11.7%	-1.3%
	Public & Commercial/Industrial Sectors	4.0%	2.8%
	Total	5.2%	1.6%
National	Households	8.4%	-0.4%
	Public & Commercial/Industrial Sectors	4.0%	1.0%
	Total	4.5%	0.5%

Sources: NERM projections; UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

5.5.2.2 *NERM and GGGI Energy Efficiency BAU Scenarios Comparison*

In the NERM 2013–2020, the projected level of electricity consumption in 2030 is much lower than the one calculated in this report. This is mostly due to the electrification rate estimated in the scenarios put forward in this report, and thus the growth rate of new connections. Different growth rates are assumed for commercial and public consumption in this report, while the NERM adopted a flat 4% growth rate for all commercial and public consumption in all concessions, based on the utility trends.

These projections show that if current trends are followed and in the absence of interventions (especially in terms of financing for rural electrification), overall electricity consumption will increase, but at the same rate it has been happening these last 5 years, i.e., significantly less growth than in the other projections.

5.5.3 BAU Scenario and GDP Projections Comparison

There is not always a strong correlation between GDP growth and the evolution of electricity consumption in Vanuatu and past projections for GDP real growth have not always been very accurate. For example, historic data from utility reports shows that between 2010 and 2013, there was no significant increase in electricity consumption while the GDP was increasing (see Figure 32).

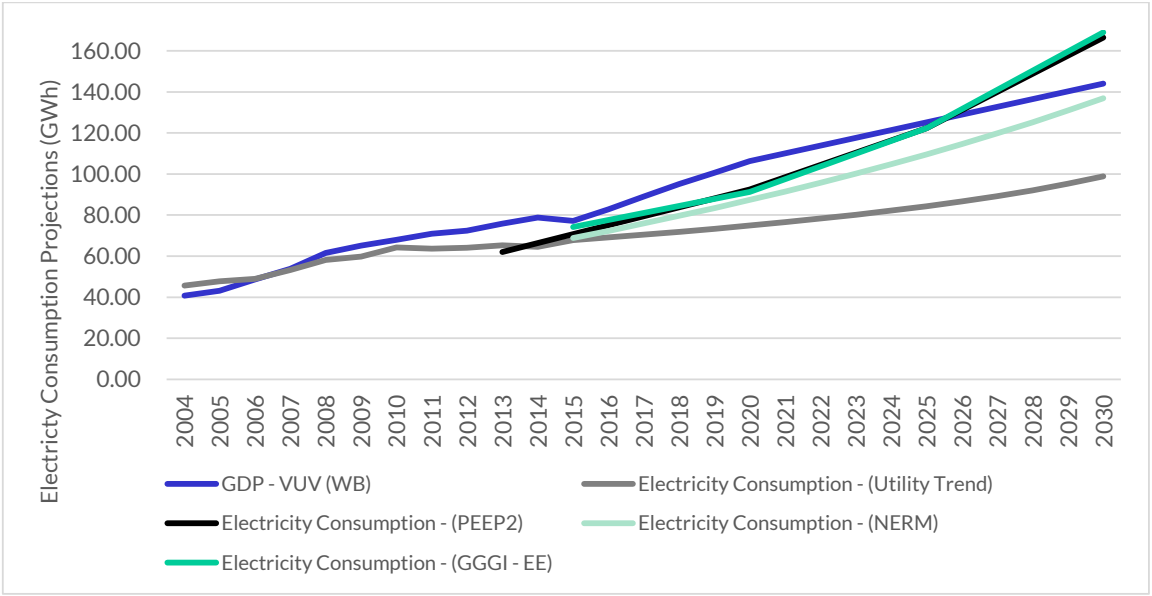
5.6 Impact of the Non-Achievement of NERM 2013–2020 Targets

In the NERM 2013–2020, the targets set in terms of electrification rates are ambitious. Currently, the number of projects planned and financed up to 2020 will only be able to partially achieve the set targets. New projects will have to be identified and funded if the targets are to be fully met by 2020.

Achieving all of the NERM's electrification targets would result in: (1) a ~65% electrification rate in Vanuatu, which means the electrification of around 36,000 households; (2) an increase of ~70% in commercial and industrial electricity consumption; and (3) an increase of ~50% in public sector consumption. [71]

If only 50% of the NERM's electrification target for households are met in 2030, the grid electrification rate in Vanuatu would be ~38% in 2030 and the BAU projected residential electricity consumption would decrease by 35%. Overall, only achieving 50% household electrification would represent a decrease of 14% of the BAU projection for total electricity consumption. In this scenario, the total electricity consumption would still increase by ~110% between 2015 and 2030, compared to an increase of ~180% if the NERM electrification targets are fully achieved.

Figure 32. Electricity consumption under BAU scenarios and GDP projections



Source: GoV, "Vanuatu National Energy Road Map 2013–2020," July 19, 2013; International Institute for Energy Conservation, Promoting Energy Efficiency in the Pacific (Phase 2): Final Report (Mandaluyong: Asian Development Bank, 2015); UNELCO, "Annual Technical Report," 2013; VUI, "Annual Technical Report," 2013; and World Bank's GDP data.

71 It is expected that public sector consumption will increase significantly through the development of provincial centers.

The NERM targets for the share of renewable energy in electricity generation are also ambitious with 40% in 2015 and 60% in 2020, while the Vanuatu INDC proposes an increase to 90% by 2030. These renewable energy targets have implications for the consumption of petroleum and have been taken into account in the above petroleum consumption projections.

If Vanuatu does not achieve the NERM targets or the INDC target, petroleum consumption projections will increase compared to the BAU scenario. In the case where only two-thirds of the targets are achieved, i.e., 29% renewable energy in 2015, 40% in 2020 and 60% in 2030, this would result in a 90% increase in the BAU projection of cumulative petroleum consumption for electricity generation by 2030 (this increase is projected to be 90% of BAU). With only two-thirds of the renewable energy for electricity generation targets achieved, the annual petroleum consumption for electricity would increase by 24% between 2015 and 2030, instead of the 62% decrease currently projected under the BAU.

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Appendix - Analysis of UNELCO and VUI Technical Reports of 2013

1. National-Level Analysis

Customers

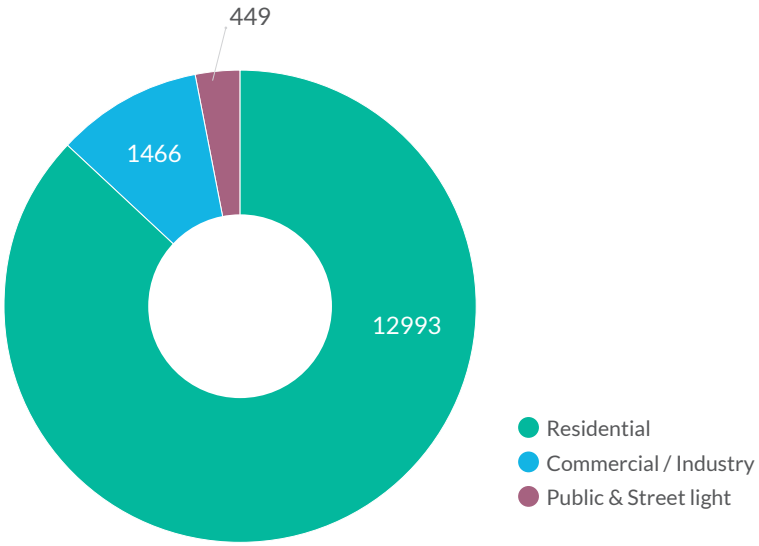
The overall number of customers grew 3.3% per year on average, from 12,645 in 2009 to 14,908 customers in 2013.

The numbers of customers by end-users' groups remained roughly the same. The sales distribution was 87% residential customers, 10% commercial and industrial customers, and 3% public sector customers.

Per Capita Electricity Consumption

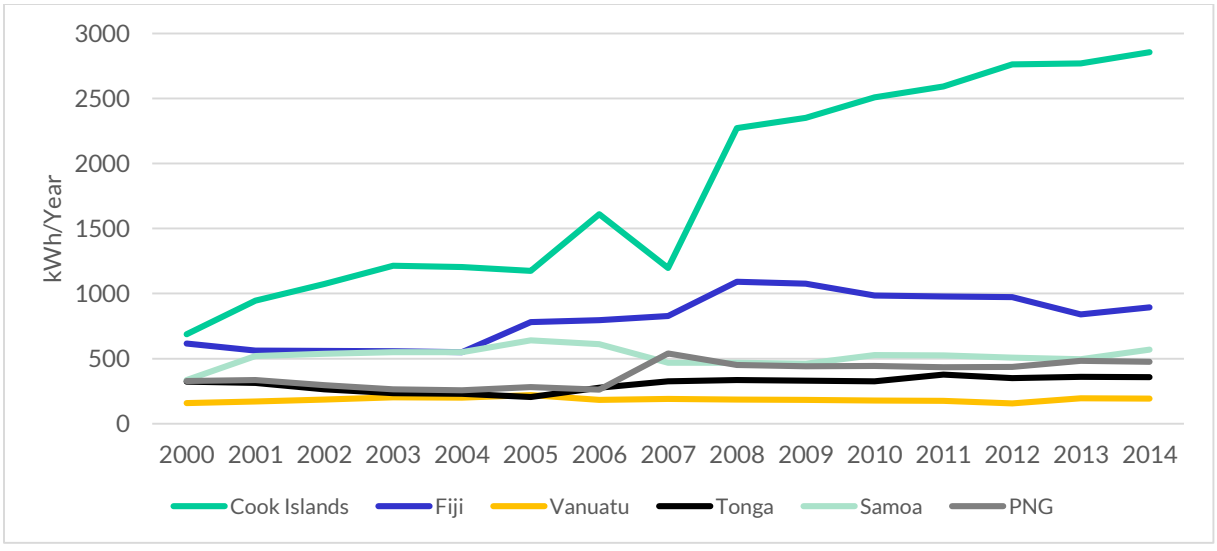
In 2014, per capita electricity consumption in Vanuatu was 255 kWh/year, one of the lowest per capita electricity consumption rates among the Pacific Island countries. This was due to both very low electrification rates, and low commercial and industrial development.

Figure 33. Distribution of the total number of electricity customers, by end-user sector



Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Figure 34. Evolution of per capita electricity consumption in the Pacific Island countries



Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Average Annual Electricity Consumption of End Users

The average consumption growth per consumer for both the residential sector and the commercial and industry sector was found to be negative. This was calculated based on the evolution of annual electricity consumption and the number of consumers by end-user sector. This unexpected trend could be explained by the increase in electricity access of low-income households (low-income customers consume less), and also possibly by improved energy efficiency of new appliances.

Sales

National electricity sales from 2009 to 2014 in Vanuatu are shown in Table 35.

Despite the decrease in consumption of both residential users and commercial and industry users, sales grew by 1.3% per year between 2009 and 2014, on average. This increase could be explained by the increase of customers.

The distribution of sales remained more or less the same between 2009 and 2013: 63% for the commercial and industry sector; 28% for the residential sector; and 9% for the public sector.

Table 34. CAGRs of average electricity consumption by end-user sector, 2009-2013

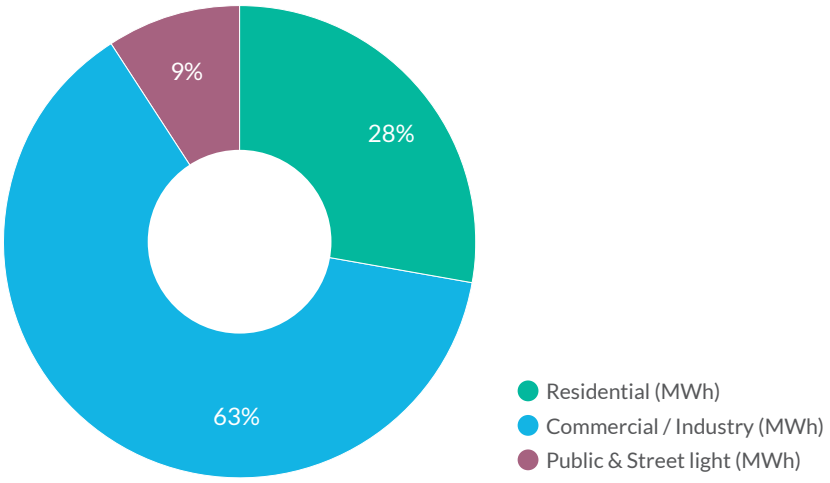
	CAGRs of Average Electricity Consumption (2009–2013)
Residential Sector	-2.2%
CCommercial/Industrial Sector	-0.2%
Public Sector & Street Lights	1.0%

Table 35. National electricity consumption

National Electricity Consumption	2009	2010	2011	2012	2013
Residential Sector (MWh)	17,092	18,420	17,865	17,759	18,217
Commercial/Industrial Sector (MWh)	37,331	39,566	39,186	39,942	40,952
Public Sector & Street Lights (MWh)	5,432	6,228	6,593	6,338	6,184
Total (MWh)	59,855	64,214	63,644	64,039	65,354

Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Figure 35. Electricity sales distribution, by end-user sector in 2009–2013



Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

2. Residential Sector Analysis

Customers

Between 2009 and 2013, the overall number of residential customers of UNELCO and VUI increased from 10,907 to 12,993, particularly in the Port Vila and Tanna concessions. Two major reasons for the increase in connections were: (1) the new network of extensions to populated areas in Port Vila and Tanna; and (2) the expansion of the concession boundaries in Port Vila, Tanna and Malekula in 2012, which resulted in electricity network extension.

The higher increase in Tanna compared to Malekula was due to network extensions to larger community settlements, which enabled more people to connect.

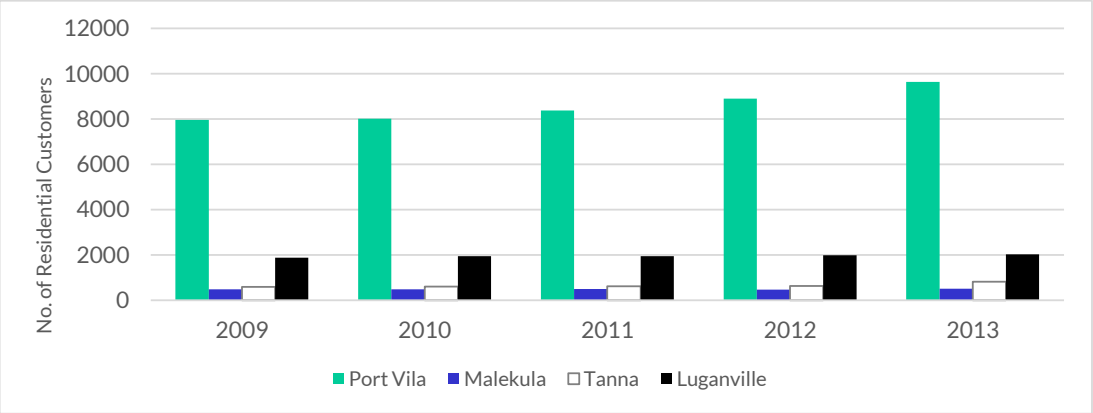
During the period 2009–2013, the geographical distribution of UNELCO and VUI customers remained similar with 74% of customers in Port Vila, 16% in Luganville, 6% in Tanna and 4% in Malekula.

Table 36. CAGRs of residential customers by concession, 2009–2013

	Residential CAGR 2009 - 2013
Port Vila	3.9%
Malekula	1.0%
Tanna	7.0%
Luganville	1.6%

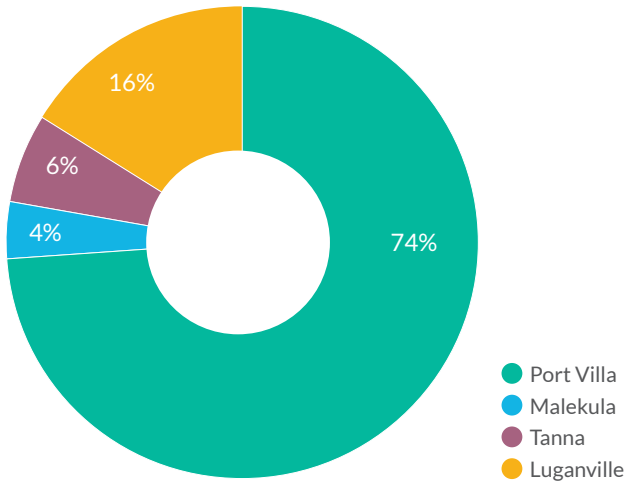
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Figure 36. Number of residential customers by concession, 2009–2013



Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Figure 37. Geographical distribution of electricity customers from the residential sector



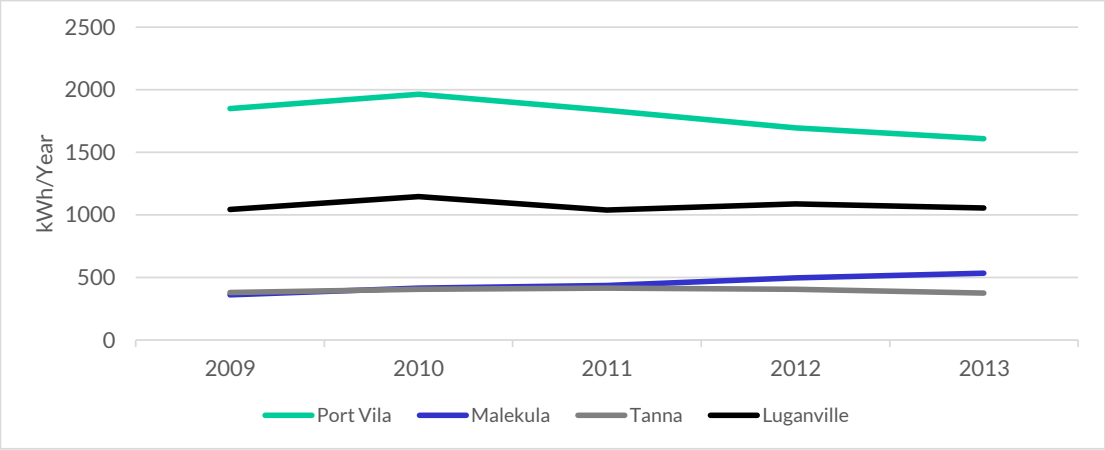
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Average Electricity Consumption

In terms of geographical distribution, Port Vila had the highest per capita consumption with 1,610 kWh/year (134 kWh/month). Average electricity consumption in Luganville, Tanna and Malekula was 70% (1,054kWh/year), 20% (375 kWh/year) and 30% (534 kWh/year) of Port Vila, respectively.

Analyzing the evolution of the residential sector's average consumption and the number of new users gives the energy profile of new customers and the effect that new customers had on overall average electricity consumption. For example, the CAGR in Malekula was 1% between 2009 and 2011, yet over the same period the average consumption CAGR was 8.2%. Contrastingly, average electricity consumption decreased in both Port Vila and Tanna, which experienced higher growth in customers, over the same period.

Figure 38. Average annual consumption of the residential sector by concession, 2009–2013



Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Table 37. CAGRs of residential per capita consumption and residential customer number

	Residential Per Capita Consumption CAGR, 2009–2013	Residential Customer Number CAGR, 2009–2013
Port Vila	-2.8%	3.9%
Malekula	8.2%	1.0%
Tanna	-0.2%	7.0%
Luganville	0.2%	1.6%

Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

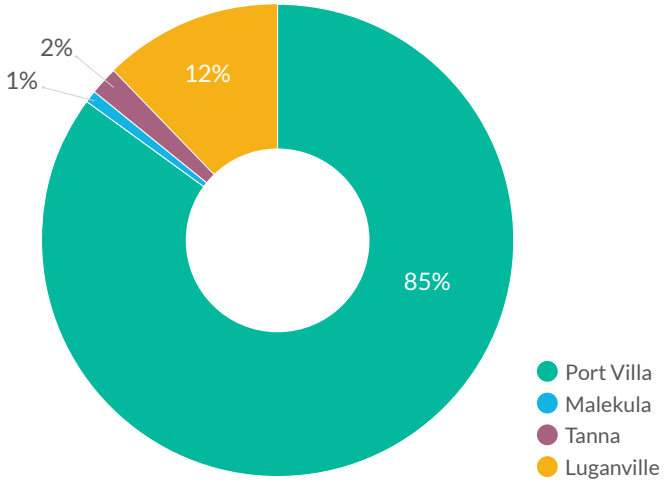
Sales

From 2009 to 2013, 85% of the residential sector's electricity sales were in Port Vila and 12% in Santo (Luganville), leaving only 1% and 2% in Malekula and Tanna, respectively.

The different concessions had different rates of electricity sales growth, with rural areas experiencing higher growth than urban areas. This could be linked to the fact that households in urban areas already had, on average, more electrical appliances than rural households.

From 2009 to 2013, total residential electricity consumption increased annually by 1.3% with the majority of the demand coming from urban areas.

Figure 39. Geographical distribution of residential electricity sales in 2013



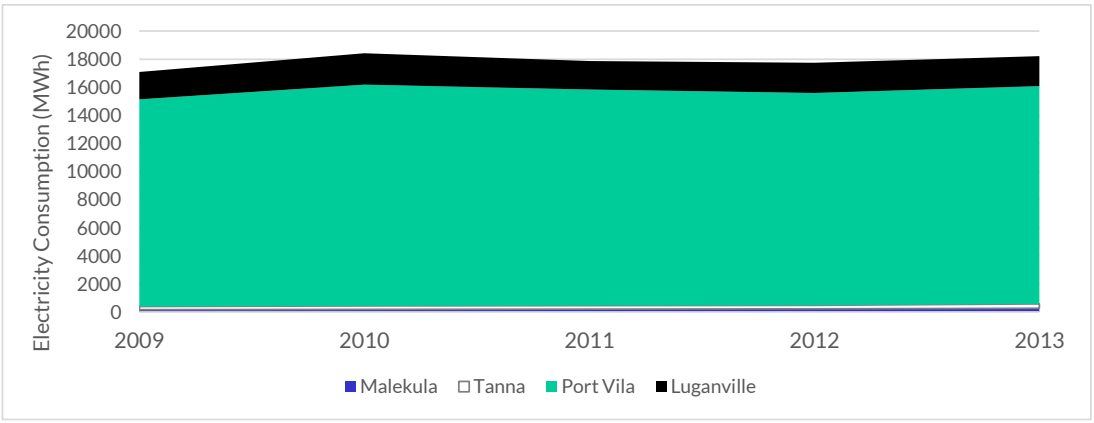
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Table 38. CAGRs of residential electricity sales

	Residential Average Consumption CAGR, 2009–2013	Residential Customer Number CAGR, 2009–2013	Residential Sales CAGR, 2009–2013
Port Vila	-2.8%	3.9%	1%
Malekula	8.2%	1.0%	9.3%
Tanna	-0.2%	7.0%	6.8%
Luganville	0.2%	1.6%	1.8%

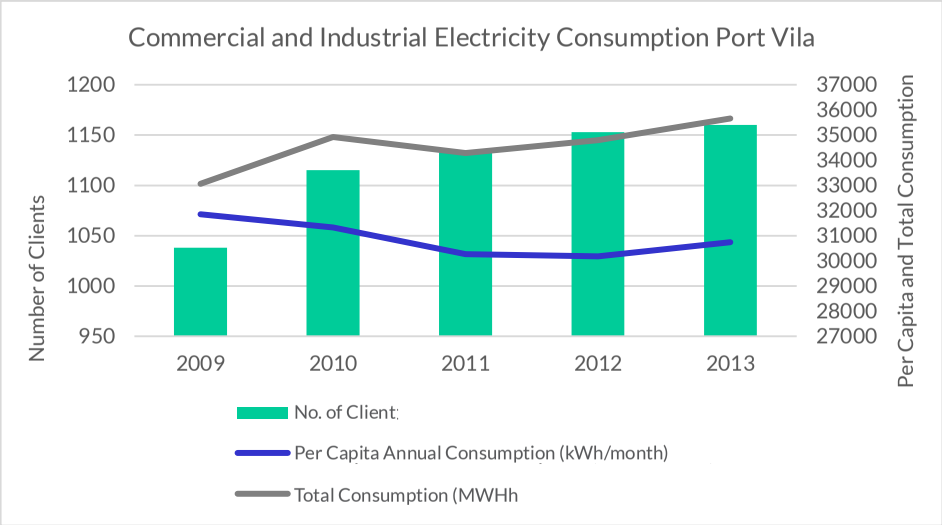
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

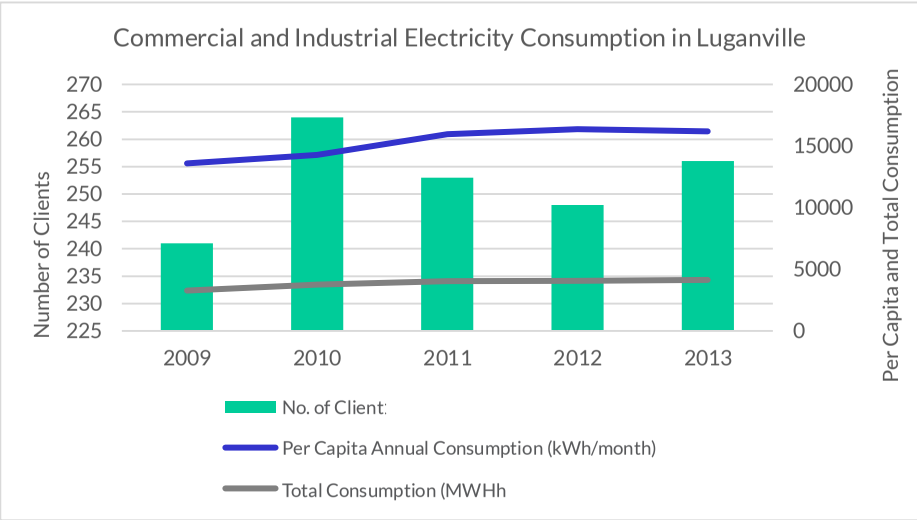
Figure 40. Total electricity consumption in the residential sector by concession, 2009-2013

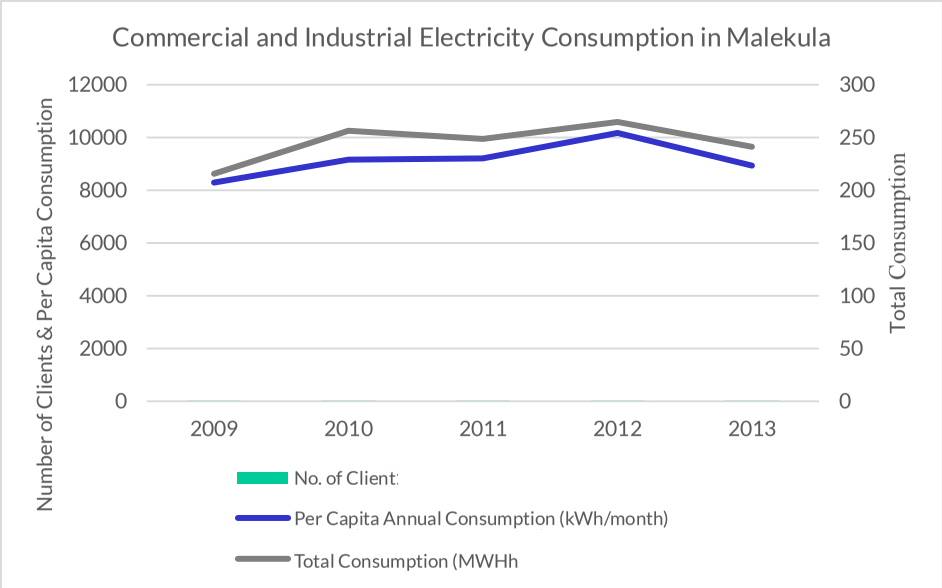


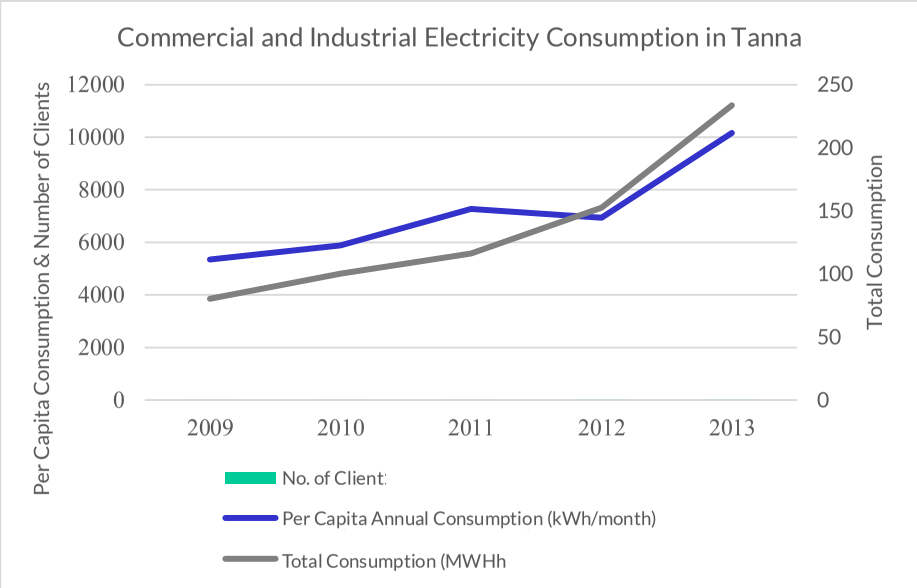
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Synthesis of the Residential Sector's Electricity Consumption Analysis







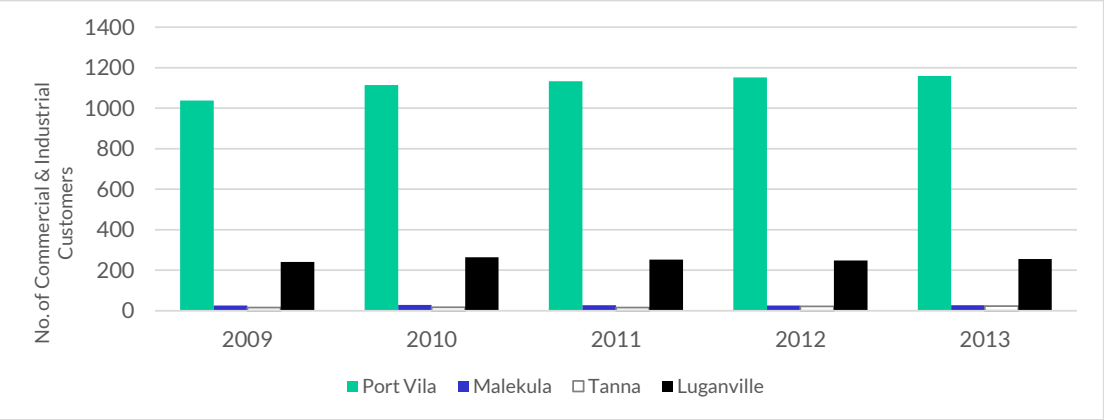


3. Commercial and Industrial Sector Analysis

Customers

Between 2009 and 2013, the number of UNELCO and VUI commercial and industrial customers increased from 1,320 to 1,466, which means a CAGR of 1.9%.

Figure 41. Number of commercial and industrial customers by concession, 2009–2013

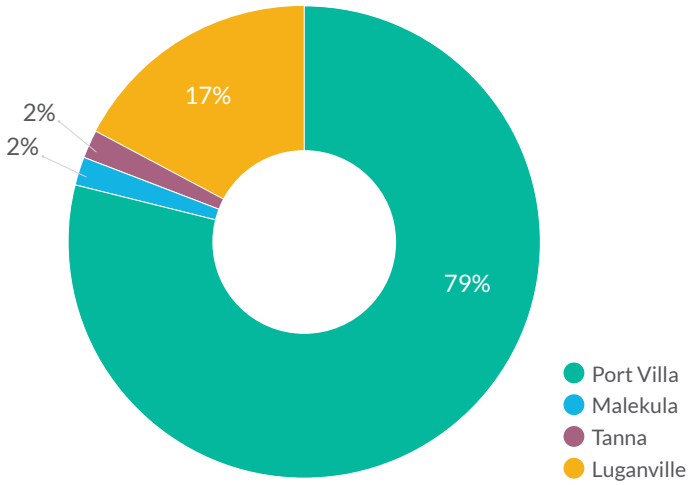


Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Figure 41 shows the high number of commercial and industrial customers in Port Vila in relation to other concession areas.

Between 2009 and 2013, the geographical distribution of commercial and industrial customers remained similar. As of 2013, the distribution was as follows: 79% of commercial and industrial customers were in Port Vila, 17% in Luganville, 2% in Tanna and 2% in Malekula. This distribution closely matches the distribution of residential customers.

Figure 42. Geographical distribution of electricity customers from the commercial and industrial sector

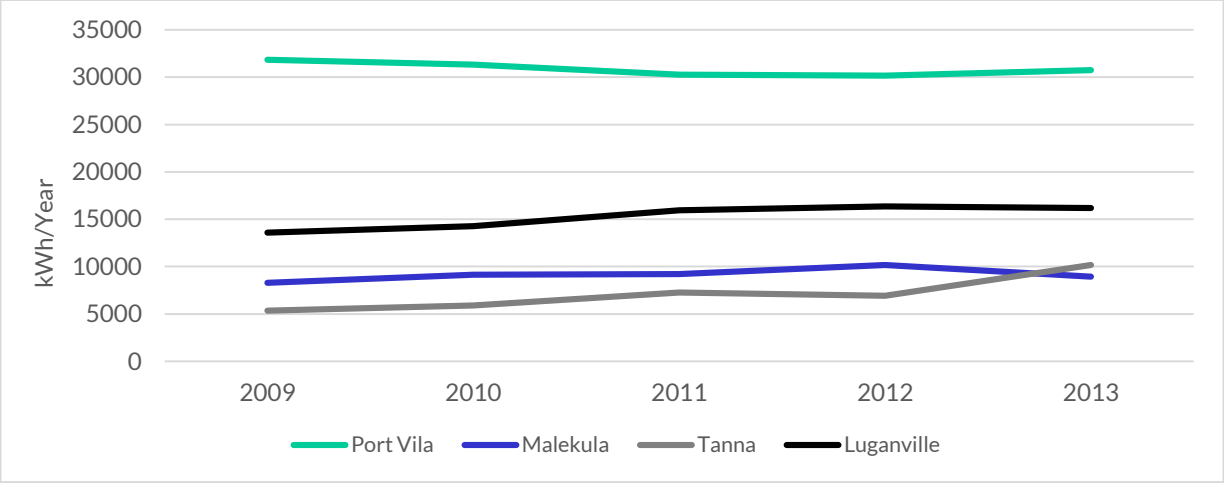


Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Average Electricity Consumption

Port Vila had the highest average electricity consumption with 32MWh/year (2,600 kWh/month). Average electricity consumption in Luganville, Tanna and Malekula was 50% (16MWh/year), 30% (10MWh/year) and 30% (9MWh/year) of the consumption of Port Vila, respectively.

Figure 43. Average annual consumption of the commercial and industrial sector by concession, 2009–2013



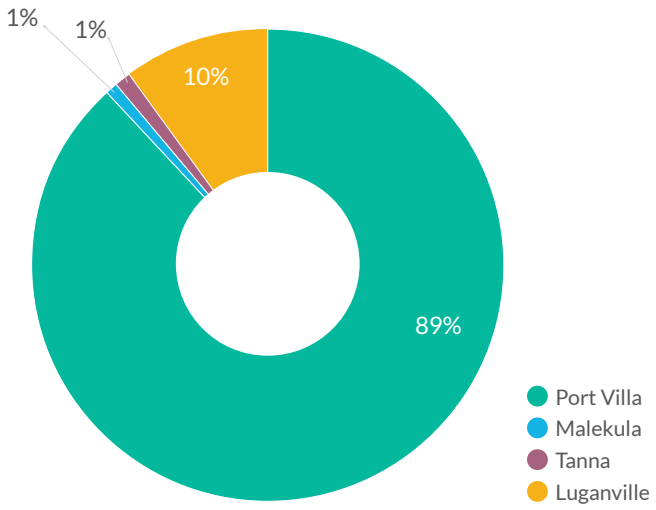
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

With the exception of Port Vila, average electricity consumption increased between 2009 and 2013. In Port Vila, the average electricity consumption decreased.

Sales

In the five years from 2009 to 2013, the distribution of sales remained the same. In 2013, 89% of electricity sales were in Port Vila and 10% in Santo (Luganville), leaving only 1% in both Malekula and Tanna.

Figure 44. Geographical distribution of commercial and industrial electricity sales in 2013



Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

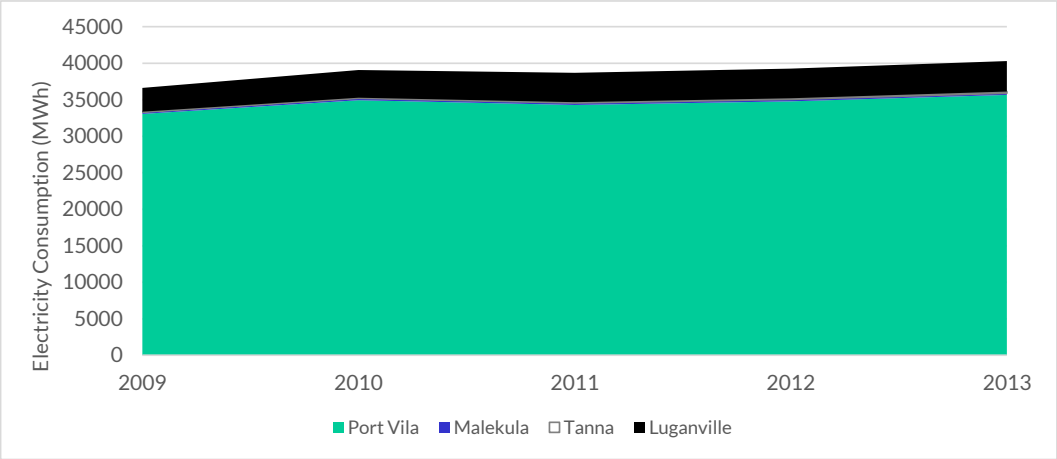
The different concessions had seen electricity sales grow at different paces. Tanna and Luganville experienced higher commercial and industrial sales growth, and this was probably because of an increase in the number of customers and the increase in average electricity consumption.

Table 39. CAGRs of commercial and industrial electricity sales

	Commercial & Industrial Sales CAGR, 2009–2013	Commercial and Industrial Average Consumption CAGR, 2009–2013	Number of Commercial & Industrial Customers CAGR, 2009–2013
Port Vila	1.5%	-0.7%	2.2%
Malekula	2.3%	1.5%	0.8%
Tanna	23.8%	13.7%	8.9%
Luganville	4.8%	3.6%	1.2%

Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

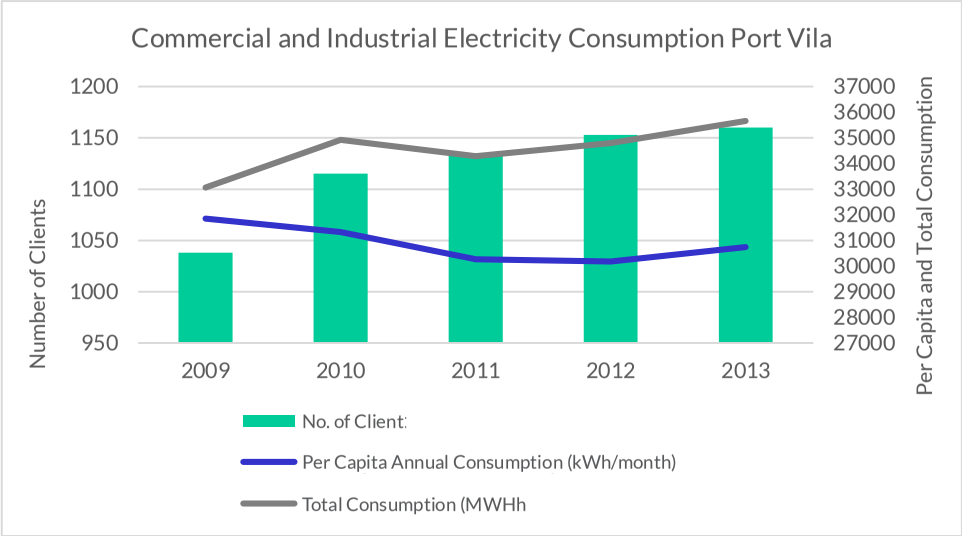
Figure 45. Commercial and industrial sales by concession, 2009-2013

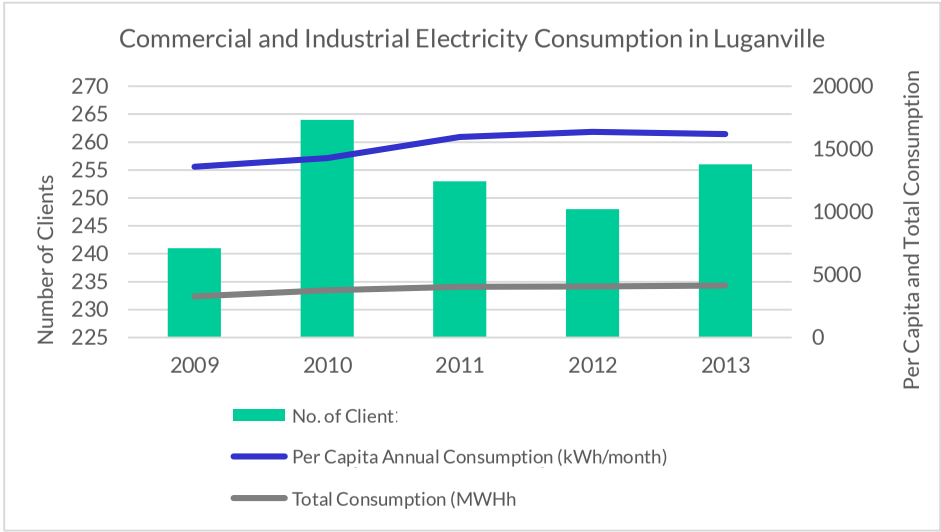


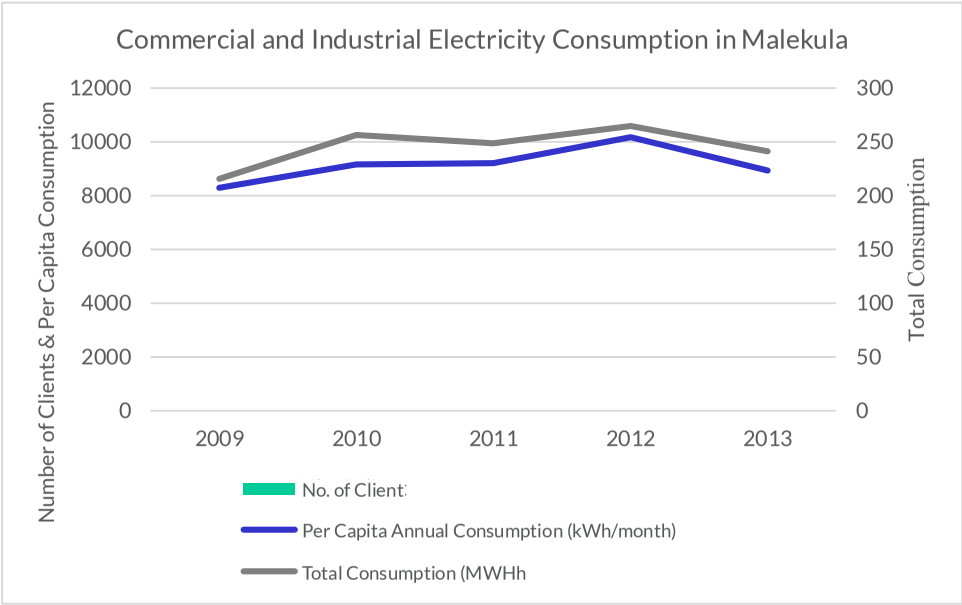
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

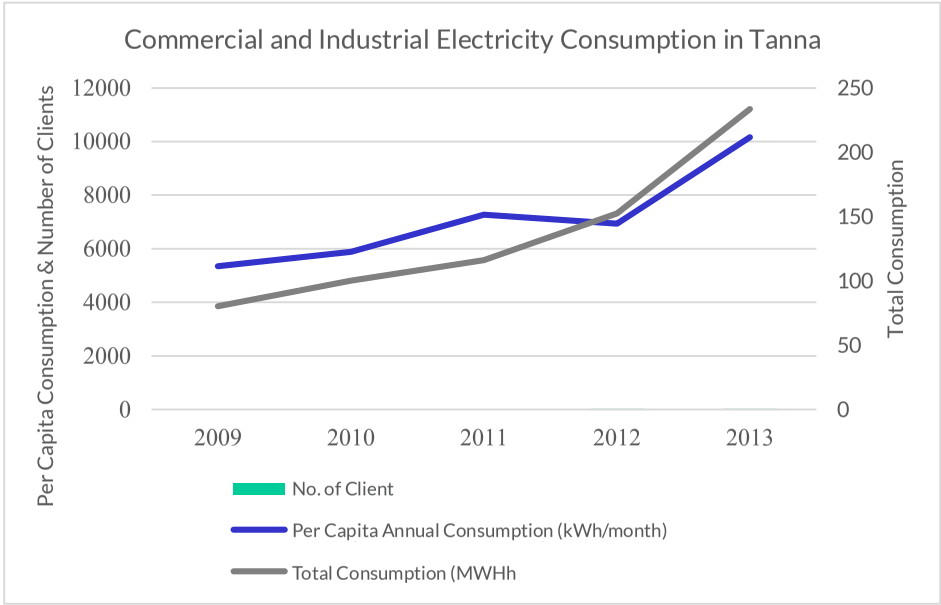
Even though commercial and industrial sales in rural areas strongly increased between 2009 and 2013, they remained negligible in comparison to electricity sales in urban areas, and particularly in Port Vila. The overall commercial and industrial sales increased by 1.6% annually, representing a 10% growth rate between 2009 and 2013.

Synthesis of the Commercial and Industrial Sector's Electricity Consumption Analysis









4. Public Sector Analysis

Customers

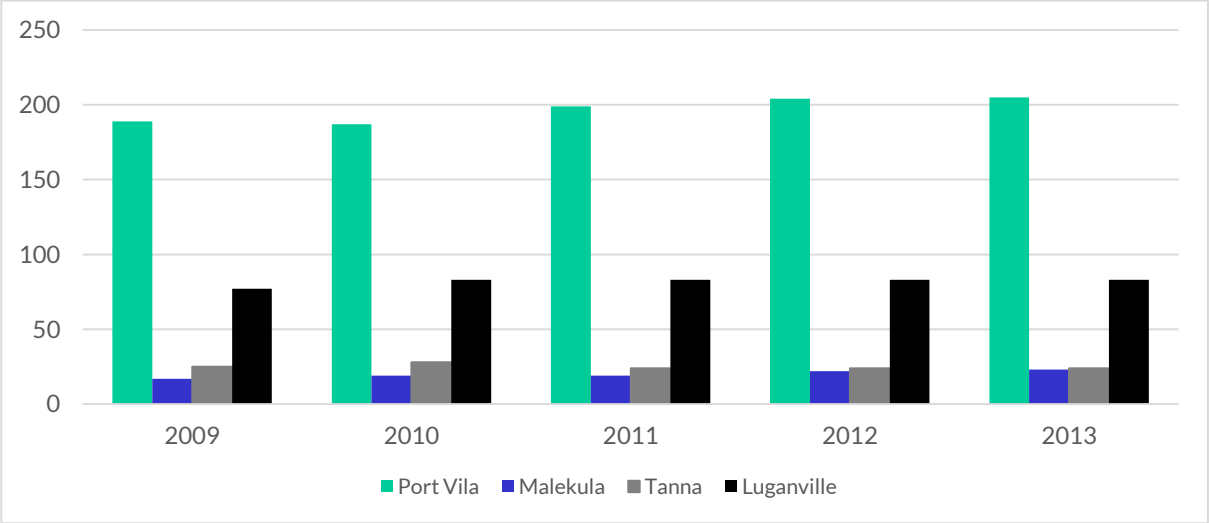
Between 2009 and 2013, the number of public sector customers increased from 308 to 335, which is a growth rate of 2.7%. Over this period, public sector customers in Malekula increased by 6%.

Table 40. CAGRs of public sector customers by concession, 2009–2013

	Public CAGR 2009 - 2013
Port Vila	1.6%
Malekula	6.2%
Tanna	-0.8%
Luganville	1.5%

Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

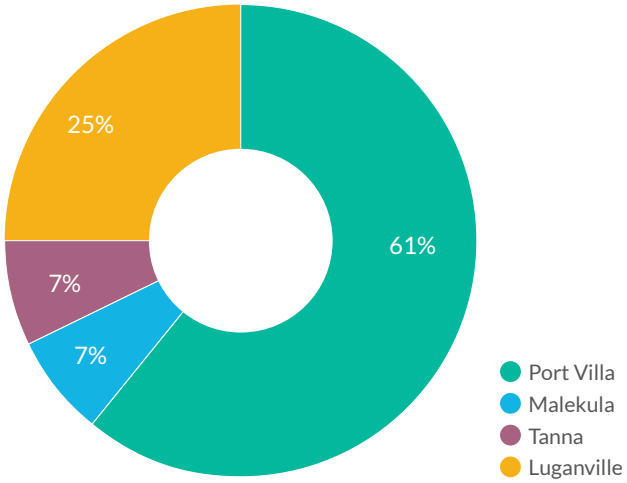
Figure 46. Number of of public sector customers by concession, 2009–2013



Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

From 2009 to 2013, the geographic distribution of public sector customers remained similar: 61% of public sector customers were in Port Vila, 25% in Luganville, 7% in Tanna, and 7% in Malekula. The share of public sector customers in Malekula and Tanna was similar to the residential distribution, whereas the proportion in Luganville was higher than the residential user base.

Figure 47. Geographical distribution of electricity customers from the public sector



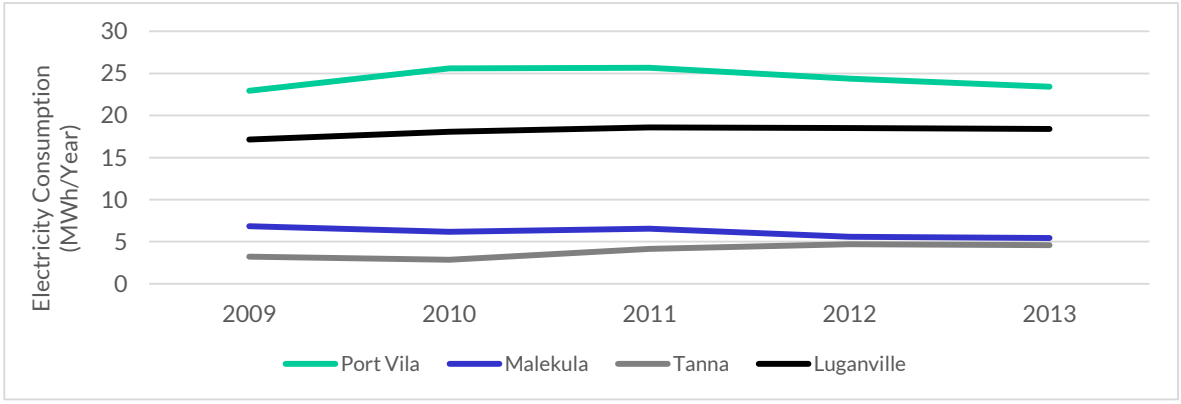
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Average Electricity Consumption

Port Vila had the highest average electricity consumption with 23MWh/year (1,900 kWh/month) followed by Luganvile with 18 MWh/year, and 5MWh/year for both Tanna and Malekula.

Between 2009 and 2013, the public sector's average electricity consumption increased by 1% per year.

Figure 48. Average annual consumption of the public sector by concession, 2009–2013



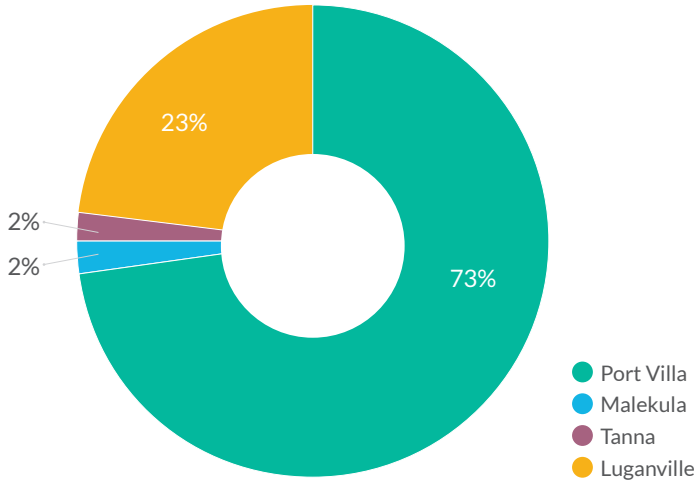
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Sales

From 2009 to 2013, the sales distribution remained similar, with 73% of electricity sales in Port Vila, 23% in Santo (Luganville), and 2% in Malekula and Tanna.

As shown in Figure 50, electricity sales for public sector customers were significantly higher in urban areas. Between 2009 and 2013, public sector demand increased overall by 2% annually, representing a total growth of 14%.

Figure 49. Geographical distribution of public sector electricity sales in 2013



Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

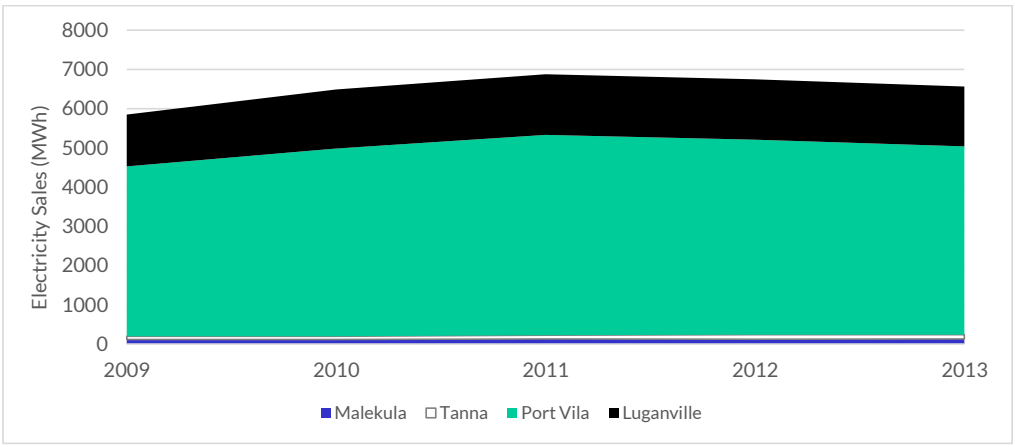
With the exception of Tanna, electricity sales grew at similar rate between concessions. In Tanna, public sector sales increased because of increasing per capita consumption.

Table 41. CAGRs of public sector electricity sales

	Public Sector Sales CAGR, 2009–2013	Public Sector Average Consumption CAGR, 2009–2013	Public Sector Customers CAGR, 2009–2013
Port Vila	2.1%	0.4%	1.6%
Malekula	1.4%	-4.5%	6.2%
Tanna	6.4%	7.3%	-0.8%
Luganville	2.9%	1.4%	1.5%

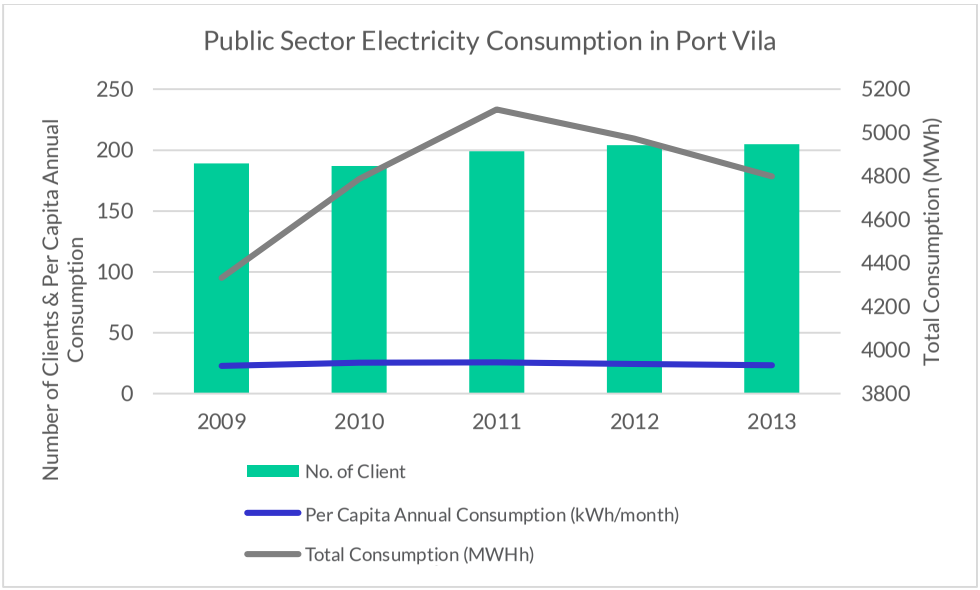
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

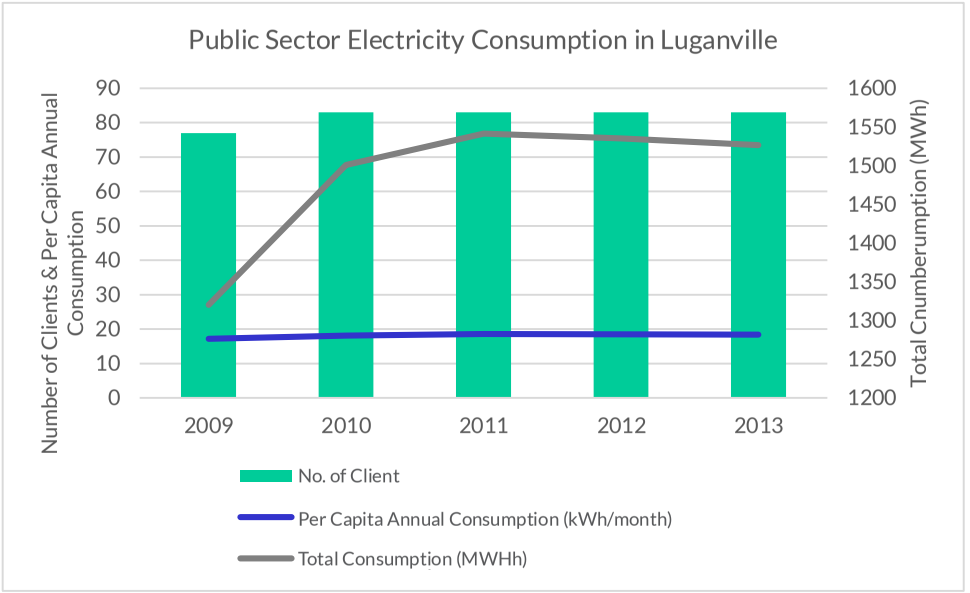
Figure 50. Public sector electricity sales by concession, 2009–2013

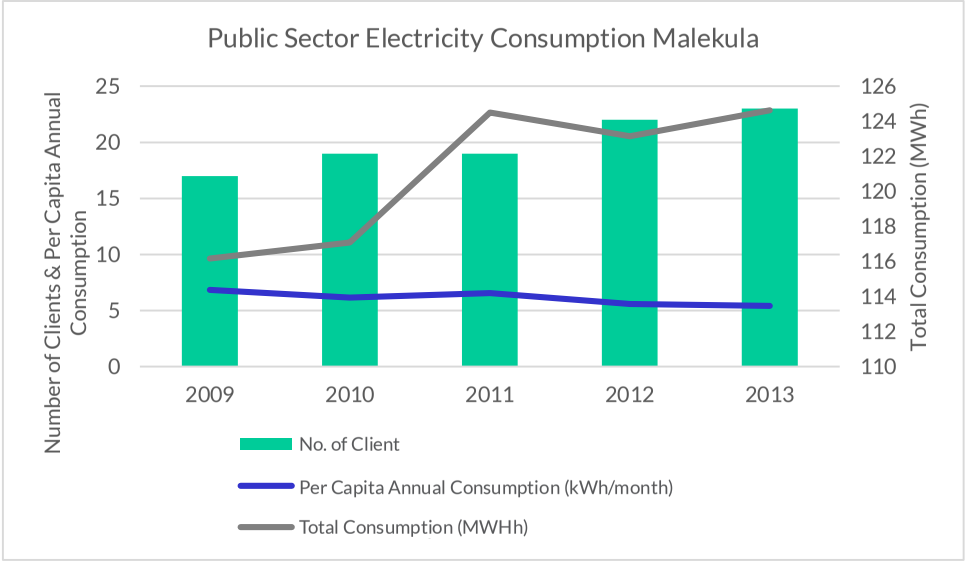


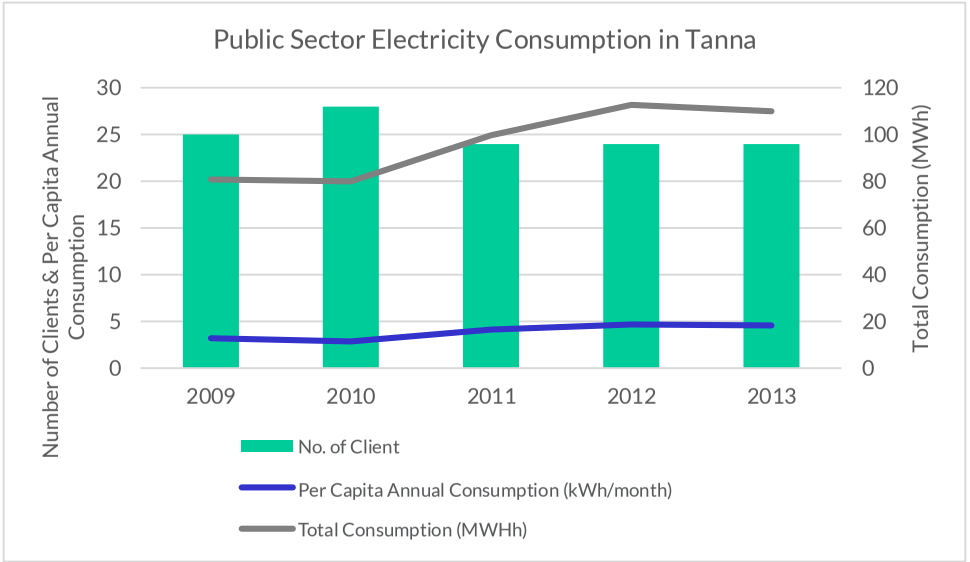
Sources: UNELCO, "Annual Technical Report," 2013; and VUI, "Annual Technical Report," 2013.

Synthesis of the Public Sector's Electricity Consumption Analysis









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