Pacific Region Infrastructure Facility

Study on Pacific Clean Energy Financing Potential

Annex 2: Country Energy Profiles

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Note: In this publication, "$" refers to United States dollars unless otherwise stated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ADB	Asian Development Bank
BAU	business as usual
BESS	battery energy storage system
CFL	compact fluorescent lamp
CIREC	Cook Islands Renewable Energy Chart
CITTI	Cook Islands Tertiary Training Institute
cm	centimeter
CNO	coconut oil
COVID-19	coronavirus disease 2019
DBK	Development Bank of Kiribati
DBSI	Development Bank of Solomon Islands
GDP	gross domestic product
GEF	Global Environment Fund
GHG	greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
GWh	gigawatt-hour
HIES	household income and expenditure survey
IFC	International Finance Corporation
INDC	Intended Nationally Determined Contribution
IPP	independent power producer
JICA	Japan International Cooperation Agency
KIER	Kiribati Integrated Energy Roadmap
km	kilometer
km^2	square kilometer
kW	kilowatt
kWh	kilowatt-hour
LAIF	Livelihood and Investment Facility
LED	light-emitting diode
LFL	LED flat light
LPG	liquefied petroleum gas
m^2	square meter
MW	megawatt
MWh	megawatt-hour
MWp	megawatt-peak
NASA	National Aeronautics and Space Administration
NBV	National Bank of Vanuatu
NERM	National Energy Road Map
NGEF	National Green Energy Fund
O&M	operations and maintenance
PIC	Pacific island country
POIDIER	Promoting Outer Island Development through the Integrated Energy Roadmap (project)
PPA	Pacific Power Association
PRIF	Pacific Region Infrastructure Facility

PUB	Public Utilities Board
PV	photovoltaic
RE-SIP	Renewable Energy Strategy and Investment Plan
SAIDI	System Average Interruption Duration Index
SHS	solar home system
SINEP	Solomon Islands National Energy Policy
SPC	Secretariat of the Pacific Community
SREP IP	Scaling-Up Renewable Energy Program Investment Plan
TPL	Tonga Power Limited
UNDP	United Nations Development Programme
UNELCO	Union Electrique du Vanuatu
URA	Utilities Regulatory Authority
US	United States
USAID	United States Agency for International Development
VREP	Vanuatu Rural Electrification Project
VUI	Vanuatu Utilities & Infrastructure
WTP	willingness to pay

1 INTRODUCTION

Energy demand in the Pacific region has grown vigorously, along with higher energy access rates, poverty reduction, and the levels of energy use demanded by a modern lifestyle. Past and ongoing support programs sponsored by Pacific Region Infrastructure Facility (PRIF) partners have contributed substantially to making this change possible. However, there is limited information on the quality of energy access and on the numbers and types of appliances used by households in the region.

There is also little information on the levels of public awareness of the economic benefits of energy-efficient appliances, and little has been done to identify and measure the trends in demand for renewable-energy products and energy-efficient appliances. In particular, it has been difficult to disaggregate these trends into urban and rural households, income levels, or gender of the household head. As result, the demand potential (market size) for renewable-energy products and energy-efficient appliances in the Pacific island countries (PICs) is largely unknown. Since 2010, most PICs have put in place loan facilities to improve the livelihoods of their citizens. However, the effectiveness of such loan facilities needs to be assessed.

A previous step toward demand analysis and toward determining the market size, is adequate organization and the selection of countries to be analyzed in detail. The selected countries must be representative of the PICs in general. First, the countries were classified by subregion:

- Melanesia: Fiji, Papua New Guinea, Solomon Islands, Vanuatu
- Micronesia: Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau
- Polynesia: Cook Islands, Niue, Samoa, Tonga, Tuvalu

Five PICs were selected to represent all three subregions and different economic levels: Solomon Islands and Vanuatu in Melanesia, Kiribati in Micronesia, and the Cook Islands and Tonga in Polynesia. In addition, validation surveys were carried out in Kiribati and Tonga to verify the assumptions and findings.

2 OBJECTIVES

The objective of the country energy profiles is to gain a deep understanding of the market drivers and market barriers for the upscaling of renewable-energy products and energy-efficient appliances in the five selected PICs. The country energy profiles identify the threats and opportunities that urban and rural households face when trying to fulfill their purchasing needs and aspirations. The profiles look in detail at the learning experiences and lessons from relevant past and ongoing support programs, and at the challenges households face in accessing adequate clean-energy financing. Special attention is given to those barriers that prevent poor households and women-led households from escaping the high levels of energy poverty suffered by most PICs.

The country energy profiles provided valuable information to the final report of this study, which sought to determine more accurately the size of the market for renewable-energy products and energy-efficient appliances. They have also provided the information needed to reflect on the incentives that could prove useful for future support programs and future assistance to PICs by PRIF partners.

3 COOK ISLANDS

3.1 Country Context

3.1.1 Macroeconomic overview

Demographics

The Cook Islands is a small PIC situated in the South Pacific Ocean with a total land area of 240 square kilometers (km^2) plus an exclusive economic zone of 1.8 million km^2. It comprises 15 islands that are divided into two main groups, one in the north (six atolls) and one to the south (nine volcanic islands), where most of the population lives.[1] The capital is Avarua, which is situated on the island of Rarotonga.

The resident population in 2019 was approximately 17,100,[2] with a declining growth rate due to out-migration. The urban population is 10,626, or 71% the country's total; they live in 3,386 households. The remaining segment of the population, making up 1,257 households, lives in the outer islands.[3] The labor force was estimated at 8,056 in January 2020, of which 69% were engaged in the private sector, and 26% in the public sector. Female labor force participation for the same period was 67%, lower than male rate of 78% (footnote 2). Unemployment is low, at 5%.[4]

The Cook Islanders are Polynesian in race; their ancestors voyaged across the Pacific Ocean in canoes. The country became Christian with the arrival of missionaries two centuries ago.[5] The official languages are Cook Islands Maori and English.[6] The local currency is the New Zealand dollar.

The Cook Islands has been an independent state since 1965, and its Constitution provides for a parliament, the House of Ariki, which consists of 14 appointed members who oversee the welfare of the nation. The Cook Islands is a parliamentary democracy, and is in a free association with New Zealand, which means that Cook Islanders are also New Zealand citizens, with the right to work and reside in New Zealand (footnote 2). Its head of state is the Queen of England, who is represented by a local resident.

Gross Domestic Product

The total gross domestic product (GDP) of the Cook Islands in 2020 was $106.8 million, or $24,913 GDP per capita.[7] The service industry grew by 1.3% that year, and primary industries grew by 1.2%, but the manufacturing industries decreased by 25.2% due to the growth in construction activities during this period.[8] Prior to the pandemic, the GDP had grown in real

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1 The Cook Islands. Where Are We. http://www.ck/geog.htm.
2 Government of the Cook Islands, Ministry of Finance & Economic Management. 2021. *Cook Islands Economic Development Strategy 2030: Working Together to Build Quality Growth*. Avarua, Cook Islands. http://mfem.gov.ck/images/ECON/1-EDS_Final_for-publication_Optimized.pdf.
3 Government of the Cook Islands, Cook Islands Statistics Office. 2018. *Cook Islands Household Income and Expenditure Survey (HIES) 2015-2016.* Avarua. http://www.mfem.gov.ck/statistics/census-and-surveys/household-expend-survey.
4 Government of the Cook Islands, Ministry of Finance & Economic Management. Census 2016: Census of Population & Dwellings. http://www.mfem.gov.ck/statistics/census-and-surveys/census/142-census-2016 (accessed 15 September 2021).
5 Government of the Cook Islands. Religion in the Cook Islands. http://www.ck/religion.htm.
6 Pacific Islands Forum. Cook Islands. https://www.forumsec.org/cook-islands/.
7 Pacific Community. Cook Islands. https://www.spc.int/our-members/cook-islands/details.
8 Government of the Cook Islands, Ministry of Finance & Economic Management. National Accounts: June Quarter 2021. http://mfem.gov.ck/statistics/134-economic-statistics/national-accounts.

terms by 5.3% in 2018-2019, increasing from NZ$505 million to NZ$531 million (2016 prices) (footnote 8).

The Cook Island's economy is predominantly based on tourism (68% of GDP),[9] and this industry is currently struggling due to the coronavirus disease 2019 (COVID19). Tourist arrivals in 2019-2020 amounted to 123,786 visitors, representing a 26% fall from 2018. The main sources of tourists are New Zealand, Australia, the European Union, United States, and Canada. In terms of trade, the principal export markets include Japan, the People's Republic of China (PRC), New Zealand, and Australia. Imports come mainly from New Zealand, the United States, Fiji, and Australia.[10]

In the domestic banking sector, total domestic lending dropped by 5.7% in 2019. That same year, personal service loans accounted for 45% of total lending, loans to hotels and motels accounted for 20%, and business loans in general accounted for 12%. Interest rates varied for home loans (8.25%–9.5%), business loans (7.7%–10.5%), and personal loans (10.25%–15.8%) (footnote 2).

3.1.2 Energy resources

The Cook Islands is heavily dependent on imported fossil fuels to meet its energy needs for economic development, especially for electricity generation and transportation (land, air, sea); it is therefore vulnerable to external price shocks. The demand for fossil fuels increased from 18.9 million liters in 2015 to 21.5 million liters in 2017.[11] The main fuel for electricity generation is diesel oil, accounting for 87% of the total. Fuel prices are expensive; for instance, wholesale prices in November 2018 were set at a maximum of NZ$2.08 for diesel and NZ$2.10 for gasoline.[12]

The indigenous energy resources consist largely of biomass (for cooking in the outer islands). Solar energy utilization is growing, with applications in the electricity sector and in road transport. Wind is also being utilized for electricity generation.

3.2 Sector Overview

3.2.1 Sector performance

Problems

The salient issues for the Cook Islands energy sector are the high reliance on imported fossil fuels and the slow progress of the country's effort to diversify its fuel sources with the support of development partners. Other ongoing issues include technology applications, labor and skill constraints, the lack of financing options, and infrastructure requirements.

Institutional arrangement

The energy sector of the Cook Islands is served by diverse agencies, each with its own mandate. Table A2.1 lists the agencies and describes their roles.

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[9] Government of the Cook Islands, Ministry of Finance & Economic Management. The Cook Islands Renewable Energy Chart (CIREC). Jhttp://mfem.gov.ck/images/MFEM_Documents/DCD_Docs/ADB/Southern_Renewable_Energy_reports/June-2016-Cook_Islands_Renewable_Energy_Chart_and_Plan.pdf.

[10] Government of Australia, Department of Foreign Affairs and Trade. Cook Islands (fact sheet). https://www.dfat.gov.au/sites/default/files/cook-cef.pdf.

[11] Pacific Regional Data Repository for SE4ALL. Fiji Petroleum Imports and Re-exports 2015-2017. https://prdrse4all.spc.int/data/fiji-petroleum-imports-and-re-exports-2015-2017.

[12] Government of the Cook Islands, Cook Islands Price Tribunal. Price_order_06.2018_nov_-_dec_2018.pdf (spc.int).

Table A2.1: Energy-Sector Institutions Working for Clean Energy in the Cook Islands

Agency	Role/Function	Sector
Office of the Energy Commissioner (Prime Minister's office)	Head of the planning and coordination of energy development activities	National energy planning and coordination, energy efficiency
TAU	Utility that supplies electricity on Rarotonga	Electricity
TMUA	Utility on the island of Aitutaki	Electricity
Outer Island Energy Councils	Eleven community councils that manage their own islands' electricity supplies	Electricity
REDD	Energy department responsible for implementing CIREC renewable-energy projects.	Renewable energy

CIREC = Cook Islands Renewable Energy Chart, REDD = Renewable Energy Development Division, TAU = Te Aponga Uira O Tumu Te Varovaro, TMUA = Te Mana Uira O Araura.
Sources: Pacific Clean Energy Financial Potential project team; The Pacific Community (SPC), Stocktake Report: Energy Sector Institutions, Legislation, Policies and Fiscal Incentives of Pacific Island Countries

Electricity demand

Electricity peak demand has grown from 4.5 megawatts (MW) in 2015 to 5.13 MW in 2019,[13] a 23% increase, demonstrating a steady demand growth. The main customers are residential, commercial, and industrial. Electricity use is low by international standards; for example, on Rarotonga electricity use per capita is 2,200 kilowatt-hours (kWh) per year, and it is lower in the outer islands (footnote 9). Demand is concentrated largely on Rarotonga and Aitutaki, which have higher populations than the rest of the islands. Households, businesses, and hotels account for over two-thirds of electricity demand.

Electricity supply

The Te Aponga Uira (TAU), a small to medium-sized utility owned by the Government of the Cook Islands, is the sole supplier of grid electricity on the main island, Rarotonga. Te Mana Uira O Araura (footnote 2), formerly known as the Aitutaki Board, is a state-owned utility that supplies electricity to the islands in the Southern Group. The rest of the islands manage their electricity supplies through councils or island administrators (footnote 9).

The generation output for 2019 was 31,207 megawatt-hours (MWh), of which renewable energy accounted for 13.7%. The renewable energy mix in 2016 was approximately 32% from an airport solar farm, 30% net metering, 32% gross metering, and 5% from independent power producers (IPPs), and 3% from TAU. The IPP contribution has recently increased to a 10.15% share. According to the Cook Islands Renewable Energy Chart (CIREC) for 2016, there are no supply constraints, as the generation capacity exceeds current demand.

3.2.2 Policy framework

Strategic policy documents

The development of the energy sector development has been guided first by the 2012 Cook Island Renewable Energy Chart (CIREC), and later by CIREC 2016. The CIREC Implementation Plan outlines key development priorities for reducing dependence on fossil fuel for power generation by increasing renewable energy integration. There are supporting policy frameworks providing guidance on tariff setting and grid integration through net metering (Table A2.2). Legal instruments are essential for guiding and establishing rules for the

[13] Pacific Power Association (PPA). Benchmarking Portal. https://www.ppa.org.fj/benchmarking-portal/ (accessed 15 November 2021).

industry. See Table A2.3 for a list of energy regulations in the Cook Islands and Table A2.4 for a list of policy incentives.

Table A2.2: Policy Framework for the Energy Sector in the Cook Islands

Title of Policy	Purpose
The CIREC 2012, including the CIREC Implementation Plan	Set the targets of 50% renewable electricity by 2015 and 100% renewable energy electricity by 2020, with the guidelines for achieving the targets specified by the Implementation Plan
Tariff Group Determination Policy No. FPO 06, 2010	Provides a uniform approach to the selection of tariffs by TAU that would be applicable to all electrical installations
Grid Connected Renewable Generators and Net Metering - Amendment Policy, 2013	Includes gross metering, IPP connections, and OEC oversight on tariffs and renewable energy requirements
Grid Connected Renewable Generators and Net Metering Amendment Policy, 2009	A net metering policy introduced by TAU, a state-owned utility that is the sole supplier of grid electricity on Rarotonga.

CIREC = Cook Islands Renewable Energy Chart, IPP = independent power producer; OEC = Office of the Energy Commissioner; TAU = Te Aponga Uira.
Source: Pacific Clean Energy Financial Potential project team.

Table A2.3: Regulation of the Energy Sector in the Cook Islands

Title of Legal Instrument	Description	Implementing Agency
Energy Amendment Act 2012	Amended the Energy Act 1998 to establish the office and functions of the energy commissioner	Office of the Energy Commissioner
Energy Standards and Labelling 2014 (Draft)	Lists product classes subject to minimum performance standards	
Te Aponga Uira O Tumu-Te-Varovaro Act 1991	Act to constitute TAU, the state-owned utility that is the sole supplier of grid electricity on Rarotonga, and to define TAU's functions and powers	TAU (Rarotonga)
Outer Islands Local Government Act 1987	Consolidated local government in the outer islands	Outer islands councils
Cook Island Investment Corporation Act 1998	Established CIIC to control and manage statutory corporations. CIIC oversees and regulates TAU and TMUA (state-owned utility and sole supplier of grid electricity on Aitutaki)	Ministry of State Owned Enterprises

CIIC = Cook Islands Investment Corporation, TAU = Te Aponga Uira, TMUA = Te Mana Uira O Araura.
Source: Pacific Clean Energy Financial Potential project team.

Table A2.4: Policy Incentives for the Energy Sector in the Cook Islands

Incentive	Purpose
Direct grant	Annual grants from the government for power-generation fuel in the outer islands, direct government grants to renewable-energy projects, and funding from development partners
VAT exemption	Electricity exempted.
Lifeline tariffs	For domestic consumers using less than 60 kWh, NZ$0.57 rate; for those using 60 kWh–300 kWh, NZ$0.80 rate

kWh = kilowatt-hour; NZ$ = New Zealand dollar; VAT = value-added tax.
Sources: Pacific Clean Energy Financial Potential project team; Energy_stocktake_report_web.pdf

Targets

The Cook Islands does not have an energy access target, as the whole population has access to electricity. The 2012 Cook Islands Renewable Energy Chart (CIREC) set the targets of converting 50% of the country's electricity from diesel to renewable energy by 2015 and 100% by 2020, with the first 50% covering the six outer islands comprising the Northern Group. In 2019, the Cook Islands reached 26% of electricity generation from renewable sources. The Economic Development Strategy proposes a review of the targets by 2022 to ensure that they are still achievable. The Strategy further proposes adjusting the renewable energy target to 60% by 2030.

The Cook Islands does not have a quantitative energy efficiency target. However, the Economic Development Strategy aims to increase energy use efficiency because that could substantially boost economic productivity, lower consumer energy costs, and reduce greenhouse gas emissions. In 2019, the ratio of GDP to total energy consumed was estimated at 14.9, a substantial improvement over the 2018 ratio of 12.6.

Expected investments

The government is committed to reducing the country's heavy reliance on diesel and is working with development partners to build the appropriate infrastructure for achieving this goal. The CIREC 2016 estimated investments of NZ$20 million for the Northern Group transition (completed) and NZ$17 million for the Southern Group, excluding Rarotonga and Aitutaki. The estimated investment cost for Aitutaki is approximately NZ$23.3 million, and that for Rarotonga is NZ$200 million to NZ$300 million.

Other investment opportunities include wind turbines for Rarotonga, renewable energy transport,[14] and a grid upgrade and increased storage capacity in Rarotonga.[15]

3.2.3 Tariffs

Charges for electricity service vary, depending on the customer category. In 2018-2019, residential customers were charged $0.47; and commercial, industrial, and government customers were charged $0.52. Under the tariff regulation, the utilities can pass fuel costs directly on to the consumers, and they can charge an inflation-indexed nonfuel tariff. The Competition and Regulatory Authority determines the TAU tariff structures and maximum prices (footnote 2). The tariffs for the outer island systems are based on the system size and output and are heavily subsidized by government. The cost of electricity is high relative to incomes, despite the heavy subsidy support provided by the government.

3.2.4 Relevant support programs

There are currently no loan facilities specifically targeting energy-efficiency and renewable-energy programs at the household level. The commercial banks offer personal loan products to pay for new household appliances and solar home systems for water heating and other applications. The lending market is declining due to COVID-19, and a willingness-to-pay (WTP) survey may be needed to determine the appetite for lending programs that target energy-efficient appliances and renewable-energy products.

[14] TAU has set up charging station for electric vehicles in Rarotonga.
[15] Pacific Energy Conference 2016, Pacific Energy Country Profiles, New Zealand Ministry of Foreign Affairs, https://prdrse4all.spc.int/sites/default/files/pacific-energy-country-profiles-2016.pdf

3.3 Estimation of Demand

3.3.1 Income and expenditure

The Cook Islands per capita GDP is higher than that of most PICs, and its average household size (3.5 members) is smaller. A household survey by the United Nations Development Programme (UNDP) on Mitiaro Island in 2012 found that the average household monthly income there was NZ$537, generally earned from public-sector jobs or fishing.[16] In 2015-2016, the Cook Islands Household Income and Expenditure Survey (HIES) found that the national average income was NZ$50,620 per year, and the median income NZ$42,050 per year. The main income sources were employment (68.9%), imputed rents (14.5%), and transfer income (10.9%), among others. The distribution of income was unequal, with urban households earning more than rural households (Table A2.5). Regarding the types of income, 83.3% of household net income was cash-based. And as for employment categories, 87% of household income came from wages and salaries, 7% from non-subsistence businesses, 2.4% from agriculture, and 2% from home production.

Table A2.5: Average and Median Annual Household and Per Capita Incomes in the Cook Islands (NZ$)

	Per Household		Per Capita	
	Average	Median	Average	Median
Urban	55,150	46,700	17,570	14,120
Rural	38,420	33,000	11,020	8,050
Total	**50,620**	**42,050**	**15,660**	**12,540**

NZ$ = New Zealand dollar.
Sources: Government of the Cook Islands, Cook Islands Statistics Office. 2018. *Cook Islands Household Income and Expenditure Survey (HIES) 2015-2016.* Avarua.

In terms of expenditure, the total annual average expenditure was NZ$39,770, and the median was NZ$33,050. About 85.5% went to consumption, 3.8% to nonconsumption, and 10.7% to investments (Table A2.6). Urban households spent mostly on utilities (29.3%), while rural households as spent mainly on food (31.6%).

Table A2.6: Average and Median Annual Expenditures per Household and per Capita in the Cook Islands (NZ$)

	Per Household		Per Capita	
	Average	Median	Average	Median
Urban	42,760	36,070	13,620	11,290
Rural	31,720	27,050	9,100	7,430
Total	**39,770**	**33,050**	**12,300**	**10,010**

NZ$ = New Zealand dollar
Sources: Government of the Cook Islands, Cook Islands Statistics Office. 2018. *Cook Islands Household Income and Expenditure Survey (HIES) 2015-2016.* Avarua.

When balancing expenditure against per capita income, the savings are equivalent to 22% of the average income, or NZ$3,360 per capita per year. It is reasonable to infer that households will be willing to pay more for energy-efficient appliances through their cash savings, a loan facility, or a hire purchase arrangement.

[16] T.L. Jensen. 2012. *Mitiaro Island, Cook Islands Energy Survey Report*. Suva, Fiji: UNDP Pacific Center. https://prdrse4all.spc.int/system/files/mitiaro_energy_survey_report_-_final_280312.pdf.

3.3.2 Appliance and equipment inventory

Households in the Cook Islands use a variety of electrical appliances, and past surveys have found an increase in appliance ownership. The 2016 national census found that the rate of ownership and the number of appliances and other products have increased by over 20% (e.g., freezers increased by 21.6%). These increases are reflected in the growing demand for electricity, including operations-and-maintenance services.

These surveys also found that ownership is high for TVs, washing machines (i.e., clothes washers), refrigerators, freezers, and electric fans (Table A2.7).

Table A2.7: Household Appliance Ownership in the Cook Islands (%)

Appliance	Rates of Household Ownership	
	SPC MEPSL 2017	National Census 2016
Lighting	69	
Air conditioners		8
Refrigerators	89	41
Washing machines	90	81
Electric fans	84	
TVs	93	100
Electric water heaters	26	15
Small electric stoves	37	19
Microwave ovens		57
Freezers	78	83
Rice cookers		48
Toasters		78
Desktops and laptops		75
Mobile phones		
Rooftop solar systems		15
Solar water heaters		29

SPC = Secretariat of the Pacific Community; MEPSL = Minimum Energy Performance Standards and Labelling, TV = television.
Sources: Government of the Cook Islands, Ministry of Finance & Economic Management. Census 2016: Census of Population & Dwellings. http://www.mfem.gov.ck/statistics/census-and-surveys/census/142-census-2016 (accessed 15 November 2021); the Pacific Clean Energy Financial Potential project team; Survey of consumer awareness and use of energy rating labels in PICs: COOK ISLANDS COUNTRY REPORT

The most common types of lighting at the time of the census were compact fluorescent lamps (CFLs) and light-emitting diode (LED) flat lights (LFLs), with 89% of the households using CFLs, and 64% using LFLs. The proportion of households using incandescent lighting was found to be low (14%), and only 4% of households were using it as the main type of lighting.

3.3.3 Awareness of energy efficiency

Consumer awareness of energy efficiency is higher in the Cook Islands (91%) than in the other PICs because most of the household appliances with energy-efficiency labels are well-known brands imported from Australia and New Zealand.[17]

The Energy Labelling and Minimum Energy Performance Standards for Appliances and Lighting Impacts survey in the Cook Islands, carried out by the Secretariat of the Pacific Community (SPC), found that despite seeing the labels on appliances at home and in stores,

[17]The Pacific Community, Survey of consumer awareness and use of energy rating labels in PICs: COOK ISLANDS COUNTRY REPORT

only 51% of consumers understood the information on the labels or knew how to calculate running costs. About 70% understood that the stars have positive meaning, and the same proportion stated that the star rating was important to them, but only 43% intended to use it when considering their next purchase. The survey also found that males and those living in rental properties were more likely to recognize the labels.[18]

These results indicated the need to improve consumer's' understanding of appliance labelling and rating, as well as their ability to estimate the running costs of preferred appliances.

3.3.4 Costs of ownership

The cost of ownership takes into account the price for which an appliance or piece of equipment is purchased plus the cost of operating it. The cost of ownership of an inefficient refrigerator is likely to be higher than that for an efficient one, as is illustrated in Table A2.8.

Table A2.8: Sample Costs of Ownership for Certain Products (NZ$)

Appliance	Purchase Price	Operating Cost	Lifetime Cost	Total Cost of Ownership
Refrigerator: Panasonic, 4-star, 342 liter, 299 kWh/year, 10-year lifetime[a]	1,599.00	141.00	1,405.00	3,004.00
Refrigerator: Beko, 3.5-star, 335 liter, 330 kWh/year, 10-year lifetime[b]	935.00	155.00	1,551.00	2,485.00
Incandescent bulb: 60 W, 1,000-hour lifetime	1.50	51.40	103.00	104.50
CFL: 15 W, 5,000-hour lifetime	7.90	35.25	75.00	82.90

CFL = compact fluorescent light, kWh = kilowatt-hours, W = watt.

[a] CIPS Electronics. Panasonic 342L Fridge Freezer. Panasonic 342L Fridge Freezer – CIPS Electronics (cips-electronics.com).

[b] Smiths City. Beko 335L White Bottom Mount Fridge/Freezer - BBM335W. Beko 335L White Bottom Mount Fridge/Freezer - BBM335W (smithscity.co.nz).

Source: Pacific Clean Energy Financial Potential project team.

A star rated appliance may be the most natural choice given the saving benefits; however, it is not as easy as it seems because there are other factors that influences a consumer's purchase decision.

3.3.5 Willingness to pay

The Minimal Energy Performance Standards (MEPS) Survey conducted by the SPC in the Cook Islands found that 41% of the surveyed group stated that the lack of affordability was a barrier. This ratio is high, but there is only limited information on the consumers' purchase preferences with regards to energy-efficient appliances and renewable-energy products and equipment. However, an analysis can be done based on factors such as income, appliance use, and the availability of operations and maintenance (O&M) services, including market incentives.

[18] SPC. Energy Labelling and Minimum Energy Performance Standards for Appliances and Lighting Impacts in CI.JF.KI.SA.TO.VA. https://pacificdata.org/data/dataset/energy-labelling-and-minimum-energy-performance-standards-for-appliances-and-lighting-impacts-i (15 April 2020).

Urban grid-connected households

The last energy household survey revealed that just over a third of the group (39.3%) did not know what they were going to buy next. However, most stated that their next buy would be a refrigerator, clothes washer, freezer, or TV. The respondents thought that 3 to 6 months was enough time to think about a purchase and to mobilize resources for the purchase. Since 2017, there has apparently been no WTP survey of households in the Cook Islands focused on energy, so perhaps one is now due.

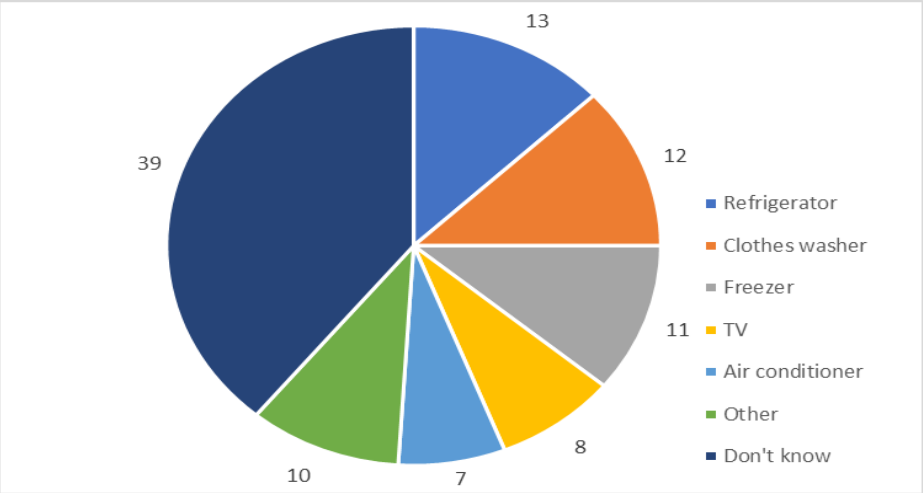
Rural off-grid households

The 2012 survey by UNDP on Mitiaro Island found that most preferred appliance in off-grid households is a washing machine. This survey result is very outdated, although some issues do persist over the years. A WTP survey may be due now.

3.3.6 Demand forecast

The SPC 2017 survey on consumer awareness and the use of energy-rating labels in the Cook Islands found that the major appliances of interest were refrigerators, washing machines, and freezers, among others (Figure A2.1). For homeowners, the most preferred appliance was the washing machine. Those living in apartments were likely to purchase a refrigerator first, then a freezer.

Figure A2.1: Next Planned Appliance Purchases in the Cook Islands (%)



TV = television.
Sources: Survey by the Pacific Clean Energy Financial Potential project team; Tebbutt Research. 2017. *Survey of Consumer Awareness and Use of Energy Rating Labels in PICs: Cook Islands Report*. Pacific Community.

3.4 Market Overview

3.4.1 Suppliers

There are retail stores selling a range of electrical products and a limited selection of renewable-energy equipment. A list of shops selling white goods and electrical appliances is shown in Table A2.9.

Table A2.9: Electrical Product and Service Suppliers

Supplier	Product Ranges, Prices, and/or Services	Brands
CIPS[a]	Electronics, copiers and printers with spare parts, lighting, household appliances (refrigerators, cookers, solar panels, fans, TVs, security systems, furniture, etc.) Refrigerator/freezer prices: NZ$899–NZ$3,499 Washing machine prices: NZ$1,099–NZ$2,249 LED lighting prices: NZ$39–NZ$169 Services: laybuy, refunds, shipping and delivery	Panasonic, Bosch, Apple, HP, Canon, OKI, Ricoh, Acer, ASUS, Intel, ViewSonic, AOC, ADATA, ASUSTOR, GoPro, Marley
CITC[b]	Wholesaler and retailer importing a variety of products: household appliances, souvenirs, clothing, hardware tools, medicines, and much more	Fisher & Paykel, Sony, etc.
John Koteka Electrical Limited	Local company providing electrical services	-
RaroWatt Cook Islands[c] (Rarotonga)	Provider of renewable energy systems (modules, batteries, etc.) that are compliant with New Zealand and Australian standards	Solarwatt, Delta Controls, Optergy, Janitza, Tridium
Andersons[d] (Rarotonga West)	Energy and contracting company providing electrical installations Services: energy, heating, ventilation, air conditioning and refrigeration, machinery, information technology services, construction, waste management Projects have included: Mangaia; Mauke; Mitiaro; Atiu Island: 1.3 MWp PV solar, 7.3 MWh BESS, $16 million funded by ADB	
PRIME Solutions LTD[e]	Electricians offering heating, ventilation, air conditioning, and refrigeration services	Toshiba
George Electrical Company	Electrical contractor offering installation, repair, and electrical services	-

ADB = Asian Development Bank; BESS = battery energy storage system; CIPS = Cook Islands Printing Services, CITC = Cook Islands Trading Corporation, LED = light-emitting diode; MWh = megawatt-hour; MWp = megawatt peak; NZ$ = New Zealand dollar; PV = photovoltaic, TV = television.

[a] CIPS Electronics. https://cips-electronics.com/.

[b] CITC. https://www.citc.co.ck/.

[c] RaroWatt Cook Islands. https://m.facebook.com/Rarowatt/.

[d] Andersons. https://www.andersons.co.ck/.

[e] PRIME Solutions LTD. https://www.facebook.com/primesolutionsrarotonga/.

Source: The Pacific Clean Energy Financial Potential project team.

3.4.2 Lending agencies

There are commercial banks and financial institutions operating in the Cook Islands that provide various financing products, including savings accounts and loans for personal needs, business ventures, and for refurbishing a home or building a new one (Table A2.10).

Table A2.10: Financial Institutions in the Cook Islands

Bank of the Cook Islands
• Various lending services, among them personal loans (secured or unsecured), 12.5% per year (secured interest rate), 16.5% per year (unsecured interest), minimum NZ$2,000; home loans (for new homes or renovations), 8.25% per year. • Currently going through the accreditation process for GCF. Once accreditation is awarded, the Bank of the Cook Islands will directly access GCF funding.[a]
Cook Island ANZ Bank
• Personal loans, minimum NZ$500, 5-year maximum term, variable interest. • Business lending.
Bank South Pacific
• Personal loans, 10.25% secured, 17.25% per year unsecured; home loans 8.25% per year.
Westpac Bank
• Loan products, including personal and home loans.

ANZ Bank = The Australia and New Zealand Banking Group, GCF = Green Climate Fund, NZ$ = New Zealand dollar.

[a] Bank of the Cook Islands. 2021. News release. One Step Closer for the Cook Islands. 22 September. https://bci.co.ck/news/archive/one-step-closer-for-the-cook-islands/.

Source: Survey by the Pacific Clean Energy Financial Potential project team.

3.5 Opportunities for Local Operations and Management and Job Creation

3.5.1 Repair services

Repair services are available in the Cook Islands as per the list in section 3.1. Rarotonga appears to be well established with suppliers and service providers, which have a special arrangement with the outer islands, possibly at very high prices. There is limited information available on the number and type of repair services available in the outer islands, but demand there may be high, so there may be opportunities to set up new businesses, and thus contribute to the creation of more jobs. Perhaps the opportunity to build local O&M should focus on solar grid and off-grid skills, given the recent growth in outer-island system installations. Upskilling in wind technology should also be included. In terms of appliances, there will always be a demand for repair services, and building local capacity will be very critical for ensuring that the energy market remains robust.

3.5.2 Capacity needs

The Cook Islands economy is currently experiencing a labor shortage due to a brain drain, and the government is encouraging the recruitment of foreign workers to fill the gap. There is insufficient data to quantify skill gaps in each discipline, particularly the energy sector, but the local reliance on external contractors to implement renewable energy projects has demonstrated the severity of the matter. In terms of gender balance, the participation of women in the workforce is lower than that of men, although it is improving at the utilities. The gender ratio for TAU is 76% male and 24% female (footnote 14).

There are local institutions such as the Cook Islands Tertiary Training Institute (CITTI) and the University of the South Pacific that provide a range of programs, including academic and vocational courses. There are also educational scholarships for students who wish to continue their education. This assistance targets mainly students pursuing higher education in New Zealand, Australia, and other destinations. And the government is committed to establishing a tertiary and vocational student loan scheme for students at domestic institutions. It will be accompanied by a repayment scheme (footnote 2).

In the future, capacity building and labor shortage reduction in the Cook Islands will require more planning, a thorough review of existing policies, and the identification of institutional-strengthening opportunities. There should be a range of strategies focused on enhancing existing financial assistance through loans for study locally and abroad, expanding and improving current programs delivered through CITTI, and strengthening twinning and mentoring programs involving the utilities and external partners.

3.6 Development Partners

The government works with many development partners in the energy space, and these agencies have played an important role in realizing the CIREC strategy. The completion of the Northern Group Renewable Energy Project demonstrated the value of the development partners to the country's energy sector development. Table A2.11 lists the partners and their contributions to the expansion of renewable energy in the Cook Islands.

Table A2.11: Development Partners Working in the Cook Islands

Project	Activities and Objectives	Development Partners
Southern Group Renewable Energy Project (Atiu, Aitutaki, Mangaia, Mauke, Mitiaro, Rarotonga)	Installation of solar energy systems with storage capacity and diesel backup ($33 million funding)	ADB, GEF, EU
Northern Group Renewable Energy Project (Manihiki, Nassau, Palmerston, Pukapuka, Rakahanga, Suwarrow, Penryhn)	Installation of solar hybrid systems	Government of New Zealand
Te Mana O Te Ra (at Rarotonga International Airport)	Installation of 1 MW grid-connected solar power station	Government of New Zealand

ADB = Asian Development Bank; EU = European Union; GEF = Global Environment Facility; MW = megawatt
Source: Pacific Clean Energy Financial Potential project team.

4 KIRIBATI

4.1 Country Context

4.1.1 Macroeconomic overview

Demographics

Kiribati is a remote Central Pacific country comprising of 32 atolls and a coral island, with a total land area of 810 km^2 that is widely dispersed over an exclusive economic zone of 3.5 million km^2, and spans three island groups and three time zones. The total population of Kiribati is 119,940, and it is distributed across three island groups: (i) the heavily populated Gilbert Islands to the west, including the capital and main economic center, South Tarawa, which is home to over half the country's residents; [19] (ii) the almost unpopulated Phoenix Islands in the center (with Kanton Island having only a few permanent residents); and (iii) the Line Islands to the east, with three populated islands: Kiritimati, Tabueran (or "Fanning Island"), and Teraina.

South Tarawa is the most populated area of Kiribati (53% of Kiribati's population) with a total population of 63,439 (52% female). The population of South Tarawa grew by 26.4% from 2015 to 2020. The populations of the Line and Phoenix island groups grew by 24.4% over the same period, and these groups are now home to 11,279 people (9.4% of Kiribati's total population).

Kiritimati Island is the most populated of the Line Islands, with 7,380 residents in 2020. There are 20,731 households in Kiribati, including 9,576 in South Tarawa, around 12,000 in the outer Gilbert Islands, and 1,979 in the Line and Phoenix island groups (including 1,253 on Kiritimati Island). Average household size is 6.6 people[20]. About 23% of households are headed by women.[21]

Kiribati's poverty rate is among the highest in the Pacific. Poverty tends to be concentrated in the southern Gilbert Islands and South Tarawa. In 2006, the poverty rate was estimated at 22% for the whole county and 24% for South Tarawa.[22] In 2019, it was estimated that 19.8% of the country's population were multidimensionally poor, while an additional 30.2% were classified as vulnerable to multidimensional poverty.[23] Unemployment is also high (31%), and even higher among women (58%). Gender inequalities are present in the public and private sectors, and within the home.[24]

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[19] Asian Development Bank (ADB). 2021. *Pacific Energy Update 2020*. Manila. https://www.adb.org/documents/pacific-energy-update-2020; Government of Kiribati, National Statistics Office. Kiribati 2020 Population and Housing Census: Provisional Results. https://kir20phc.prism.spc.int/.

[20] Government of Kiribati, National Statistics Office. Kiribati 2020 Population and Housing Census: Provisional Results. https://kir20phc.prism.spc.int/.

[21] Government of Kiribati, National Statistics Office. 2018. *Kiribati Gender Statistics Abstract 2017*. Bairiki, Tawara, Kiribati. https://pacificdata.org/data/dataset/oai-www-spc-int-a8dac04e-879e-442c-b1dc-314f583d4b7e.

[22] Government of Kiribati, National Statistics Office, and UNDP Pacific Centre. 2010. *Kiribati Analysis of the 2006 Household Income and Expenditure Survey*. Suva, Fiji. https://www.asia-pacific.undp.org/content/rbap/en/home/library/sustainable-development/Kiribati_2006_Household_Income_Expenditure_Survey.html.

[23] UNDP. Human Development Report 2020: The Next Frontier; Human Development and the Anthropocene; Briefing Note for Countries on the 2020 Human Development Report. http://hdr.undp.org/sites/default/files/Country-Profiles/KIR.pdf.

[24] Government of Kiribati. 2018. *Scaling Up Renewable Energy in Low Income Countries: Investment Plan for Kiribati*. South Tarawa. https://www.climateinvestmentfunds.org/sites/cif_enc/files/srep_investment_plan_for_kiribati_-_revised.pdf.

Gross Domestic Product

Kiribati's GDP has been fluctuating since 2010 between -1.6% and 5% (negative rates were recorded in 2006, 2008 and 2010; a one-off exceptionally high peak of 10.4% was achieved in 2015). GDP per capita in 2020 was $1,670.80, which was significantly lower than the average for the small Pacific island countries (PICs). Economic growth slowed to 0.6% in 2020 from 2.4% in 2019, largely due to pandemic-related restrictions. These restrictions continued into 2021, with GDP forecasted to contract by 0.2%. However, prospects for 2022 remain upbeat, with GDP expected to grow by 2.3%, as major infrastructure and locally financed construction projects resume.[25] Kiribati's GDP is highly dependent on the revenues from the Vessel Day Scheme, implemented in 2012 by the eight Parties to the Nauru Agreement, which limited fishing activities in the combined exclusive economic zones of member nations. Before the implementation of the Vessel Day Scheme, fishing license revenue was just $29.1 million (17% of GDP). By 2015, that revenue had risen to $207.1 million (91% of GDP). In subsequent years, revenues steadily dropped, reaching an estimated $135.1 million in 2018 (51% of GDP).[26] Kiribati's sustained fishing revenues and low reliance on international tourism have helped insulate the country from the economic impacts of the COVID-19 pandemic.[27]

Disaster resilience

Kiribati seriously needs to strengthen its disaster and climate resilience. The country's climate vulnerabilities exacerbate its demographic and socio-economic challenges. Kiribati's low elevation - averaging only 2 meters above sea level - makes it vulnerable to rising sea levels and increased incidence of extreme weather events such as drought and storms. Sea levels are expected to rise 5 centimeters (cm) to 15 cm by 2030, and then 20 cm to 60 cm by 2090. This increase will heighten the impact of storm surges and coastal flooding, which can cause land erosion, loss of biodiversity, physical damage to infrastructure, human displacement, and increased scarcity of food and water (footnote 24). According to the 2020 World Risk Index, Kiribati ranks 18th (out of 181 countries) in terms of risk of disaster due to extreme natural events. According to the latest Global Climate Risk Index (2021), Kiribati ranks 11th globally in losses per unit of GDP due to extreme weather events. In the period from 1998 to 2017, Kiribati faced an annual average economic loss of $10.53 million (purchasing power parity) per year. This economic loss was equivalent, on average and for the referred period, to 6.2% of the country's GDP, the second highest loss in the Pacific region.[28] According to the Intended Nationally Determined Contribution (INDC) estimates, the annual costs of climate change for Kiribati amounts to 35% of its GDP, and that was counting only the potential climate-change impacts on coastal zones ($7-$13 million) and water resources ($1-$3 million).[29] Because of Kiribati's large dependance on fossil fuels, the reliance of its power system is significantly jeopardized when fuel supply is disrupted. Energy efficiency and renewable energy sources are opportunities to increase the resilience of the country's energy sector, particularly for vulnerable customers (notably the poor and residents of outer islands) by facilitating the continuity of access to energy and accelerating disaster recovery.

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[25] ADB. Asia Regional Integration Center: Kiribati. https://aric.adb.org/kiribati.

[26] J. Webb. 2020. Kiribati Economic Survey: Oceans of Opportunity. *Asia & the Pacific Policy Studies*. 7 (1). pp. 5–26. https://onlinelibrary.wiley.com/doi/full/10.1002/app5.297.

[27] ADB. 2022. *Asian Development Bank Member Fact Sheet: Kiribati*. Manila. https://www.adb.org/publications/kiribati-fact-sheet.

[28] D. Eckstein, V. Künzel, and L. Schäfer. 2021. *Global Climate Risk Index 2021*. Bonn and Berlin: Germanwatch. https://germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021_2.pdf.

[29] Government of Kiribati. 2015. *Intended Nationally Determined Contribution*. South Tarawa, Kiribati. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Kiribati%20First/INDC_KIRIBATI.pdf.

4.1.2 Energy resources

Dependence on fuel imports

Kiribati's fossil fuel imports have remained relatively constant; for instance, it was 49% to 52% of the country's total primary energy supply during 2010-2016. In 2016, the power sector consumed 49% of the country' imported diesel. Fossil fuel use is estimated to cause more than 98% of the reported national greenhouse gas emissions.[30] Reliance on imported diesel for power generation translates into higher costs of electricity, and it is a burden on the government budget because of the subsidies granted to the sector. These subsidies are provided because electricity tariffs are set below cost-recovery levels to enable affordability. In 2015, the government spent $700,000 to cover the revenue gap in the Kiritimati Island electricity sector and in 2017, it spent $800,000 to cover losses in the South Tarawa electricity sector (footnote 26).

Indigenous energy resources

Kiribati has no indigenous sources of fossil fuels. The technical potential for renewable energy in Kiribati is high, but its development and deployment has been limited due to several barriers, including: an inadequate enabling environment, concerns about grid stability, the limited availability of land, limited financing and delivery options for renewable energy, the high cost of importing the technologies, and limited knowledge of distributed renewable energy technologies (footnote 24).

The untapped potential of renewable energy sources for South Tarawa is estimated to be about 554 megawatts-peak (MWp) for photovoltaic (PV) energy and 1.1 MWp for wind power.[31] There is potential for solar microgrids in North Tarawa outside of the area serviced by the Public Utilities Board (PUB). PUB currently serves 48% of the residents of Nabeina, Tabiteuea, Abatao, and Buota villages.[32] Two options have been considered for bringing electrification for extending electrification there: grid extensions and the installation of separate microgrids within each village.

To increase the sustainability of renewable energy sources, the Kiribati Integrated Energy Roadmap (KIER) aims to further develop the potential of coconut oil as an alternative fuel to diesel for both power generation and transport.[33] The government has historically been active in providing agricultural subsidies to support copra production. A major boost was given in mid-2016, when government subsidies doubled the price of a kilogram of copra from $1 to $2, which was high compared with the average regional price of $1.10. The subsidy aims to maintain copra production; boost GDP and exports; and create a cash transfer to the outer island economies, to encourage residents to remain there and slow down urban migration (footnote 22).

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[30] ADB. 2021. *Basic Statistics 2021*. Manila. https://www.adb.org/sites/default/files/publication/696656/basic-statistics-2021.pdf.

[31] Asian Development Bank (ADB). 2021. *Pacific Energy Update 2020*. Manila. https://www.adb.org/documents/pacific-energy-update-2020.

[32] Government of Kiribati, National Statistics Office. 2016. *2015 Population and Housing Census—Volume 1: Management Report and Basic Tables*. Bairiki, Tarawa. https://dataspace.princeton.edu/handle/88435/dsp01f7623g255.

[33] International Renewable Energy Agency (IRENA), the Pacific Community, and the Pacific Power Association (PPA). 2017. *Kiribati Integrated Energy Roadmap: 2017–2025*. N.p. https://irena.org/-/media/Files/IRENA/Agency/Publication/2017/Jul/Kiribati_Integrated_Energy_Roadmap_2017.pdf; Government of Kiribati, National Statistics Office. Kiribati 2020 Population and Housing Census: Provisional Results. https://kir20phc.prism.spc.int/.

4.2 Sector Overview

4.2.1 Sector performance

Problems

Kiribati's energy sector faces three major challenges:

- high vulnerability to fuel import prices,
- regulatory barriers to private sector participation, and
- high subsidies to avoid fuel poverty.

More specifically, the country's remote location results in high fuel costs. Renewable energy is the cheaper solution, but there are barriers hindering scale-ups of renewable energy generation, particularly in South Tarawa and Kiritimati, including: (i) the lack of energy storage capacity to manage intermittency, (ii) limited financing options apart from development partner resources, and (iii) a policy and regulatory environment that is not conducive to private sector investment.[34] In relation to the outer islands, a remaining challenge is the need for cost-effective electricity supply through solar home systems and solar PV microgrids.

The lack of energy-storage capacity causes concerns about grid stability and the low quality of the power supply. As of 2017, solar PV energy was producing 9% of the load and made up 22% of generation capacity on South Tarawa (footnote 25). However, South Tarawa has insufficient reserve-generation and energy-storage capacity for coping with increasing intermittent power generation. Kiritimati's situation is not that different, which has caused great concern about grid stability and the addition of more intermittent resources. PUB believes that the current installed renewable-energy capacity in South Tarawa and Kiritimati is the maximum quantity of intermittent resources the two communities can manage without jeopardizing grid stability. Further, South Tarawa's grid is not automated, and the quality of the power supply is not consistent. The low reliability of the grid will eventually damage the electrical equipment installed in households. This situation does not encourage consumers to purchase more costly appliances.

Energy access

Statistics from the Asian Development Bank (ADB) show that 100% of the population in Kiribati had access to electricity in 2019 (footnote 31). This was a considerable increase from 63% in 2010. However, the share of households with access to grid-connected electricity and the quality and use of the electricity were much lower. Only 38% of the population had access to the grid in 2018, which was a little higher than the regional average of 30% (footnote 13). In 2016, electricity made up only 3% of household energy consumption; with more than 95% coming from biomass in the form of coconut oil and palm oil residue (77%), fuel wood and wood waste (10%), and petroleum products in the form of kerosene (5%) and petroleum (5%) (footnote 24). The government subsidizes kerosene directly, through price controls, and indirectly, through value-added-tax (VAT) and excise-duty exemptions; and this has led to kerosene prices remaining constant since 2009, despite the volatility of world prices. One study estimates that the total subsidies for kerosene could be as high as A$0.60 a liter.[35] The average household in South Tarawa and Kiritimati Island uses both bioenergy and kerosene.

Information on the quality of off-grid energy access in the outer islands is scarce. Outer islands with larger populations are served by diesel microgrids that often incorporate PV generation.

[34] ADB. 2021. *Pacific Energy Update 2020*. Manila. https://www.adb.org/documents/pacific-energy-update-2020.
[35] Pacific Community. 2017. *Review of Fuel Subsidies in Kiribati*. Suva, Fiji. https://prdrse4all.spc.int/sites/default/files/review_of_fuel_subsidies_in_kiribati.pdf.

Less-populated islands are often dependent on individual diesel generators and/or solar home systems that usually provide only minimal service.

Electricity demand

The annual peak demand in South Tawara was close to 6.0 MW in 2019, and the energy demand was 24.7 gigawatt-hours (GWh). The energy demand was fulfilled by 9% of energy from solar PV systems and 91% of energy from diesel generation.[36] During 2010-2016, the demand increased in South Tarawa by 15%, while the customer base increased by 40%. This result was likely because newly connected customers consumed, on average, less electricity than existing customers. Estimates for South Tarawa demand by 2030 are 9.87 MW and 51.6 GWh in the business as usual (BAU) scenario, and 8.89 MW and 47.3 GWh in the energy efficiency scenario. Demand is also expected to increase for Kiritimati Island, though estimations are more uncertain due to migration. The estimated combined demand in the three zones of Kiritimati Island is 2.4 GWh per year. Demand scenarios for Kiritimati by 2030 range from 918 kilowatts (kW) and 5.7 GWh under the BAU scenario, and 2,493 kW and 12.2 GWh in the energy efficiency scenario (footnote 25).

Sector performance

In Kiribati, electricity generation, transmission, and supply activities are not unbundled. The Ministry of Infrastructure and Sustainable Energy is responsible for the planning, management, and coordination of the energy sector, including the supervision of supply. Consumers in the grid-connected areas of South Tarawa and Kiritimati are served by the state-owned PUB, which was established under the Public Utilities Ordinance of 1977 (amended in 2000), to provide and maintain quality, reliable electricity, water, and sewerage disposal services to Tarawa. PUB is supervised by a board of directors appointed by the Ministry of Infrastructure and Sustainable Energy (footnote 28).

South Tarawa has a high share of unbilled demand. The KIER reported that in 2014, total generation was 23,774 MWh, but only 18,587 MWh was billed by PUB. The discrepancy resulted from line losses (1,484 MWh); station and auxiliary-station losses (1,209 MWh); and nontechnical losses, consisting of unmetered demand (1,179 MWh) and unbilled demand (1,314 MWh). The unbilled portion of annual demand (nontechnical losses) has increased significantly since 2010. The missing revenues from unbilled and unmetered demand pose a threat to PUB's continued operations. Until May 2018, the power system on Kiritimati Island was operated by the Ministry of Line and Phoenix Islands Development; but since then, PUB has been responsible for the grid system there. In 2018 the Kiritimati grid system received a complete overhaul. The formerly separate systems in zones 1 and 2 were upgraded and interconnected. An isolated grid for zone 3 was constructed (footnote 26). In 2015 and 2017–2019, PUB reported financial losses despite a subsidy from the government equivalent to about 10% of total revenues. The main reasons for the losses in electricity revenues were the below-cost recovery tariff and the subsidies provided to the water operations. Fuel costs are the largest expense for PUB, although decreasing steadily from 63% of total expenditure in 2015 to 50% in 2019 (footnote 29).

Electricity generation

In 2019, 86% of total electricity generation was from diesel (31 GWh) and 14% from solar PV energy (5 GWh).[37] The combined nominal capacity of the two diesel-fueled power stations in South Tawara was 5,540 kW. However, these generators were installed during 2002-2005,

[36] ADB. 2020. *Pacific Renewable Energy Investment Facility: Republic of Kiribati; South Tarawa Renewable Energy Project*. Manila. https://www.adb.org/sites/default/files/project-documents/49450/49450-021-pfrr-en.pdf.
[37] IRENA. Energy Profile: Kiribati. https://www.irena.org/IRENADocuments/Statistical_Profiles/Oceania/Kiribati_Oceania_RE_SP.pdf.

and all the generators there have been derated, bringing the total diesel capacity down to 4,700 kW. This means that at peak demand times there is no spare generation capacity.[38] Total installed PV capacity was 1.56 MWp in 2019. ADB and the KIER identified grid-connected PV energy as the least-cost option for South Tarawa: costing $245/MWh, compared with $347/MWh for diesel (footnote 32). Since PUB is not able to consistently provide 24-hour electricity in South Tarawa, some consumers maintain their own diesel generators to ensure a continuous electricity supply (including a fish processing and freezing facility, among other businesses). Private PV generators are allowed to connect to the grid if given permission by PUB. The electricity generation capacity on Kiritimati Island in 2018, upon the completion of the Kiritimati Island Energy Sector Programme (funded by the European Union and the Government of New Zealand), consisted of 945 kW diesel generation capacity plus 150 kWp PV generation capacity in zone 1, 280 kW diesel generation capacity in zone 2, and 48 kW diesel plus 36.5 kWp PV generation capacity in zone 3 (footnote 27). Solar PV systems in the outer islands are mostly installed and serviced by the Kiribati Solar Energy Company, which was formed in 1984 by a nongovernment organization, and is now owned entirely by the government.[39] The total estimated installed PV capacity in the outer islands in 2015 was 1,229.8 kWp, excluding an unknown quantity of fully private PV installations.

Grid reliability

Kiribati intends to transition from an electricity-generation portfolio that relies mostly on diesel generation by scaling up its renewable energy. However, grid reliability is a serious concern, as the percentage of intermittent generation increases in line with government's goal to reduce its reliance on fossil fuels. The current level of solar PV in South Tarawa is around 9% of the annual load. This is thought to be the maximum system operators can currently manage without energy storage investments. With that challenge in mind, the investment in any grid-connected renewable energy technologies will need to be paired with batteries that allow for more reliable, stable generation. In addition, substantial repairs, large capital replacements in generation assets, and fuel shipments take a long time to procure due to Kiribati's remoteness, reliance on development partner funding, and lack of backup generation assets. As a result, the state-owned PUB conducts load shedding to cope when catastrophic events occur, such as generator failures (footnote 25).

Expected investments

In November 2018, the government published it's Scaling-Up Renewable Energy Program Investment Plan (SREP IP). The SREP IP maintains that $76 million will be needed to meet the 2025 KIER targets and the INDC targets. The SREP IP lays out a renewable energy investment plan over two phases, for which it is requesting support from the SREP IP and international donors. SREP IP Phase 1 consists of two projects involving investments totaling $15.4 million: the South Tarawa Renewable Energy Project and the Kiritimati Island Electricity Access Project, which together will help the government achieve 69% of its 2025 KIER target of reducing fossil fuel consumption by 23% in South Tarawa, 40% of its INDC greenhouse gas (GHG) reduction targets, and its target of expanding electricity access on Kiritimati Island (footnote 31). Further information from donors revealed that funding from ADB, among other partners, helped to realize the planned projects in South Tarawa, and that the European Development Fund and the New Zealand government also helped to achieve the Kiritimati government's goals (footnotes 31 and 36).

[38] International Renewable Energy Agency (IRENA), the Pacific Community, and the Pacific Power Association (PPA). 2017. *Kiribati Integrated Energy Roadmap: 2017–2025*. N.p. https://irena.org/-/media/Files/IRENA/Agency/Publication/2017/Jul/Kiribati_Integrated_Energy_Roadmap_2017.pdf.

[39] Common Wealth Governance: Kiribati; Utilities of Kiribati. https://www.commonwealthgovernance.org/countries/pacific/kiribati/utilities/.

4.2.2 Policy framework

Kiribati Integrated Energy Roadmap

*T*he KIER, which was published in July 2017, includes a policy framework with specific targets for reducing fossil fuel use, switching to renewable energy sources, and achieving greater energy efficiency - to be achieved by 2025. It also contains a prioritized action plan that provides cost estimates and timelines. The plan aims at supporting the government's efforts to improve energy independence and sustainable. The KIER identifies solar power as the least-cost option for scaling up renewable power generation and improving fuel security. South Tarawa has 1.57 MWp of grid-connected solar energy plants, but there remains a significant untapped potential for boosting the use of renewable energy for power generation - about 554 MWp of solar and 1.1 MWp of wind potential (footnote 32). As in most small island states, increases in the use of renewable energy would lower fuel imports, and therefore improve the trade balance, create jobs in both urban and rural communities, and improve energy affordability for households and businesses.

Upcoming Energy Act

A draft Energy Act was developed during 2020-2021, but it has not yet been adopted. One of the main aims of the Act is to broaden the options for increasing the use of renewable energy (footnote 13). It also provides proper regulations to support the participation of independent power producers (IPPs), sets well-defined rules for tariff setting and approval, and aims to boost the use of a battery energy storage system (BESS) to manage power-supply intermittency. These measures would promote the KIER objectives. The development of clear technical guidelines by PUB for the grid connection of rooftop solar PV systems is also needed to ensure that renewable energy will account for a larger share of the South Tarawa and Kiritimati electric systems. With respect to the outer islands, the new Energy Act is expected to provide a regulatory framework to incentivize the development of solutions, including options for fiscal support for poverty alleviation. In line with other recently developed energy regulations in the region, the new Energy Act could be expected to include minimum performance standards and energy labelling requirements.

Nationally Determined Contribution

In its first INDC report, submitted in 2015, Kiribati committed to a reduction in GHG emissions of 12.8% by 2030, compared with the BAU projection (extrapolating data from 2000-2014). With additional assistance, Kiribati committed to a further 49%, bringing the total potential GHG reductions to 61.8% by 2030.

Targets

Kiribati has not set any specific targets for electricity access, other than to maintain current access levels. With regard to renewable energy targets, Kiribati wants to become an energy-independent nation, and sees renewable energy as the main contributor to that goal. The country hopes to replace imported oil with energy from local renewable sources, a change that should reduce the vulnerability to oil price volatility and lower energy costs, thus increasing affordability. The KIER sets targets for 2025, including raising the share of electricity generation from renewables to 23% in South Tarawa, 40% in Kiritimati, and 40% in the outer islands (and to 100% in public and private institutions in the outer islands).

The KIER also includes targets for improving energy efficiency by 2025, including a 22% improvement for South Tawara and 20% for Kiritimati and the outer islands. The approach includes supply side measures (e.g., replacing diesel generators, reducing technical and nontechnical losses), demand side measures, and the reduction of fossil fuels (e.g., using

higher efficiency transport, resorting to alternative fuels). The KIER sees energy-efficiency demand-side management in the residential, commercial, and government sectors as one of the priority activities the government must engage in to reach its energy targets. Demand-side management under the KIER includes such measures as replacing inefficient lighting with efficient choices such as compact fluorescent lamps (CFLs) and LED bulbs; reducing cooling loads in government and commercial buildings; and implementing the Pacific Community's Pacific Appliance Labelling and Standards Programme (PALS), which means mandating the use of more efficient electric appliances (e.g., lighting, freezers, refrigerators, and air conditioners) that satisfy minimum energy performance standards and energy rating labels.

4.2.3 Tariffs

There are no formal regulatory frameworks for setting electricity tariffs in South Tarawa and Kiritimati. Tariffs are proposed by PUB and approved by the cabinet (footnote 26). The benchmark study of power tariffs in the region conducted by the Pacific Power Association (PPA) in 2019, shows that the consumer costs of power supplies in Kiribati were considerably below the regional average.[40] The tariff for households in 2018-2019 was $0.25 per kilowatt-hour (kWh), compared with the regional average of $0.36 per kWh and the mean of $0.31 per kWh; for commercial consumers, $0.39 per kWh (compared with the regional average of $0.41 per kWh and the mean of $0.40 per kWh); for industrial consumers, $0.49 per kWh (compared with the regional average and mean of $0.41 per kWh); and for government, $0.39 per kWh (compared with the regional average of $0.48 per kWh and the mean of $0.40 per kWh) (footnote 27). A proposal for reforming the tariffs is part of the project to support the drafting of the Energy Act. This is assumed to include a procedure for approving tariff proposals, as well as guidance on the formulation of a tariff structure that would offer full cost recovery for energy suppliers.

4.2.4 Relevant support programs

POIDIER project

The "Promoting Outer Island Development through the Integrated Energy Roadmap" (POIDIER) project, funded by the Global Environment Fund (GEF), was officially launched on 28 January 2021. The project aims to promote outer island development through the achievement of the government's renewable-energy and energy-efficiency targets.

POIDIER is organized in four components: (i) capacity building; (ii) strengthening of the institutional framework and planning; (iii) a financial support mechanism through grants to households purchasing solar products and energy efficient appliances; and (iv) the development of mini-grids in the outer islands. For phase 1 of the project, $3 million has been allocated by UNDP for interventions in nine outer islands in the Gilbert group (Abaiang, Butaritari, Makin, Marakei, Tabiteuea North, Arorae, Tamana, Nikunau, Nonouti) and two outer islands in the Line group (Tabuaeran and Teraina).

The first actions of the project are aimed at improving capacity building at the institutional level, and training and awareness for the general public. Capacity building and public awareness are being developed on the islands through a series of visits and community awareness events and trainings. The aim of community awareness is to enable people in each village to categorize their own energy needs. Training offered to people in the outer islands includes basic operations and maintenance (O&M) of mini-grids and solar products. Usually two people, one male and one female, are trained on each island.

[40] PPA. 2019. *Pacific Power Utilities Benchmarking Report: 2019 Fiscal Year*. Suva, Fiji. https://www.ppa.org.fj/wp-content/uploads/2020/12/2019-FY-Benchmarking-Report.pdf.

For 2022, the POIDIER project aims to install 15 hybrid solar PV-diesel mini-grids, 50 kW to 200 kW in size, and to offer grants to residents in the outer islands to cover part of the cost of solar products and energy-efficient appliances.

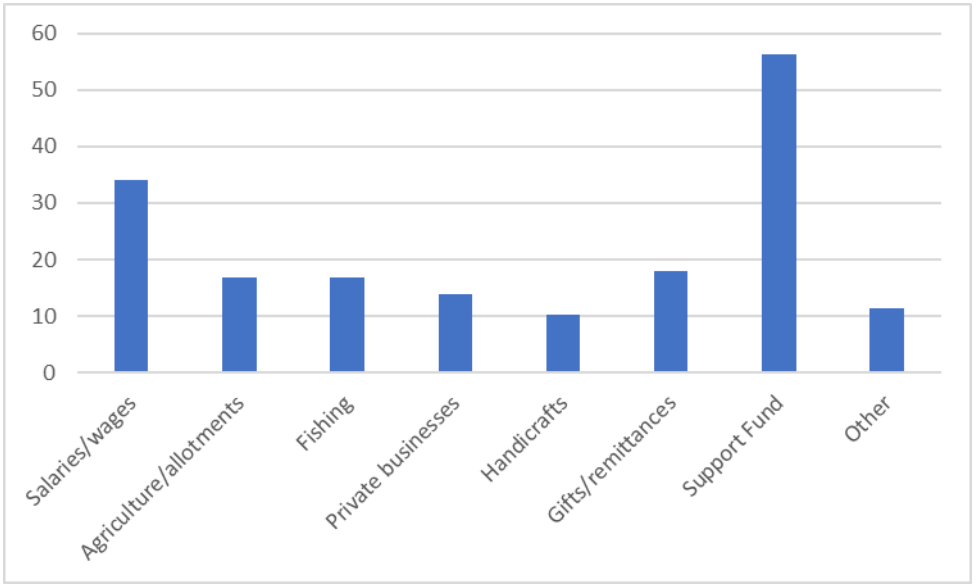
4.3 Estimation of Demand

4.3.1 Income and expenditure

Urban grid-connected households

According to the survey carried out in Kiribati, monthly household incomes in South Tarawa ranged considerably from $36 to $792, with an average income of $319, which is 27% higher than the median income of $252. The median income is in the exact middle of all incomes earned or, in other words, the most typical income earned by a household. The average income is the mathematical mean of all incomes reported in the survey. The existence of a considerable number of high or low incomes causes the average to be higher or lower than the median income, indicating inequalities. The distribution of monthly household income in Kiribati found in the survey is shown in Figure A2.2. The considerable number of monthly incomes in the top range (i.e., higher than $900) causes the average income to be higher than the median (typical) household income of $252.

Figure A2.2: Sources of Income for Grid-Connected Households in Kiribati (%)



Note: Each bar in this graph indicates the percentage of grid-connected households that claimed the associated category as one of their sources of income or as their only income.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

Employment is the main source of income for urban households. However, the survey revealed a very low employment rate of 28%.

There are around 7,000 public sector employees (including those working at publicly owned enterprises) and 3,000 private sector employees registered with the Kiribati Provident Fund. They work mainly in the urban center of South Tarawa, but some are on Kiritimati Island. The Kiribati Provident Fund is a savings scheme for workers in the formal sector. The combined contributions from the employer and the employee add up to 15% of the employee's salary, and the savings accumulate at a guaranteed minimum of 4% per year. Around 1,200 school leavers enter the workforce each year, but vocational training is limited and literacy outcomes

are poor compared with those in other Pacific nations, so many are not considered to be employable in the formal economy.

Work on ships has been an important source of employment in the past, mainly for men. However, there has been increased competition from countries with lower wage expectations. There are an estimated 4,000 trained i-Kiribati seamen, but possibly only a quarter of them are employed at any one time.[41]

About 34% of surveyed households identified wages and salaries as one of their sources of income. About 56% of surveyed households stated that they relied on the government's Support Fund to sustain their family needs. The Support Fund is a government allowance for unemployed adults to help them buy food and other much-needed goods and services. Monetary gifts from family and friends living abroad were also noted as a source of income by 18% of surveyed households.

The other sources of income were diverse. About 17% of households made some income by selling their catch of the day. The same proportion of households generated income from agricultural activities, 14% from private businesses, and 10% from handicraft production (**Error! Reference source not found.**).

Informal cash-based employment includes harvesting coconuts for the making of copra, small-scale manufacturing and service businesses, and fishing from small boats. Substantial government fees for small businesses are an impediment to informal economic activity, but in South Tarawa stall fees for some informal traders have been waived in recognition of their need for their small incomes.

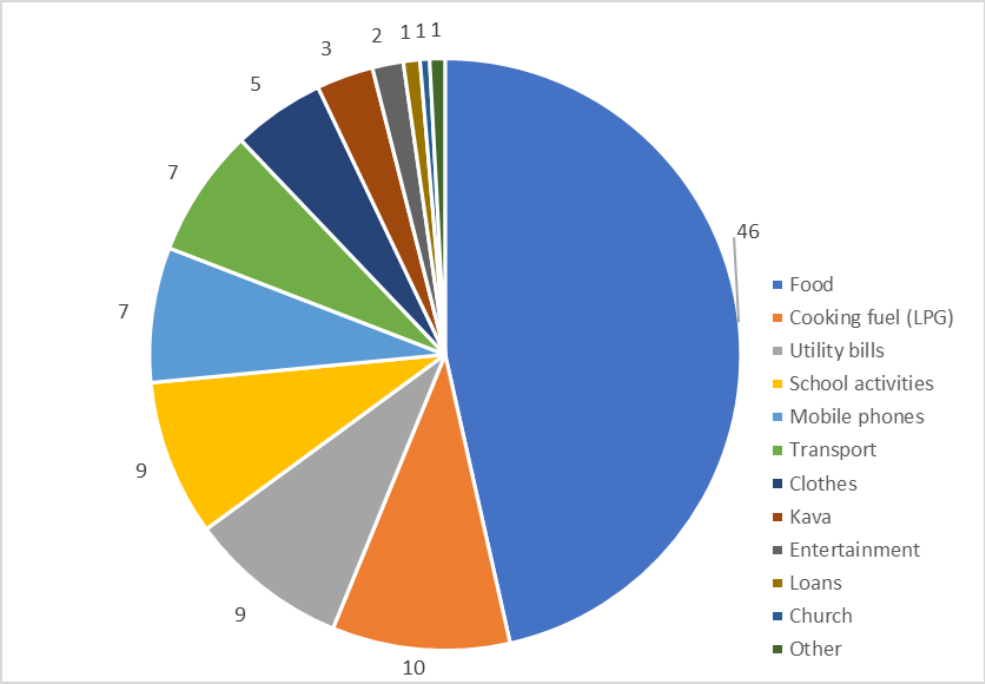
Women's unemployment was higher than men's (47% compared with 36%), and even worse for young women (73%) in comparison with young men (62%) (footnote 33). There has been significant migration into South Tarawa, particularly of adults seeking jobs and older children seeking education, with elderly people left in the outer islands to look after their young grandchildren.

The estimated average monthly expenditure, calculated from the data collected in urban South Tarawa, was $189; and the estimated median income was $167. The lack of knowledge on the part of many respondents regarding their household spending on several basic items led the authors to conclude that the estimated average and median expenditure values were substantially underestimated. Another conclusion was that the low average and median income levels make it practically impossible for the majority of Kiribati's urban population to accumulate any relevant savings. A lack of savings will affect a household's ability and willingness to pay (WTP) for energy-efficient appliances.

The overall expenditure on food represented 46% of total monthly spending, followed by cooking fuel at 10%; utility bills and school activities, each at 9%; and mobile-phone and transport costs, each at 7% (Figure **A2.3**A2.3).

[41] S. Kidd and U. MacKenzie. 2012. *Kiribati Country Case Study.* Canberra: Government of Australia, AusAID. https://www.researchgate.net/publication/271326814_Kiribati_country_case_study_AusAID_Pacific.

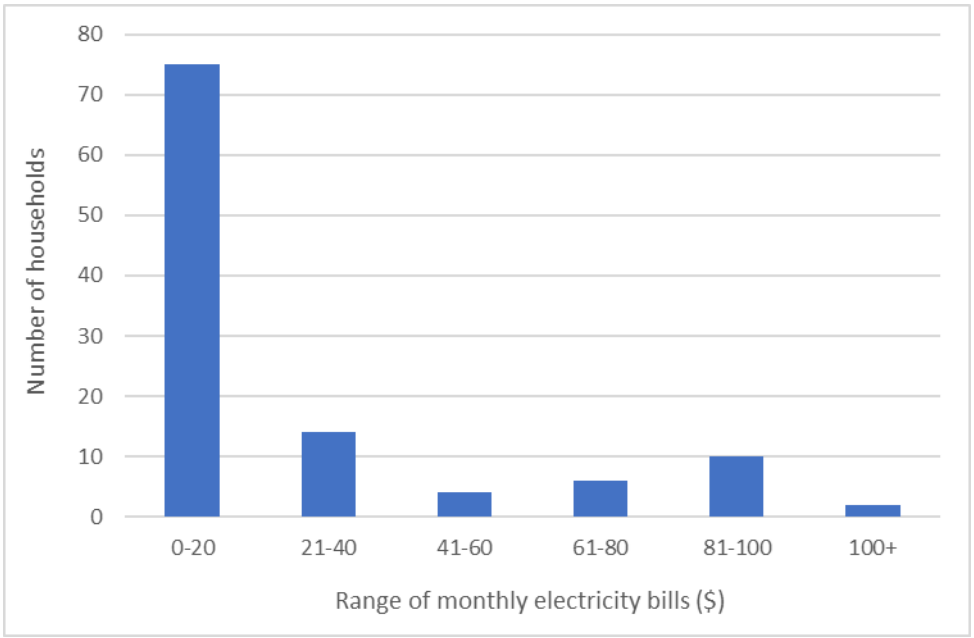
Figure A2.3: Monthly Expenditures of Grid-Connected Households in Kiribati (%)



LPG = liquefied petroleum gas.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

The minimum value recorded for a monthly electricity bill was $4 and the maximum was $144. The median electricity bill was $15 (Figure A2.4).

Figure A2.4: Monthly Electricity Bills of Grid-Connected Households in Kiribati

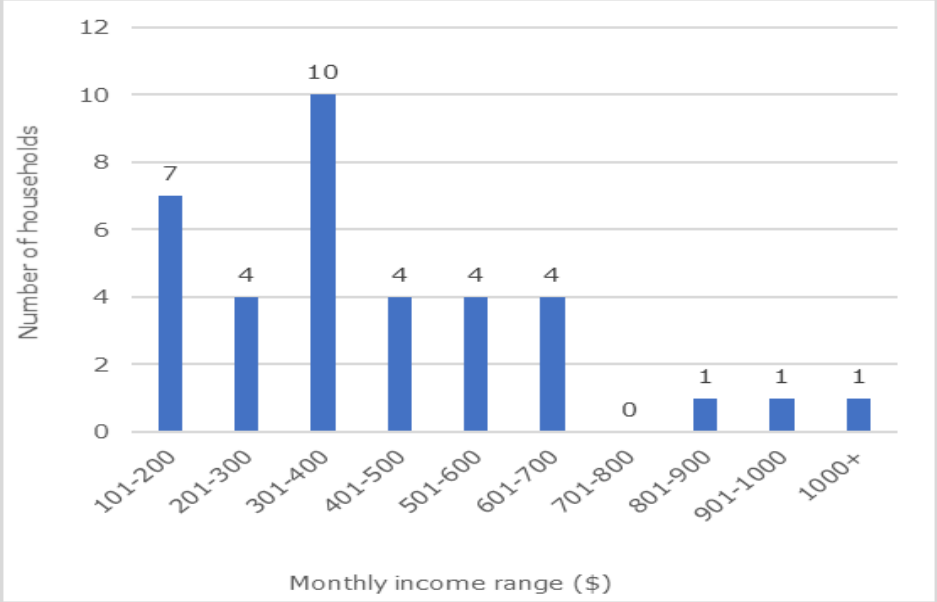


Source: Survey by the Pacific Clean Energy Financial Potential project team.

Rural off-grid households

The survey found that monthly household incomes in rural North Tarawa ranged from $144 to $1,296. The average monthly income was $420, which was 11% higher than the median income of $378 (Figure A2.). The median income is the most typical income earned by households. In this case, the higher average income, compared with the median income, indicated some level of inequality, though not the high level the survey found in urban areas.

Figure A2.5: Distribution of Monthly Incomes in Off-Grid Households in Kiribati



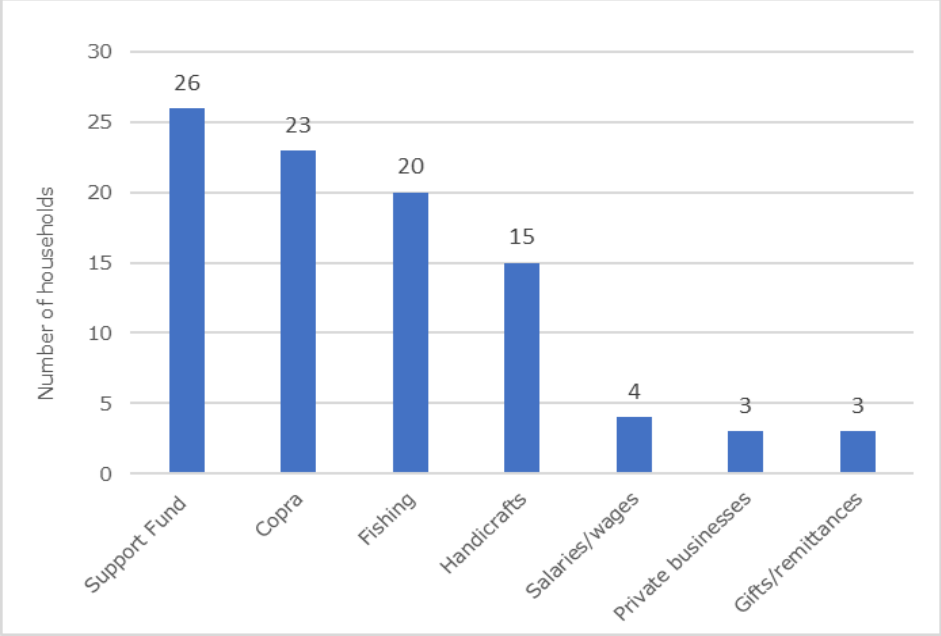
Source: Survey conducted by the Pacific Clean Energy Financial Potential project team.

Households in rural and remote locations have irregular incomes due to the limited economic activities there, so they are mostly dependent on handicraft production and on agricultural and fishing activities. The monthly incomes in the survey sample came from a variety of sources (Figure A2.66). Copra production was a major source of income in remote and rural villages. North Tarawa produced 330 tons of copra in 2017.[42] About 64% of household surveyed earned cash from copra processing and production. Fishing for subsistence and commercial sales is also a very common occupation in the remote islands and rural locations in Kiribati. Approximately 56% of respondents stated that they earned an income from fishing. The fourth main income source was handicraft production, and it was cited by 42% of the households surveyed.

The estimated average monthly expenditure for off-grid rural households, calculated from the data collected in the survey, was $54; and the estimated median expenditure was $37. The lack of knowledge on the part of many respondents regarding household spending on several basic items led the authors to conclude that the estimated average and median expenditure values were substantially underestimated. Another conclusion was that the low average and median income levels make it practically impossible for the majority of Kiribati's rural population to accumulate relevant savings; or, at best, they might be able to manage some modest savings.

[42] Government of Kiribati, National Statistics Office. Production. https://nso.gov.ki/statistics/economy/copra-production/.

Figure A2.6: Sources of Income for Off-Grid Households in Kiribati



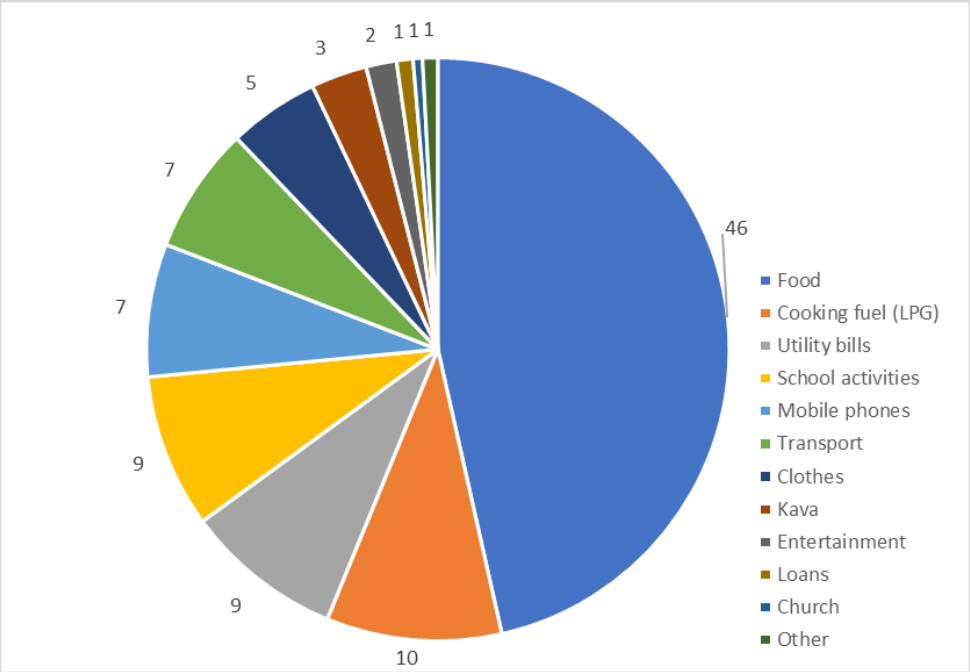
Note: Each bar in this graph indicates the number of off-grid households that claimed the associated category as one of their sources of income or as their only income.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

The combined expenditure on food and cooking fuel accounted for 35% of total expenses. Expenditure on energy-related items other than cooking fuel accounted for 19%. Food plus energy amounted to 54% of overall household monthly expenses. Expenditure on kava in this sample was high, averaging 22% of total monthly expenses (Figure A2.7).

The concept of poverty is not well accepted in Kiribati. There is a strong tradition of mutual obligation (*bubuti*) within family groups and among neighbors: If anyone is in need, they ask for help, and it is given.[43] Nevertheless, social inequities are becoming more evident in the urban centers. In 2006, the richest 10% of households were 10 times better off than the poorest. It has previously been assessed that around 57% of the population should be considered poor by international standards, but the reality is that families drift in and out of poverty from time to time (footnote 42). Households with children are most likely to be poor, with the poorest households living in the outer Gilbert Islands, where 29% of children are living in households headed by elderly people.[44]

[43] J. Gheuens. 2017. "Landscape and Identity in Kiribati" (master's thesis, University of Uppsala). http://www.diva-portal.org/smash/get/diva2:1112545/FULLTEXT01.pdf.
[44] Government of Kiribati. 2019. *National Policy on Gender Equality and Women's Development: 2019-2022*. South Tarawa. https://pacificwomen.org/wp-content/uploads/2019/07/Kiribati-GEWD-Policy.pdf.

Figure A2.7: Monthly Expenditures of Off-Grid Households in Kiribati (%)



LPG = liquefied petroleum gas.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

4.3.2 Appliance and equipment inventory

Urban grid-connected households

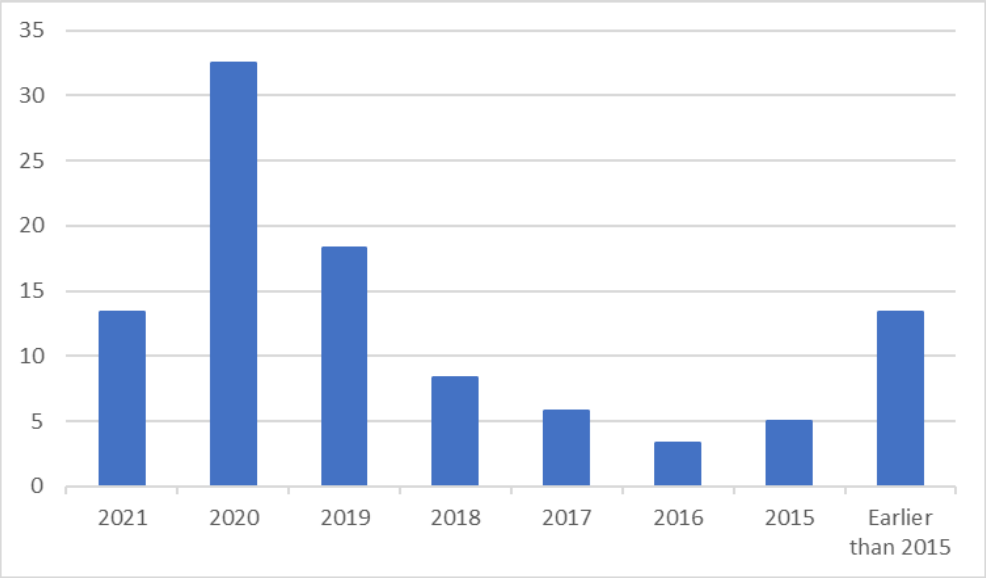
In 2015, 52% of households used solar power for lighting and 37% used mostly electricity from the grid. Other households used kerosene, generators, or batteries. Very few families used electricity for cooking - just 0.4% of households in 2015. Most households used firewood (44%) or kerosene (40%). In South Tarawa, most households used wood (50%) or kerosene (35%) for boiling water; women are primarily responsible for this task.[45] In 2015, 1,772 households owned a generator and 10,302 households owned at least one piece of solar equipment (footnote 33). Purchases of solar-powered equipment is being promoted by the state-owned Kiribati Green Energy Solutions (KGES) Company and the Development Bank of Kiribati (DBK). The national target is to raise the uptake of renewable energy to between 23% and 40% by 2025.

Solar streetlights are available from 10 W to 100 W in different capacities. Streetlight installations only cover a small portion of South Tarawa and Kiritimati, leaving many roads and residential areas without public lighting. The uptake of solar street lighting has been limited: In 2018, there were only 147 solar streetlights (using a 80 Wp solar panel with sealed underground battery) on South Tarawa and 60 solar streetlights on Kiritimati (footnote 24). Solar street lighting uses a solar PV module to accumulate power in a digitally controlled battery. The power is discharged at night to power-efficient LED light sources. Such systems can also be used as public charging stations for small electronic devices. Solar streetlights can support the government's load shifting strategy by replacing existing grid-connected sodium lamps.

[45] Asian Development Bank. 2021. *Climate Change, Water Security, and Women: A Study on Boiling Water in South Tarawa, Kiribati*. Manila. https://www.adb.org/sites/default/files/publication/722186/climate-change-water-security-women-kiribati.pdf.

The results of the survey carried out in Kiribati were aligned with the results of other recent surveys.[46] For South Tarawa, based on the survey data, it was estimated that 72% to 84% of households owned a freezer and/or a refrigerator to preserve their food. With regards to comfort, 78%-87% of households owned fans, at least 7% of households had air conditioning equipment, and 48% had a washing machine. With regards to entertainment, 62% of households had a television (TV) and 70% owned radios. The survey also revealed that up to 64% of households bought a major appliance during 2019–2021 (Figure A2.8), with a freezer being the most common appliance, followed by TVs, fridges, and washing machines.

Figure A2.8: History of Major Appliance Purchases in Grid-Connected Households in Kiribati (%)



Source: Survey by the Pacific Clean Energy Financial Potential project team.

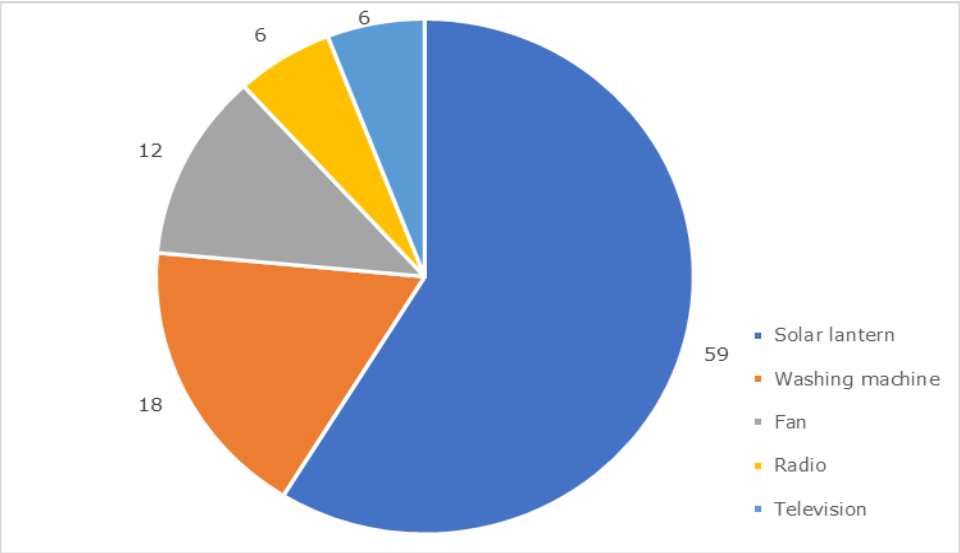
Regarding lighting, most households on South Tarawa (71%) and Kiritimati (85%) have access to electric lighting, but that lighting is often poor, inefficient, and expensive (footnote 47). Long fluorescent tubes are the most commonly used lighting equipment (40% of all lighting units in use), while LED lighting accounts for 28% and compact fluorescent lights (CFLs) account for 21%. The common use of long fluorescent tubes instead of the more energy-efficient LED lighting may be prompted by the cost, product availability, and the perception that LFLs provide better lighting.

Rural off-grid households

With regards to the off-grid population, the survey revealed that while most households own at least one solar lighting device, lighting remains an essential service that still needs to be fully and adequately provided to rural communities (Figure A2.). Families use lighting mainly for reading, studying, cooking, and socializing. The duration of use varied among households, from a minimum of three hours to overnight. The survey also revealed that up to 83% of the rural households own at least one mobile phone, usually charged by solar chargers.

[46] T.L. Jensen. 2017. *Kiribati 2016 Urban Household Electrical Appliances, Lights, and End-Use Survey: Process and Findings*. Suva, Fiji: UNDP Pacific Office – Fiji Office. https://prdrse4all.spc.int/sites/default/files/kiribati_2016_urban_household_energy_survey_report_-_final_080317.pdf.

Figure A2.9: Ranking of Importance of Solar Products in Off-Grid Households in Kiribati (%)

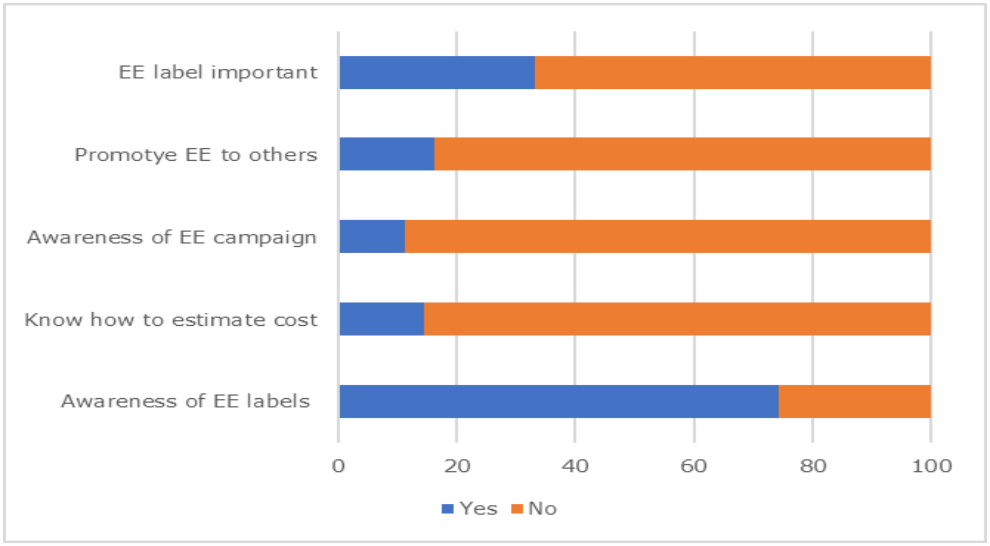


Source: Survey by the Pacific Clean Energy Financial Potential project team.

4.3.3 Awareness of energy efficiency

The awareness of energy-efficiency labelling is very low in Kiribati (Figure A2.10). The survey revealed that only 14% of grid-connected households knew how to read labels and estimate energy consumption and costs. Awareness of the promotion of energy-efficient appliances was also very low, with only 11% of households aware of such appliances. The lack of formal energy standards does not help the situation, and there is only limited control over the quality of imported renewable-energy technologies and appliances. Imported appliances and equipment do not have to meet energy-label or similar standards. As a result, the market offers a mix of efficient and cheaper inefficient appliances. KGES does not enforce energy labelling in its purchases either, though the company does expect its vendors to provide good-quality equipment in general, and that includes equipment with better energy efficiency.

Figure A2.10: Awareness of Energy Efficiency and Labels in Grid-Connected Households in Kiribati (%)



EE = energy efficiency. Source: Pacific Clean Energy Financial Potential Study Survey.

4.3.4 Costs of ownership

The costs of solar products listed by the KGES are shown in Table A2..

Table A2.12: Costs of Solar Products Listed by the Kiribati Green Energy Solutions Company, September–December 2021

Solar Product	Cost ($)
Prewired solar set (500 W, 12 V)	1,835
Prewired solar set (800 W, 12 V)	2,015
Prewired solar set (800 W, 24 V)	2,935
Off-grid solar power system (5.58 kWp)	29,255
Solar lighting kit	126
Solar freezer set (340 liter)	2,585
Solar washing machine (300 liter)	3,310
Solar water pump (17 liter per minute)	135
Solar Water Pump (32 liter per minute)	280
Hybrid air conditioner	1,750

kWp = kilowatts peak, V = volts, W = watts.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

4.3.5 Willingness to pay

Urban grid-connected households

About 73% of the surveyed grid-connected households stated that they were willing to pay a higher price for energy-efficient appliances. Roughly 19% of the respondents stated that they would be willing to pay up to 5% more, 36% of households indicated their willingness to pay up to 10% more, while 20% were willing to pay up to 20% extra. The survey also revealed that 41% of households would consider taking out a loan to purchase energy-efficient appliances.

The survey found a correlation between household income among employed people and WTP, but the correlation was not a clear-cut as expected. Many of the respondents (41%) stated that they were willing to pay higher prices and were willing to take out a loan or use a hire purchase facility to buy energy-efficient appliances at prices that were 5%–80% higher. However, the average monthly income ($349) of this group was the second-highest of the survey sample. The second group of respondents (26%) reacted positively when asked if they would pay more for energy-efficient appliances, but they were not so sure about taking out a loan; their average monthly income was $376, and they were willing to pay up to 80% extra. The third group (7%) stated that they were willing to pay extra for efficient-energy appliances, but they would not be willing to take out a loan or use a hire purchase facility; their average monthly income was $324. Of the remainder, 15% of the respondents were not willing to pay more or take out a loan to buy energy-efficient appliances, and 1s% were not willing to pay more, and were unsure about taking out a loan (Table A2.12).

In a result that seemed to undermine the correlation between household income and WTP, about 64% of the unemployed respondents in South Tarawa said that they were willing to pay higher prices for more for energy-efficient appliances. The survey concluded that this result reflected the strong desire on the part of this group to enjoy the associated benefits of energy-efficient appliances.

Table A2.12: Comparison of Income, Willingness to Pay More, and Willingness to Borrow to Buy Energy-Efficient Appliances in Urban Kiribati

Willingness to Pay More/Borrow	Percentage of Respondents[a]	Average Monthly Income ($)	Extent of Acceptable Extra Cost (%)
No/No	15	257	
Yes/No	7	324	5-50
Yes/Unsure	26	376	5-80
No/Unsure	12	169	10
No/Yes	0		
Yes/Yes	41	349	5-80

Note: A blank cell indicates that the column head does not apply.
[a] Percentages may not total 100% due to rounding.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

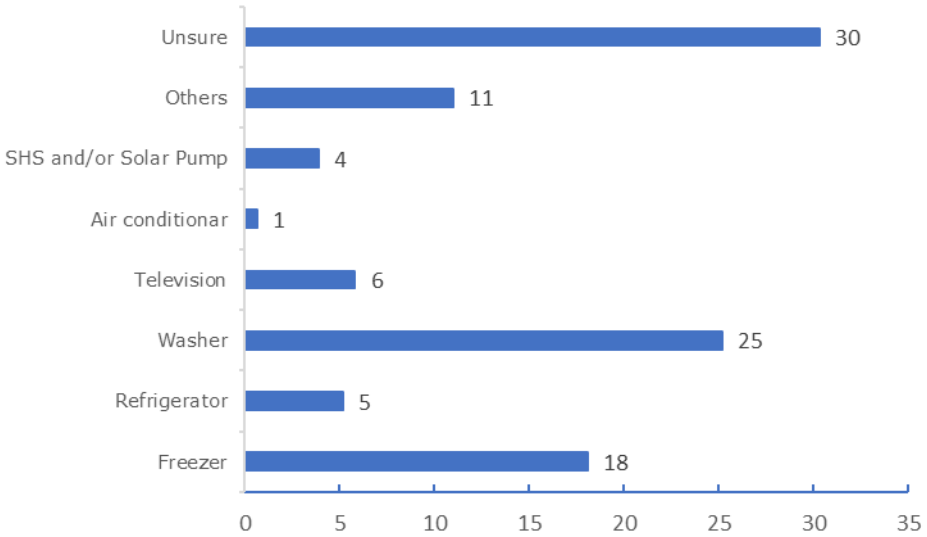
Rural off-grid households

In the rural population segment, the POIDIER project awareness-raising consultations revealed that people in the rural areas were interested in solar home systems of 500 W, 800 W and 1,000 W, and in adequate lighting. Regarding appliances, they preferred solar freezers and solar water pumps. Energy-efficient alternating current (AC) refrigerators were the most preferred appliance in areas where mini-grid services were or would soon be offered. The survey confirmed these preferences and revealed that most rural off-grid households were willing to pay more for access to sufficient electricity for better lighting, followed by radio use, phone charging, and refrigeration for food preservation.

4.3.6 Demand forecast

The survey of grid-connected households in South Tarawa revealed that freezers, refrigerators, washing machines, and TVs were their most preferred next purchases (Figure A2.11).

Figure A2.11: Preferences for Next Appliance Purchases in Grid-Connected Households in Kiribati (%)



SHS = solar home system, TV = television.
Source: Survey by Pacific Clean Energy Financial Potential project team.

4.4 Market Overview

4.4.1 Suppliers

There are private retailers in South Tarawa selling household appliances. A few of them also sell small solar home systems (SHSs) and solar products from Australia, Fiji, Malaysia, New Zealand, and the People's Republic of China (PRC). Some of these retailers also provide installation, repair, and training services; and they sometimes sell their products to outer islands on demand (Table A2.13 and Table A2.14).

The largest vendor serving the outer islands is KGES, which generally sells solar appliances and direct current (DC) solar equipment, mostly from Australia, Germany, and the PRC. The appliances most frequently purchased by outer island customers are solar lighting units, solar freezers for fishermen, and solar water pumps. KGES does not charge extra fees for transportation, and usually delivers products within one week. It has a storage warehouse in Tarawa and on Kiritimati Island. As for the outer islands, KGES currently has offices on Abaiang and Maiana islands, and plans to expand to all the inhabited outer islands by 2024.

Table A2.13: Suppliers and Distributors of Renewable-Energy Products in Kiribati

Supplier	Products	Services/ Customers	Charges/Fees	Countries of Origin
Kiribati Green Energy Solutions Company	SHSs (pre-wired), solar kits, mini-grids (5 kW and 10 kW), solar pumps, solar panels, solar streetlights, solar air conditioners, batteries, solar charge controllers, inverters, solar freezers, fans, LED lights, wind turbines	Sales, installations, repairs and maintenance, customers training Households, businesses, and communities	$50–$108 (A$70–A$150) for SHS, and $7/watt (A$10/watt) for a mini-grid system	Australia, PRC
Taotin Trading Company	Stand-alone systems customizations, solar panels, controllers, batteries, switches, solar kits, streetlights, freezers, DC breakers, arresters, DC cables, solar pumps, TVs, hi-fi, DC outboard motors	Sales, installations, repairs and maintenance, customers training Households, businesses, and communities	10% of the system cost	Australia, Malaysia, PRC
Slim Price Trading	SHSs, solar panels, batteries, controllers, solar lights	Sales, and warranty and customers training, but no installations,	No fees or charges	New Zealand, PRC
Sunrise Enterprises	Batteries, controllers, rechargeable solar lights, TV screens, home theaters	Sales, installations, repairs and maintenance, but no warranties	Installation charges (depending on cost)	Australia, PRC
JMR Group	Solar lighting, solar panels, batteries, controllers	Sales, installations, repairs and maintenance, 6-month warranties	Installation fee (depending on cost)	Australia, PRC
Darling Enterprises	Solar lighting, solar panels, controllers	Sales, installations, repairs and	installation charges	Australia

		maintenance, 6-month warranties	(depending on system cost)	
Betty Trading	SHSs, solar panels, solar lighting, solar freezers, batteries, TV screens, solar pumps, solar water heaters	Sales, installations, repairs and maintenance, 12-month warranties	Installation charges (depending on cost)	Australia, Fiji, New Zealand, PRC

A$ = Australian dollars, DC = direct current, kW = kilowatt, LED = light-emitting diode , SHS = solar home system, PRC = People's Republic of China, TV = television.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

Table A2.14: Suppliers and Distributors of Electrical Appliances and Equipment in Kiribati

Supplier	Products	Customers	Countries of Origin
Angiriin Hardware	Refrigerators, freezers, washing machines, air conditioners, LED lighting, rice cookers, microwave ovens, etc.	Households, businesses, communities, NGOs	…
Slim Price Trading	Refrigerators, freezers, washing machines, LED lighting, TV screens, water pump	Households, businesses, communities, NGOs	Australia, PRC
Sunrise Enterprises	LED lighting, washing machines, TV screens, water pumps	Households, businesses, communities, NGOs	PRC
JMR Group	Refrigerators, freezers, washing machines, air conditioners, LED lighting, TV screens, fans, cooking appliances	Households, businesses, communities, NGOs	PRC
Darling Enterprises	Refrigerators, freezers, air conditioners, cooking appliances, electric tools	Households, businesses, communities, NGOs	Australia
Betty Trading	Refrigerators, freezers, washing machines, air conditioners, LED lighting, TV screens, electric tools, fans, water pumps	Households, businesses, communities, NGOs	Australia, PRC
FairPrice	Refrigerators, freezers, washing machines, LED lighting	Households, businesses, communities, NGOs	PRC

… = no data available, LED = light-emitting diode, NGO = nongovernment organization, PRC = People's Republic of China, TV = television.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

4.4.2 Lending agencies

The Development Bank of Kiribati

The Development Bank of Kiribati (DBK) offers different kinds of loans for purchasing solar products and electrical appliances. One of them is a targeted energy-efficiency loan that is mainly addressed to the outer islands. There are also generic loans that could be used to buy appliances, including home loans, social development loans, and business loans. Households may borrow up to $2,100 (A$3,000), and communities up to $7,000 (A$10,000). Thresholds may be raised to promote more loans (they are being revised). Various solar products and appliances are offered through the energy-efficiency loan, including solar lighting kits, solar refrigerators, and solar water pumps. The list of financeable products and their prices is defined by the KGES company. The bank pays the vendor, and the product is delivered to the customer. KGES monitors energy bills to collect data on energy efficiency.

Loan repayments can be made in cash at DBK agencies, of which there are 19 in the outer islands. Banaba is the only important inhabited island without a DBK agency or branch. The

main responsibilities of DBK agents in the outer islands are to support the loan application process and pass the applications to the head office for further processing and decision-making. The agents also collect the cash payments and communicate with past-due borrowers.

Customers in outer islands have not yet shown any interest in energy-efficiency loans. Most of the loan products are too expensive for them, given their incomes.

Other lending institutions

Other lending institutions include the Kiribati Provident Fund; the commercial Australia and New Zealand Banking Group (ANZ Bank); the Ministry of Women, Youth and Social Affairs and the Ministry of Commerce and Cooperative, which offer loans jointly; and the Kiribati Chamber of Commerce and Industry. The Provident Fund lends to its members to improve their living standards, help them start new businesses, and enable them to refinance other loans. Small SHSs, solar products, and electrical appliances are considered in these loans. The ANZ Bank provides personal and businesses loans. In addition, the state-owned Kiribati Housing Association's core business is the provision of housing for government employees, but it also offers small loans to assist other people in building or improving their housing.

There are also some private lending agencies that offer micro loans. This system appears to have been revitalized recently with donor assistance, working through the island councils. There are now 182 village banks across 22 islands, managed by local communities, with oversight by the Ministry of Home Affairs and Rural Development. Loans are decided locally by community leaders based on the applicant's reputation (rather than material collateral), but there appears to be a strong bias in favor of male applicants.[47]

Challenges in accessing loans

- **Ineligibility for loans.** The rates of unemployment, informal employment, and self-employment are high, particularly in the outer islands. People living in the outer islands with no official income are hardly eligible for DBK loans, and many of them do not have a bank account. Actually, applicants for DBK loans are not required to have a bank account, nor are they required to have a mobile phone. But not having a bank account or a mobile will diminish their chances for approval. Further, all loans approved by DBK require applicants to present a collateral, the value of which must be at least 150% of the loan amount. DBK prefers to use the customer's Provident Fund assets as collateral but will take physical assets if the Provident Fund assets are insufficient. For physical assets, real estate is preferred.
- **Indebted population.** In the outer islands, most potential DBK customers are to be found among the employed population. According to DBK, however, many of them are already indebted, and cannot take on more loans to buy solar products.

4.5 Opportunities for Local Operations and Maintenance and Job Creation

Infrastructure maintenance is a key institutional weak spot in Kiribati, with limited funding prior to the 2019 budget cycle.[48] A focus on improving repair and maintenance services would enable the creation of a maintenance industry, and local companies would have a comparative advantage over foreign repair services. But this would entail building technical and

[47] United Nations Conference on Trade and Development (UNCTAD). 2020. *Women Producers in Kiribati and Their Participation in Inter-Island and International Trade*. Geneva. https://unctad.org/system/files/official-document/ditc2020d4.pdf.

[48] International Monetary Fund (IMF). 2018. Kiribati: 2018 Article IV Consultation—Press Release; Staff Report; and Statement by the Executive Director for Kiribati. IMF Country Report No. 19/26. Washington, D.C. https://www.imf.org/~/media/Files/Publications/CR/2019/cr1926-kiribati.ashx.

organizational capacity within the local institutions and society, in addition to instilling an asset-management culture in the country.

4.5.1 Repair services

Registered private electricians provide installation, repair, and maintenance services to households, private businesses, and community facilities. However, the survey revealed that only 38% of households in South Tarawa have sufficient access to repair and maintenance services. Many respondents in rural North Tarawa stated that solar equipment repair was a service mostly provided by the community council (33%). About 21% of respondents indicated that they fixed their own equipment and 15% indicated that a household member fixed their equipment. For 30% of respondents, no way of repairing their equipment was available.

4.5.2 Capacity needs

Technical skills and capacities in Kiribati are fairly sufficient, but could be reinforced. Currently, the POIDIER project includes a training program in renewable energy and energy-efficiency technologies aimed at local technical experts and outer island personnel.[49] The last relevant operations and maintenance (O&M) training in the country was undertaken by project developer Global Sustainable Energy Solutions (GSES) at the Kiribati Institute of Technology (KIT) in 2014-2015. KIT is a regionally accredited vocational education and training provider, and a leader in delivering international-standard degree programs and short courses in high-demand skills and trades.

4.6 Development Partners

Kiribati's effort in transitioning to a clean energy sector is progressing very well due to the significant input of its development partners (Table A2.15).

Table A2.15: Kiribati's Development Partners

Development Partner	Project Title
ADB, EU, MFAT	Kiribati Scaling-Up Renewable Energy Program Investment Plan
IRENA, SPC	Kiribati Integrated Energy Roadmap (KIER) 2017–2025; Renewable Energy Readiness Assessment
GEF, UNDP	Promoting Outer Island Development Through the Integrated Energy Roadmap (POIDIER)
ADB, EDF, MFAT	South Tarawa Renewable Energy Project
GEF, MFAT, World Bank	Kiribati Grid Connected Solar PV Project

ADB = Asian Development Bank, EDF = European Development Fund, EU = European Union, GEF = Global Environment Fund, IRENA = International Renewable Energy Agency, MFAT = New Zealand Ministry of Foreign Affairs and Trade, PV = photovoltaic, SPC = Secretariat of the Pacific Community, UNDP = United Nations Development Programme.
Source: Pacific Clean Energy Financial Potential project team.

[49] UNDP, Pacific Office in Fiji. 2021. Kiribati Government Promotes Indigenous Renewable Energy for Power and Non-Power Applications. News release. 4 February. https://www.pacific.undp.org/content/pacific/en/home/presscenter/pressreleases/2021/Kiribati_Government_promotes_indigenous_renewable_energy_for_power_and_non-power_applications.html.

5 SOLOMON ISLANDS

5.1 Country Context

5.1.1 Macroeconomic overview

Demographics

The Solomon Islands consists of six major islands and nearly 1,000 smaller islands covering a land area of about 28,000 square kilometers. The islands are grouped into three major "geological" provinces: the Pacific Geological Province, the Central Geological Province, and the Volcanic Geological Province. The largest island is Guadalcanal, home to the capital city of Honiara. Situated mainly in the Central Geological Province, Guadalcanal is characterized by a rugged and mountainous landscape of volcanic origin. Honiara is the only major area of economic activity. The total population counted in the 2019 census was 721,445, of which approximately 65,000 lived in Honiara. Around 75% of the population lives in villages of just a few hundred people each.[50] The population growth rate has been steadily decreasing. For instance, it dropped from about 2.5% in 2011 to just over 2% in 2018, and it is expected to drop to 1.8% by 2025.[51]

Gross Domestic Product

The Solomon Islands' main economic drivers are mining, agriculture, fishing, logging, manufacturing, and tourism. The bulk of the population depends on agriculture, fishing, and forestry, for at least part of its livelihood. Logging activities have been declining and most manufactured goods and petroleum products must be imported, but the islands are rich in undeveloped mineral resources such as lead, zinc, nickel, and gold.[52]

The country's exclusive economic zone is 1,589,477 km^2 in size, about five times larger than Nauru's (308,480 km^2) and more than twice as large as Vanuatu's (663,251 km^2). Among the developing member countries of the Asian Development Bank (ADB) in the Pacific region, Solomon Islands has one of the highest average tuna catches, valued at about $426 million annually from 2013 to 2019, more than twice the $172 million value for Nauru.[53] However, COVID-19 disrupted offshore fishing through shipping quarantine restrictions and the suspension of observers on purse seine vessels. The value of Solomon Islands' fish exports thus fell by 12% in 2020.[54] After rising by 38% in the first half of 2021, Solomon Islands fish exports are expected to exceed $50 million in 2021, up from $43.4 million in 2020. Although fish accounted for only 10.5% of Solomon Islands' exports, a distant second to logs and timber, at 70%, the fishing industry is expected to be an important driver of growth for 2022.

Real GDP during 2004 to 2016, fluctuated between 1.8% and 9.7%. From 2016, however, the trend was downwards, with real GDP decreasing from 5.9% in 2016, to 5.3% in 2017, 3.0% in 2018, and to 1.2% in 2019. The economy contracted by 4.5% in 2020, mainly due to the effects

[50] ADB. 2021. *Asian Development Bank Member Fact Sheet: Solomon Islands*. Manila. https://www.adb.org/publications/solomon-islands-fact-sheet

[51] Japan International Cooperation Agency (JICA), Tokyo Electric Power Services Co. Ltd., and Deloitte Tohmatsu Consulting LLC. 2021. *The Project for Formulating Renewable Energy Road Map in Solomon Islands: Final Report*. Tokyo. https://openjicareport.jica.go.jp/pdf/12341525_01.pdf.

[52] Government of Solomon Islands. 2015. *Solomon Islands Government: Intended Nationally Determined Contribution*. Honiara. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Solomon%20Islands%20First/SOLOMON%20ISLANDS%20INDC.pdf.

[53] SPC. Aquaculture Portal. https://aquaculture.spc.int/index.php?option=com_content&view=article&id=13&Itemid=2.

[54] Western & Central Pacific Fisheries Commission. Coronavirus Related Measures. https://www.wcpfc.int/covid19.

of the COVID-19 pandemic (including a 40% reduction in fish catches and a slowdown in construction activities) and the impacts of Cyclone Harold (including declines in log output and crop production). As a result, GDP per capita in 2020 was $2,295. The economy is forecast to grow by 1.0% in 2021 and by 4.5% in 2022, as fishing and construction rebound.[55]

Disaster resilience

The Solomon Islands urgently needs to strengthen its disaster and climate resilience. Several islands are mountainous, while others are low-lying coral atolls. The country's maximum height above sea level is 2,335 meters; and coral reefs, beaches, and lagoons are abundant. The Solomon Islands is situated within the earthquake belt, or "Ring of Fire" which makes it extremely vulnerable to the effects and impacts of earthquakes. According to the 2020 World Risk Index, Solomon Islands ranks fifth (out of 181 countries) in terms of risk of disaster due to extreme natural events, such as droughts, extreme rainfall, floods, king tides, and sea level rises. As seen from previous climate disasters, the results can include food and water shortages, coastal inundation, coastal erosion, and infrastructure damage (footnote 52).

Insufficient resilience is also due in large part to the fact that over 80% of the population lives within 1.5 km of the coastline. In addition, high poverty rates, excessive dependence on foreign aid, and remoteness make Solomon Islands particularly vulnerable to weather variability and climate change. The 2007 earthquake and resulting tsunami affected about 40,000 people and caused extensive damage worth hundreds of millions of dollars, equivalent to 80% of the GDP. According to the Global Climate Risk Index 2021, Solomon Islands faced average annual economic losses of $3.91 million (purchasing power parity) from 1998 to 2017. Estimates by the Global Facility for Disaster Reduction and Recovery (GFDRR) show that, in the next 50 years, there will be a 50% chance of losses exceeding $240 million and casualties of more than 1,600 people, and a 10% chance of losses exceeding $520 million and casualties of more than 4,600 people.

5.1.2 Energy resources

Dependence on fuel imports

Nearly all grid-connected power is generated by diesel. Fuel and lubricants account for most of the electricity-production costs, but due to tariff increases, their share in the electricity-production costs dropped from 67.4% in 2010 to 37.5% in 2019. The power sector is responsible for 39% of greenhouse gas (GHG) emissions, with the transport sector accounting for the other 61% (footnote 52). Fossil fuel was 18% of total imports in 2018-2019, which was comparable to that of other countries in the region.

Indigenous energy resources

Solomon Islands has no indigenous fossil fuel resources. There is substantial potential for mini- or micro-hydropower development in Solomon Islands. A study by the Japan International Cooperation Agency (JICA) in 2000 identified 130 potential hydropower sites with a total maximum capacity of 326 megawatts (MW). The study assessed resource potential, but the economic feasibility of these locations still needs to be studied. In relation to solar photovoltaic (PV) electricity generation, Solomon Islands has a high potential. Insolation values are about 5 kilowatt hours (kWh)/square meter (m^2)/day, and current solar PV projects have been showing promising results. However, no direct measurements of solar insolation levels have been conducted in Solomon Islands, and any available data comes from the

[55] Asia Regional Integration Center. Solomon Islands. https://aric.adb.org/solomon-islands.

United States (US) National Renewable Energy Laboratory, along with global data from the US National Aeronautics and Space Administration (NASA).[56]

Solomon Islands also has the potential to use coconut oil (CNO) in place of diesel. In fact, a successful trial was held in 2014 in which CNO replaced up to 90% of diesel at a test facility, with no impact on reliability of supply or on the operation of the generator. However, no significant further actions have been taken to increase the use of CNO, and renewable power development has concentrated on the use of hydro and PV. Increased demand for CNO would have strong economic advantages for the local economy, which would benefit from coconut production, but CNO offers marginal to no advantages to the power utility or to the government in terms of lowering power-production costs.[57] CNO is also not included in the various scenarios presented in the Renewable Energy Road Map (RERM) for Solomon Islands, which was formulated in 2019 (footnote 52). As for other sources of renewable energy, there have been only limited studies to assess the potential of wind power in Solomon Islands.

5.2 Sector Overview

5.2.1 Sector performance

Problems

Solomon Islands has overcome the challenge of a poorly performing national power company and is in the process of restructuring the power sector to facilitate private sector participation. Although there have been substantial improvements, electricity access and high electricity prices remain the two major challenges for the energy sector. To address these challenges, the government resorted to a high increase in grid-connected renewable electricity, but this approach led to follow-up infrastructural challenges, as it necessitated the connection of the PV energy system and battery energy storage system (BESS) to the main Honiara grid, as well as the development of microgrids in other areas. The Solomon Islands RERM addresses these challenges, and several projects are underway to facilitate the generation of large amounts of renewable electricity and the corresponding infrastructural measures.

The RERM identifies PV solar energy and the 15 MW Tina River Hydropower Plant as the only renewable energy resources that can be feasibly developed by 2030, and there are ongoing projects aimed at achieving the ambitions for both technologies. An analysis of future supply and demand shows that estimated PV and hydropower output will exceed demand during the daytime in the rainy season, but that a BESS will be needed to support peak shifting during the night in the dry season. Furthermore, several measures will be needed to support the grid interconnection of the PV system and the BESS, including voltage maintenance and a virtual synchronous generator function (footnote 52). The ongoing Solar Power Development Project will facilitate a high increase in grid connections in five provinces. As is the case for most small island states, an increase in renewable energy would lower fuel imports, and thus improve both electricity tariffs and the national trade balance. It would also create jobs in the maintenance and supply of PV systems.

Energy access

ADB statistics show that 70% of the population in Solomon Islands had some access to electricity in 2019. This was a considerable increase from the 23% in 2010 but still lower than the percentages in most other PICs. The difference between rural and urban households is

[56] International Finance Corporation (IFC). 2021. *Powering the Pacific: A Guide to Investing in Renewable Electricity Generation in the Pacific*. Washington, DC. https://www.eca-uk.com/wp-content/uploads/2021/11/IFCPoweringthePacificGuide-FINAL.pdf.

[57] ADB. 2016. *Pacific Project Brief: Solomon Islands; Auki Coconut Oil Biofuel Trial*. Manila. https://www.adb.org/sites/default/files/publication/228826/sol-auki-biofuel-trial.pdf.

quite large. Whereas in 2018, 70% of urban households already had access to electricity, the share for rural households was only 54%. Still, this share was high compared to the regional average of 30% for rural areas. However, only 16% of the residents in Solomon Islands are connected to the electricity grid.

Electricity demand

As of 2019, the Solomon Islands Electricity Authority (Solomon Power), the country's main electricity provider, had 19,000 customers connected to the Honiara grid. The Honiara electricity system is by far the largest grid in Solomon Islands, supplying Honiara and nine other town centers around the capital. In 2019, annual electricity consumption in Honiara reached 87.3 gigawatt-hours (GWh), comprising about 88% of all electricity consumed in the country. The grid's peak demand that year reached 16 MW.[58]

Sector performance

Solomon Power is a vertically integrated state-owned enterprise that owns, maintains, and operates the country's national electricity grid, and also owns most of the power-generation units.[59] The company was established under the Electricity Act of 1969, and is governed by the State-Owned Enterprises Act of 2007 and the associated regulations. As a grid operator, the company was mandated by the Electricity Act to decide on the licensing of standby generators, independent power producers (IPPs), and cogeneration units. Solomon Power's financial situation used to be very poor, but after a restriction on operational costs and tariffs in 2011, its sales and profits have been stable. In fact, by 2019 the profit margin was about 20%. The government has developed a plan to restructure the energy sector, and implementation has already begun.

IPP guidelines are currently being drawn up; also, an IPP office and a Consumer and Competition Commission will be established to facilitate private sector participation in the energy market. The energy sector regulator will be restructured by 2024, and private investors will gradually become the main players in power generation. This means that regulation will be unbundled from power transmission and distribution. Under the government's energy-sector restructuring plan, Solomon Power will be able to focus more on the electrification of currently unelectrified areas.

Electricity generation

The country's main source of electricity is its diesel generators. In total, 33.75 MW of installed capacity (30.65 MW of available capacity) is connected to the Honiara grid. The Lungga power plant has 10 diesel units, with a total installed capacity of 29.7 MW. The Honiara power plant has two diesel units totaling 3 MW. In addition, two PV plants are feeding into the Honiara grid. The RERM includes another 20.22 megawatts-peak (MWp) of planned PV capacity, which would be connected to the grid during 2020–2024, alongside 15 MW from the planned Tina River Hydropower Plant.

The Department of Energy is supporting the development of new mini-grids outside the areas covered by Solomon Power. This work is also supported by development partners, such as ADB, which has funded feasibility studies on hydro mini-grids. The Department of Energy, with the assistance from Solomon Power, has identified 35 priority mini-grid opportunities. Both the Department and Solomon Power recognize that the latter has limited capacity to develop all these projects quickly, so they are open to private sector involvement.

[58] Solomon Power. 2020. *Annual Report 2019*. Honiara. https://solomonpower.com.sb/wp-content/uploads/2020/12/Final-REPORT-10.07.20b-Lr-1.pdf.
[59] Solomon Power. 2017. *Solomon Power Network Development Plan 2017–2022*. Honiara.

Expected investments

Total energy sector investments in Solomon Islands from 2007 to 2020 was $249 million, which was higher than in any of the other small PICs. This can mostly be explained by the fact that donors such as the ADB have focused their first energy projects on the countries with the largest populations: Papua New Guinea and the Solomon Islands.

The 2014 Solomon Islands National Energy Policy (SINEP) estimated the costs for the implementation of all energy policy plans through 2020 at $165.71 million, of which $78.57 million would go to increasing access to electricity to targeted levels by 2020 (100% in urban areas, 35% in rural areas), and $75.00 million would go to increasing the use of renewable electricity to 79% by 2030. The Renewable Energy Strategy and Investment Plan (RE-SIP), 2014–2019, updated the targets and estimates, determining that a total investment of $75.00 million would be required through 2020 to achieve a 44% countrywide household electrification rate, and that a total investment of $234.15 million through 2030 would be required to achieve a 71% household electrification rate by that year (footnote 53). Although these official estimates have since been increased, they still seem to underestimate the amount of investment required, given that the current cost for the largest project involved in achieving these targets, the Tina River Hydropower Development Project, already stands at $240.48 million.

5.2.2 Policy framework

Solomon Islands National Energy Policy

The 2014 SINEP includes targets for increased electrification rates and for the share of renewable energy used to generate electricity.[60] The 2014 RE-SIP defines the path towards its renewable-energy targets, and gives the corresponding estimated costs.[61]

Nationally Determined Contribution

Solomon Islands submitted its first Intended Nationally Determined Contribution (INDC) in 2015, committing to a reduction on GHG emissions to 12% below the 2015 level by 2025, and to 30% below the 2015 level by 2030, compared with the business-as-usual (BAU) projection (extrapolated from data covering 1994-2010). With additional assistance, Solomon Islands committed to reducing GHG emissions to 27% below the 2015 level by 2025 and 45% by 2030, compared with the BAU projection. All of the planned mitigation actions are in the energy sector. The total costs for realizing this increase in renewable energy production are estimated at over $170 million. The 2014 SINEP includes further details on the planned actions and costs involved in achieving greater energy efficiency.

Amendments to the Electricity Act

Amendments made to the Electricity Act of 1992 exempted private generators with an installed capacity below 50 kilowatts (kW) from having to obtain a license to operate. The exemption allows small rural villages to self-supply electricity if their generation capacity does not exceed 50 kW. This amendment would also allow rural rooftop solar PV installations, as well as small mini-grids, to be mounted without a license. However, neither the act nor the amendments

[60] Government of Solomon Islands; Ministry for Mines, Energy and Rural Electrification. 2014. *Solomon Islands National Energy Policy and Strategic Plan*. Volume 1, *Solomon Islands National Energy Policy 2014*. Honiara. http://prdrse4all.spc.int/system/files/volume1_solomon_islands_national_energy_policy.pdf.

[61] Government of Solomon Islands; Ministry for Mines, Energy and Rural Electrification. 2014. *Solomon Islands National Energy Policy and Strategic Plan*. Volume 4, *Renewable Energy Strategy and Investment Plan 2014*. Honiara. http://prdrse4all.spc.int/sites/default/files/re_strategy-investment_plan.pdf.

specify whether the supplier can charge for the energy supply, and it is unclear whether the supplier can also remain connected to the grid. In any case, all the power generators interested in connecting to Solomon Power's grid must accept Solomon Power's operation and connection requirements. Since 2020, Solomon Power has received up to 15 applications from commercial parties to connect their solar PV systems to the grid. Of those applications, eight were approved and seven declined.[62]

Targets

The 2014 SINEP targets included access to electricity for 80% of urban households and for 35% of rural households, both by 2020 (footnote 53). Currently available data shows that this will not likely be achieved (footnote 32).

The 2014 RE-SIP set a target of 50% renewable energy use for power generation by 2020. This was planned to be achieved through the 15 MW Tina Hydropower Development Project and the Savo Island Geothermal Power Project, which were to be completed by the end of 2017. The progress actually realized was not, however, in line with these expectations. The commissioning of the 15 MW hydropower plant started in December 2020, with the aim of providing 65% of the electricity needed in Honiara. The current expected completion date is December 2025.[63] Plans for the geothermal power project on Savo Island, off the coast of Honiara, were dropped due to uncertainty over the resources available and the high cost of the submarine cable needed to transmit the power to Honiara.[64] The longer-term target set by the 2014 RE-SIP was 100% renewable energy use by 2050; Solomon Power aims to achieve 100% by 2030. The 2014 SINEP also included a specific target for the proportion of homes using solar power: an increase from 15% in 2014 to 50% by 2035.

The 2014 SINEP included the target of a 10.7% improvement in energy efficiency and conservation in all sectors by 2019. A total investment of $6.29 million was estimated to be needed to achieve that target. The proposed actions included supply side measures (such as replacing diesel generators and reducing technical and nontechnical losses), demand side measures (such as efficient lighting, energy-efficiency labels for appliances, public building renovations, and energy audits), and the reduction of fuel use (through higher-efficiency transport, use of alternative fuels, etc.).[65]

5.2.3 Tariffs

Nearly all electricity in Solomon Islands is generated by diesel, using imported fuel. For this reason, the power-generation cost is susceptible to international market prices and transportation costs. To ensure financial sustainability over the longer term, Solomon Power applies an extremely high electricity tariff; as a result, the cost of electricity in Solomon Islands is one of the highest globally. Tariffs are calculated in accordance with the Electricity Tariff (Base Tariff and Tariff Adjustments) Regulations 2016. A benchmark study of power tariffs in the region confirmed that electricity tariffs in Solomon Islands were higher than in all the other

[62] Solomon Power. Interview with Donald Kiriau , CEO, 20 October 2021.
[63] The World Bank. Tina River Hydropower Development Project: Development Objective. https://projects.worldbank.org/en/projects-operations/project-detail/P161319.
[64] The WorldBank. 2017. *International Development Association Project Appraisal Document on a Proposed Credit in the Amount of US$23.375 Million Equivalent, and a Proposed Grant in the Amount of SDR7.480 Million (US$10.255 Million Equivalent) to Solomon Islands for a Tina River Hydropower Development Project.* Report No. PAD2258. N.p. https://documents1.worldbank.org/curated/en/339951498183305816/pdf/Project-Appraisal-Document-PAD-P161319-2017-05-24-15-52-rev-BOS-05312017.pdf.
[65] Government of Solomon Islands; Ministry for Mines, Energy and Rural Electrification. 2014. *Solomon Islands National Energy Policy and Strategic Plan*. Volume 2, *Energy Efficiency and Energy Conservation: A Strategy and Investment Plan (2014-2019)*. Honiara. http://prdrse4all.spc.int/system/files/volume2_solomon_islands_energy_efficiency_energy_conversation_strategy.pdf

PICs: During 2018–2019, for instance, the tariff for households was $0.72 per kWh (compared with the regional average of $0.36 per kWh, and regional median of $0.31 per kWh); for commercial consumers it was $0.70 per kWh (compared with the regional average of $0.41 per kWh, and regional median of $0.40 per kWh); for industrial consumers it was $0.79 per kWh (compared with the regional average and median of $0.41 per kWh); and for the government the tariff was $0.79 per kWh (compared with the regional average of $0.48 per kWh, and regional median of $0.40 per kWh) (footnote 32). To avoid commercial losses, Solomon Power decided to transition to prepaid meters throughout the territories it services. Currently, most consumers use prepaid meters, and spend about SI$50 per week (approximately $6.2).[66]

Solomon Power is considering piloting a net-metering framework that would allow customers to install their own solar energy system. Hotels and any other customers installing more than 50 kW of generation for self-supply require a license from Solomon Power. Any customer who wants to install a solar energy system and remain in sync with Solomon Power's grid will need to meet Solomon Power's terms and conditions, or Solomon Power may disconnect that customer on the grounds that the customer does not meet the terms of the connections agreement. Solomon Power is open to the possibility of its customers installing solar energy systems, and the technical terms of interconnection have been standardized in its net-metering framework, but each application is negotiated on a case-by-case basis. Solomon Power is also preparing IPP guidelines.

5.2.4 Relevant support programmes

Global Environment Fund Electricity Access and Renewable Energy Expansion Project

The development objective of the Global Environment Fund (GEF) Electricity Access and Renewable Energy Expansion Project is to increase access to grid-supplied electricity and to increase renewable energy generation in Solomon Islands. This project has four components:

- The first component, Renewable Energy Hybrid Mini-Grids, would finance the supply, installation, and initial maintenance of new hybrid mini-grids throughout Solomon Islands.
- The second component, Electricity Connections in Low-income Areas, would finance electricity connections to households, micro enterprises (such as small canteens), and community infrastructure (e.g., schools and hospitals) in low-income areas, through an output-based aid mechanism, building on the Electricity Access Expansion Project.
- The third component, Grid-Connected Solar Power, would finance the supply, installation, and initial maintenance for one or more grid-connected solar facilities in Solomon Islands.
- The fourth component, Enabling Environment and Project Management, consists of two subcomponents. Subcomponent 4.1 would finance specific areas of project management and implementation, including gender-related activities, as well as technical assistance and training activities for Solomon Power. Subcomponent 4.2 would finance equipment; technical assistance; and training activities, to be carried out by Solomon Power for the benefit of the Ministry for Mines, Energy and Rural Electrification.[67]

[66] Solomon Power. Interview with Donald Kiriau, CEO, 20 October 2021.
[67] GEF. GEF Electricity Access and Renewable Energy Expansion Project: Abstract. https://projects.worldbank.org/en/projects-operations/project-detail/P162902.

5.3 Estimation of Demand

5.3.1 Income and expenditure

The 2012/13 Household Income and Expenditure Survey (HIES) found that 12.7% of the population of Solomon Islands were living below the national poverty line.[68] ADB statistics have shown that, in 2019, 22.6% of the employed male population was living on less than $1.90 (purchasing power parity) a day. For women, it was 19.2%.[69] These percentages were higher than those for all the other Pacific countries, except Papua New Guinea. The 2012/13 HIES also found that there was a high degree of income inequality: The top 10% of households earned 42% of the total income in the country, while the poorest 50% of households earned just 20% of the total income.[70] The poorest households were generally found in informal settlements; for instance, the average monthly household income in Honiara's informal settlements was around $83.[71] Women-headed households earned significantly less than households headed by men = in rural areas, women-headed households' average income was just 71.5% of the average income earned by rural households headed by men; in urban areas, the rate was 70.5%. Women-headed households were also more likely to be poor: They represented 12.8% of households earning less than $1,240 a year (SI$10,000), compared with 6.7% for male-headed households.

In 2018, the labor force participation rate was 71.4%, and the employment-to-population ratio was 70%. Both of these rates were over 17% higher for men than for women. The total unemployment rate was 2.1%, and the youth unemployment rate was 4.4%, with near gender parity in both rates. Employment was heavily reliant on agriculture and medium-skilled occupations. Vulnerable employment in the Solomon Islands as of 2018 accounted for 80.3% of the labor force. This type of employment consisted of self-employed workers and contributing family workers, who are both more likely to experience low job and income security than formal employees and employers, and they receive less coverage from social protection systems, and less employment protection.[72]

The informal economy is significant in size, involving an estimated 85% of the working-age population and representing more than 20% of GDP. Subsistence food production contributes around 7% to household income in Honiara, but varies among the other localities, for instance, representing 71% of household income in Isabel Province.[73] The extent of women's involvement in the informal sector has been estimated as 66% of all women, with informal trade contributing one-third of average family incomes.

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68 Government of Solomon Islands, National Statistics Office. 2016. Poverty in the Solomon Islands. News release. 11 April. https://www.statistics.gov.sb/press-releases/95-poverty-in-the-solomon-islands.

69 ADB. Solomon Islands and ADB: Poverty Data; Solomon Islands. https://www.adb.org/offices/pacific/poverty/solomon-islands#accordion-0-0.

70 Government of Solomon Islands, National Statistics Office. 2015. *Solomon Islands 2012/13: Household Income and Expenditure Survey: National Analytical Report*. Volume 1. Honiara. https://www.statistics.gov.sb/component/advlisting/?view=download&format=raw&fileId=409.

71 E. Crispen et al. 2020. *The Impact of COVID-19 on Urban Systems, Informal Settlements and the Urban Poor in the Pacific*. N.P.: UN-Habitat. https://fukuoka.unhabitat.org/wp-content/uploads/2021/12/Pacific_Regional_SEIA_Dec2020_informal_report.pdf.

72 International Labour Organization (ILO). Solomon Islands: Employment and Environmental Sustainability Fact Sheets 2019. https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/publication/wcms_627566.pdf.

73 Pacific Partnership for the New Urban Agenda (PP-NUA). 2021. Report for the 2021 Virtual Pacific Urban Forum. Virtual. 26 August.

5.3.2 Appliance and equipment inventory

Urban grid-connected households

A 2017 Pacific Community survey of energy demand in urban grid-connected households in Honiara showed that about 80% of the households owned a freezer and/or a refrigerator to preserve their food, with 18% having both, and 22% having neither. With regards to comfort, 82% of households owned fans and at least 11% had air conditioning equipment. Washing machines were not so popular, and only 23% of households own them. Regarding entertainment, 67% of households had a TV.[74] The survey also revealed that only 36% of households had purchased an appliance in the past 2 years, mostly refrigerators and TVs. Regarding lighting equipment, long fluorescent tubes were the most commonly used option, as it was found in 96% of households and were the main lighting source in 58% of households. Compact fluorescent lights (CFLs) were the next most common, found in 78% of homes. LED lighting units were found in 25%. The popularity of long fluorescent tubes, instead of more energy-efficient LED lighting, may have been prompted by the cost of the LED units, the lack of availability, and the perception of long fluorescent tubes provided better lighting. It is likely that the share of LED lighting units has grown since then, as their prices and availability have improved over the past 5 years.

Rural off-grid households

There is not much information about energy demand in the rural off-grid areas of Solomon Islands. Hybrid solar home systems (SHSs) are becoming more popular in the outer islands, but most communities remain reliant on diesel generators. In the urban centers such as Honiara, hybrid systems remain uncommon - few households have SHSs due to higher tariffs (Solomon Power charges a flat rate to “non-regular” customers who use the grid as well as an SHS), high equipment prices, and lack of feed-in tariffs.

Generally, electricity is used for lighting, refrigeration, fans, and mobile phones. Gas is more commonly used for cooking, as it is cheaper than electricity under the current pricing regime. There is also considerable use of biomass for cooking.

Households in off-grid areas purchase their solar lighting units and small SHSs from retailers in Honiara. Certain DC-current appliances are also popular, including small TVs and fans. Some locals are skeptical of solar panels due to their experience with cheap, low-quality solar panels that were handed out by politicians and then failed after a couple of years.

5.3.3 Awareness of energy efficiency

The Pacific Community survey found that most respondents wanted to use the energy label as a deciding factor in their next purchase. The survey revealed that there was a quite good level of recognition of the Australia and New Zealand energy labels among Honiara’s households. However, energy labels from other countries were not easily recognized. While there was a strong interest in energy running costs, there was little understanding of how to calculate those costs. A significant share of the households (21%) believed that more stars meant lower energy efficiency or higher energy consumption. Solomon Power encourages the use of energy-efficient appliances and may consider selling such appliances to its clients in the future as a way to increase company’s income.

[74] Tebbutt Research. 2017. *Survey of Consumer Awareness and Use of Energy Rating Labels in PICs: Solomon Islands Report*. Honiara: Pacific Community. https://pcreee.org/publication/survey-consumer-awareness-and-use-energy-rating-labels-pics-tuvalu-country-report.

5.3.4 Costs of ownership

The costs of some solar products listed by local retailers are shown in Table A2.16.

Table A2.16: Costs of Solar Products Listed by Local Retailers in Honiara, September 2020

Product	Cost ($)
150 Wp solar kit for basic lighting and charging	800
270 Wp solar kit, AC load	1,050
540 Wp solar kit, AC load	1,920
1,080 Wp solar kit, AC load	3,500
1,650 Wp solar kit, AC load	7,700
3,200 Wp (3 kVA) solar system, AC load	11,000
5,500 Wp (5 kVA) solar system, AC load	22,300
170 liter solar freezer	2,670
433 liter solar freezer	4,650
Small solar water pump	1,300
Medium solar water pump	3,220
Small fan, DC load	30
24-inch TV, DC load	300

AC = alternating current; DC = direct current; KVA = kilovolt-ampere, TV = television, Wp = watt-peak.
Source: Pacific Clean Energy Financial Potential project team.

5.3.5 Willingness to pay

Unfortunately, no studies or surveys have been carried out in the Solomon Islands to find out how much people would be willing to pay for energy-efficient appliances, or for off-grid solar products.

5.3.6 Demand forecast

The Pacific Community 2017 survey (footnote 75) found that up to 30% of grid-connected households in Honiara intended to purchase an appliance within the next 6 months, and 55% intended to do so within a year. The most preferred appliances for those respondents were mobile phones with an internet connection, mobile solar chargers, and TVs. Refrigerators, freezers, and fans followed in the respondents' preferences. Washing machines were only mentioned by respondents with higher incomes.

5.4 Market Overview

5.4.1 Suppliers

There are at least five known private retailers in Honiara offering SHSs, other solar-energy products, and household appliances on a regular basis:

- Superfly Limited
- Sunpower Limited
- Island Enterprises Limited
- Cruz Communication and Engineering Limited
- Honiara Hardware Supplies Limited

These retailers sell appliances and equipment with the corresponding warrantee, and a few of them offer installation and repair services. In addition, other shops sometimes sell cheap, lower-quality imported SHSs and components, with no warrantees.

5.4.2 Lending agencies

The majority of Solomon Islanders are unbanked. Research conducted in 2015 found that just 26% had commercial bank accounts and 8% used other formal institutions, such as microfinance companies and credit unions. Many (35%) relied heavily on informal alternatives, such as moneylenders, shop credit, and savings groups. More men (32%) than women (20%) had bank accounts. More recent data was not available, and although the situation has almost certainly improved in recent years, most Solomon Islanders likely remain unbanked. The same research found that it would take on average 195 minutes for a person in the Solomon Islands to reach a bank branch, and 143 minutes to reach an ATM. Additionally, for more than 14% of individuals, traveling to a bank would take one day or longer. The most common reasons for not having a bank account were insufficient funds (56%), distance (43%), and a lack of documents (31%). Solomon Islanders who earned income from informal or agricultural work were more likely to be excluded from both formal and informal financial systems, with 27% of such individuals having no access to any sort of financial services.[75]

The Development Bank of Solomon Islands

The Development Bank of Solomon Islands (DBSI) started its operations in June 2020. The predecessor to DBSI was the Agriculture and Industrial Loans Board, established by the Agriculture and Industrial Loans Board Ordinance in 1955. DBSI offers the Livelihood and Investment Facility (LAIF) loans to households. These loans are meant to enable working islanders to venture into productive activities that will improve their livelihoods. They can be used to purchase small SHSs, solar lighting units, and other solar products (e.g., solar-powered refrigerators) that would promote their general purpose.

LAIF loans can range from $600 to $9,000, with an annual interest rate of 13% and a maximum 5-year term. Most applicants are from Honiara since people in the outer islands are generally unaware of these loans and might not be able to fulfill the eligibility conditions since repayment usually must be made from the borrower's salary or retirement Provident Fund assets. DBSI is also interested in lending money to the tourism sector for the purchase of solar-energy systems, solar refrigerators, solar lighting units, etc. Currently, money is paid directly to the approved applicants, not to vendors. Moreover, DBSI does not have the expertise to evaluate the technical aspects or energy-performance characteristics of the equipment or appliances to be bought with the funds.

Other lending institutions

There are only two commercial banks operating in Solomon Islands: Bank South Pacific (BSP) and the Australia and New Zealand Banking Group, Solomon Islands (ANZ Solomon Islands). BSP started operations after acquiring the National Bank of Solomon Islands in 2007 and took over Westpac's operations in Solomon Islands in 2015. It operates the largest banking network in Solomon Islands. In addition, BSP also offers microfinance in the Solomon Islands, but little information is available regarding its impact. The ANZ Rural Bank operates a service based on the collection of money from villagers on a fortnightly basis, in areas with good transport access.

Several microfinance or group savings schemes have been initiated to help women vendors and others raise venture capital for their businesses. Interest rates are high (14%–20%), and many of these schemes have failed as a result; but a few remain operational, including some managed at the village level. Some women's groups have formed cooperative savings groups, especially in the outer islands, so they can pool their earnings from trade to buy boats, install

[75] Pacific Financial Inclusion Programme. 2016. *Benchmarking Financial Inclusion in Fiji, Samoa, and Solomon Islands: Findings from the First National Demand Side Surveys*. Suva, Fiji. https://www.afi-global.org/wp-content/uploads/publications/piri_cross_country_report_final_uploaded.pdf.

solar panels, or invest in village infrastructure. There were also around 200 savings clubs with a total of 6,000 members (predominantly women) in 2014.

Challenges in accessing loans

- **Ineligibility for loans.** Unemployed, informally employed, self-employed, and partially employed people are generally not eligible for DBSI loans. This is the situation for majority of the population in the outer islands. Further, all loans approved by DBSI require applicants to present collateral covering at least 90% of the loan amount. Eligibility conditions for LAIF loans include: possessing Solomon Islands citizenship, being of legal age, and having had a full-time job for at least 2 years. DBSI loans usually require payments to be made directly from the borrower's salary or retirement Provident Fund account. These eligibility conditions bar most people who are in the greatest danger of suffering energy poverty.
- **Lack of formal energy standards.** There is limited control over the quality of imported renewable-energy appliances and equipment, as they do not have to meet energy-label or similar standards. As a result, the market offers a mix of energy-efficient and cheaper inefficient appliances and equipment. DBSI does not require energy labelling or any sort of quality guarantees as requirements for the appliances or equipment the borrowers intend to purchase.
- **Restricted lending to women.** Access to finance remains difficult for Solomon Islands women, especially for those seeking to start a new business. In a 2014-2015 survey conducted among 120 businesswomen in Fiji, Papua New Guinea, Samoa, Solomon Islands, Tonga, and Vanuatu, between 17% and 56% of them said that interest rates were too high; and up to 33% did not have the collateral required by the banks to obtain a loan.[76] Gaining credit from formal finance institutions is thus a major challenge for potential businesswomen, especially for rural women, who tend to have less knowledge about accessing financial services from formal banks.

5.5 Opportunities for Local Operations and Management and Job Creation

5.5.1 Repair services

People with technical skills and capacities exist in Solomon Islands, but there are not enough of them. Some local vendors do provide installation and repair services, however.

5.5.2 Capacity needs

There is a general shortage of skilled electricians and technicians who can repair refrigerators, washing machines, air conditioners, and freezers. This skill is an industry-specific one, and local suppliers of these appliances will need assistance in establishing a twinning arrangement with the manufacturers (e.g., Fisher & Paykel) to provide further training to local technicians when new technologies enter the market.

To ensure a higher success rate, the training should be conducted locally. For example, the Solomon Islands National University (SINU) School of Built Environment offers courses and programs in surveying and civil works, mapping, architecture, civil engineering, electrical engineering, photovoltaic energy systems, mechanical engineering, electrical and electronics engineering, and in building construction—all areas into which specific training in the operations and maintenance (O&M) of solar energy systems and solar products could be integrated. Local training initiatives could involve industry people as part-time instructors.

[76] ADB. 2018. Women and Business in the Pacific. Manila. https://www.adb.org/publications/women-business-pacific.

Examples of training and knowledge-transfer initiatives include the following:

- The German Agency for International Cooperation (GIZ) funded the development of solar training at SINU,[77] providing equipment for grid-connected and off-grid training. The students had 8 weeks of face-to-face training during January–March 2020. Unfortunately, due to the COVID pandemic, the university closed for months, the instructors returned home, and not all the students finished the follow-up assignments.
- The Vocational Training and Education for Clean Energy (VOCTEC) program, funded by the United States Agency for International Development (USAID), and under the leadership of Arizona State University, Green Empowerment, and Appalachian State University, is designed to improve the sustainability of renewable-energy infrastructure in selected developing countries by enhancing local awareness, skills, knowledge, and capacity through training in the clean energy field. VOCTEC provides three levels of training in solar photovoltaic, small wind, and micro-hydro energy systems. The program has trained faculties from the Solomon Islands University (SIU) on how to integrate a solar technician training course into their curriculum.[78]
- The Solar Training Course Development Programme (STCDP), funded by the 10th European Development Fund and with cooperation from GIZ, aims to develop a solar-energy training program at SINU.[79]

5.6 Development Partners

Multiple development partners are operating in Solomon Islands. The largest energy project being implemented is the Tina River Hydropower Development Project, led by the World Bank and financed by six development agencies: the International Development Association, the Green Climate Fund, the Republic of Korea's Economic Development Corporation Fund, the Abu Dhabi Fund for Development, ADB, and the Government of Australia.

The following development partners are currently active or have recently been active, in the Solomon Islands:

- ADB
- Australian Government Department of Foreign Affairs and Trade
- European Investment Bank
- Green Climate Fund
- International Renewable Energy Agency (IRENA)
- Japan International Cooperation Agency (JICA)
- Republic of Korea Economic Development Corporation Fund
- New Zealand Ministry of Foreign Affairs and Trade
- United Arab Emirates Government
- The World Bank via the International Finance Corporation (IFC).

[77] "GIZ" stands for "Deutsche Gesellschaft für Internationale Zusammenarbeit."

[78] USAID. 2020. USAID Trains Solar Technicians in Pacific Island Nations. News release. 21 January (updated). https://www.usaid.gov/energy/video/voctec/solar-technician-training-pacific-islands?page=60.

[79] Government of Solomon Islands, Ministry of Mines, Energy & Rural Electrification. Solar Training Course Development Programme (STCDP). https://www.mmere.gov.sb/index.php/alias-about-us/projects/energy-petroleum-projects/solar-training-course-development-programme-stcdp.html.

6 TONGA

6.1 Country Context

6.1.1 Macroeconomic overview

Demographic and socio-economic profile

Tonga is an island kingdom comprising 169 islands, 36 of them inhabited. The country is spread across 700,000 square kilometers of the South Pacific Ocean, and has an estimated population of 100,651,[80] which is concentrated in the three major island groups of Tongatapu (the main island), Ha'apai, and Vava'u, situated in the northernmost part of the country.

About 74% of the population lives on Tongatapu, with 23% of the total population living in the capital city, Nuku'alofa. Tonga's population is relatively young, with a median age of 22. The population appears to be declining due mainly to out-migration; however, internal migration from the outer islands to Tongatapu has been increasing and may result in overcrowding on the island.

Tonga is a constitutional monarchy and its political structure consists of the monarch as the head of the state; the Legislative Assembly, comprising of elected nobles and representatives of the people; and the Government of Tonga, which includes the elected officials. Tonga has introduced changes to its political structure and processes to make them more democratic by enhancing people's participation.

Culturally, Tonga is a nearly homogenous society of Polynesians, with only a few small communities of ethnic minorities, including Europeans, Chinese, and other Pacific islanders. The Tongans' social values emphasize community solidarity, peace, and reciprocity. The main religion is Christianity, with 35% of the population belonging to the Free Wesleyan Church of Tonga. Other religious denominations include the Catholic and Anglican churches, and the Church of Jesus Christ of Latter-Day Saints, among others. Trading on Sundays is prohibited by law.

Regarding economic activity, the last census, conducted in 2016, showed that 63.0% of the population aged 15 years and older was economically active, with 36.6% earning an income. Subsistence work is predominantly rural, with only 1% of the urban population engaged in it at the time of the census (footnote 81). Unemployment is relatively low. The Tonga Labour Force Survey, conducted in 2018, reported that labor force participation was 46.7%, with a total of 28,598 persons employed, 56.5% of them men and 43.5% women. By economic sector, manufacturing accounted for 20.4% of employed Tongans; with 19.8% in agriculture, forestry, and fishing; 9% in administrative and support services; and 8% in construction. Unemployment was estimated at 3.1%; youth unemployment at 8.9%.[81] Gender balance is recognized in Tonga as an important development opportunity for women and girls. The gender ratio is 99 males per 100 females. The government implements a range of initiatives to support women's economic participation and reduce the incidence of domestic violence. However, the employment of women in male-dominated fields has not significantly improved since 2010.

According to the last census, three-quarters of the population in 2016 had secondary-level education, and 19% had a higher level of education, including technical, vocational, or

[80] Government of Tonga, Statistics Department. 2017. *Tonga 2016 Census of Population and Housing*. Nuku'alofa, Tonga.
[81] Government of Tonga, Statistics Department. Labour Force Survey. https://tongastats.gov.to/survey/labour-force-survey/.

university training. The educational system works to facilitate learning, from preschool to the tertiary level. For instance, the Tonga Institute of Higher Education, the tertiary education branch of the Ministry of Education and Training, provides academic programs for management, science and technology, the arts, and other disciplines.

Health is a national issue for Tonga, given the country's high incidence of noncommunicable diseases, such as diabetes. The health facilities are limited in the outer islands, and the source of energy for medicine and vaccine storage in these remote clinics is predominantly solar.

Gross Domestic Product

Tonga is ranked as a developing country, with an estimated GDP of $500 million, or about $4,968 per capita.[82] The economy's annual growth rate has averaged 2.3% since 2010, with per capita GDP growth averaging 5.3%.[83] As of October 2021, Tonga's foreign reserves reached $757 million, equivalent to 12.7 months of import revenues.[84] However, the impacts of tropical cyclones Gita and Harold, and that of COVID19, have resulted in an economic slowdown starting in 2018, and Tonga's economy remains vulnerable due to the COVID-19 global restrictions.

The key economic sectors are agriculture and fishing, with local manufacturing limited to the production of local handicrafts. The National Reserve Bank of Tonga reported growth in agricultural export volumes by 3.9% in August 2021, but the volume of overall exports declined.[85] Remittances for the year ending in July 2021 increased by 11%, reaching $205 million (T$465 million); they accounted for over a third of overseas exchange transactions.[86] In the banking and finance sector, credit growth continues to slow down, and lending has declined due to the slow loan repayments by households and businesses. Household, personal, and vehicle loans have been decreasing. However, the loans extended by nonbank financial institutions increased by 7.4% in 2021, reflecting the limited access to financing in the banking sector (footnote 86).

6.1.2 Energy resources

Dependence on fuel imports

Tonga's energy resources are very limited, so the country relies heavily on imported fossil fuel for electricity generation and transportation (land, sea, air). The bulk of imported fossil fuel is consumed by the transportation sector, while 20% to 30% is used for electricity. Petroleum imports showed a slight increase during 2009–2014, from 20% to 21%. However, the growing demand in the transportation sector has since boosted fuel imports.

Indigenous energy resources

The indigenous energy resources are limited to biomass, which is largely used in the rural areas for cooking and other household chores. There is an increasing shift from biomass to liquefied petroleum gas (LPG) and kerosene for cooking, both in urban and rural communities. Solar energy is abundant, and the use of solar technologies for lighting has been increasing, mainly in off-grid communities. Solar farms have been built to generate electricity and feed

[82] World Bank open data, https://data.worldbank.org/ accessed on 16 November 2021.
[83] Government of Tonga, Statistics Department. NAS Release No01_2020, May 14, 2021. https://tongastats.gov.to/statistics/economics/national-accounts/
[84] National Reserve Bank of Tonga. Foreign Reserves Statistics 2021. http://www.reservebank.to/index.php/financials/financial-markets/for-res.html
[85] National Reserve Bank of Tonga. Monthly Economic Review for August 2021. http://www.reservebank.to/index.php/publications/publications/ .
[86] National Reserve Bank, Remittances for July 2021. http://www.reservebank.to/index.php/publications/publications/

into the grid; and Tonga Power Limited (TPL) is operating five grid-connected solar farms, with a total capacity of 6 MW. There are no hydropower or geothermal resources, but there have been increasing investments and use of solar and wind (to a small extent) technologies to improve access and strengthen energy security and resilience.

6.2 Sector Overview

6.2.1 Sector performance

Energy access

TPL is the sole provider of electricity service in Tonga, under an Electricity Concession contract, a service agreement including the company, the Government of Tonga, and the Electricity Commission to provide electricity to the islands of Tongatapu and 'Eua, as well as the Ha'apai and Vava'u island groups. TPL currently employs 261 people (an increase of 3.45% from previous year) to service a total of 23,607 customers, of which 80.85% are residential and 19.15% commercial.[87]

Access to electricity supply is very high. In 2018, about 98% of households had access to electricity supplies; just under 93% had access to grid electricity, while about 6% had access to off-grid electricity from solar home systems (SHSs) (footnote 13). Almost all urban households (99%), and rural households (98%) had access to grid electricity.

Electricity consumption

In terms of consumption, billing increased for all stations in 2020, except for those in Ha'apai, due to network issues following the Gita and Harold tropical cyclone disasters. In Tongatapu, billing increased by 3.7%, and it increased by even more in Vava'u (5.9%) and 'Eua (4.1%) (footnote 90). Overall demand increased by 3.6% from 62.3 million units in 2019 to 65.1 million units by June 2020.

Electricity generation

Electricity generation remains reliant on diesel fuels, so it is vulnerable to international market price fluctuations. In 2014, petroleum accounted for 21% of imported merchandise.[88] About a third of imported fuels was used for electricity generation.[89] This situation has not changed significantly since then because diesel generation still accounts for 72% of the overall energy supply.

The overall production capacity in 2020 reached 73.20 GWh, which was an increase from 70.6 GWh the previous year (footnote 87). Approximately 65.1 GWh was billed to customers, and parasitic and line losses accounted for 2.1 GWh (2.92) and 5.9GWh (8.09%) respectively. Line losses had decreased significantly, from 16% in 2011 to 11% in 2020, a reflection of ongoing improvements in the network. The installed generation capacity in 2021 was approximately 25.05 MW, of which 28% came from renewable energy sources, mainly solar and wind (Table A2.17). The installed capacity per capita was estimated at 0.18 kW, and the peak demand recorded that year was 11.3 MW.

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[87] TPL. *2020 Annual Report: A Year of Accomplishments*. Poutaha, Tonga. https://www.tongapower.to/sites/default/files/inline-files/Annual%20Report%202020.pdf.

[88] The World Bank. Fuel imports (% of merchandise imports) – Pacific island small states, Tonga. https://data.worldbank.org/indicator/TM.VAL.FUEL.ZS.UN?end=2017&locations=S2-TO&name_desc=true&start=1967&view=chart.

[89] Government of Tonga. 2010. *Tonga Energy Road Map 2010 – 2020: Final Report*. Nuku'alofa, Tonga. https://sustainabledevelopment.un.org/content/documents/1330tongaEnergy%20Strategy.pdf.

Table A2.17: Tonga Power Limited Generation and Distribution Capacity, 2021

	Tongatapu	Vava'u	Ha'apai	'Eua
Diesel generation capacity (MW)	14.93	1.87	0.67	0.67
Distribution network (km)	207	74	15	13.4
Electricity tariff (seniti/kWh)[a]	0.32	0.32	0.32	0.32
Energy generation (MWh)	4,976.87	517.62	159.46	132.46
Smart meters installed (number)	21,864	…	…	…
Peak demand (MW)	9.3	1.1	0.33	0.2
Total renewable energy capacity (MW)	5.73	0.42	0.56	0.2

… = no data available, km = kilometer; kWh = kilowatt-hour; MW = megawatt; MWh = megawatt-hour.
[a] A seniti is equal to one-hundred of a pa'anga, the national currency of Tonga.
Sources: Pacific Clean Energy Financial Potential project team; Tonga Power Limited. Tonga Power, Powering the Sustainable Development for Our Kingdom. https://www.tongapower.to/Powering%20the%20sustainable%20development%20for%20our%20Kingdom.

Renewable energy generation accounted for 12.78% of the total production capacity for the year 2019/2020; the total renewable energy generation recorded at the time was 9,363 MWh, an increase of 38.2% over the previous year. Of this capacity, the Matatoa station contributed 30%; Ii 'o Manumataongo, 28%; Maama Mai, 18%; and Mata 'o e La'a,17%.[90] Fuel savings of 2.3 million liters were achieved, although diesel consumption increased by 0.89%, with an overall fuel displacement value of 14.5%.

Grid reliability

In terms of reliability measures, the System Average Interruption Duration Index (SAIDI) was 378 minutes in 2020, compared with 719 minutes in 2019. Service disruptions were due to planned outages to facilitate a network upgrade project, and the unplanned outages resulted from road accidents.

6.2.2 Policy framework

Tonga's energy policy framework is an integrated process and structure comprising many institutions. It is based on the understanding that the diverse roles and responsibilities of these institutions are important for the development and implementation of energy policies.

Institutional structure

The institutional structure is an intricate web of agencies that work together to achieve greater energy access, as well as safe, affordable, and reliable energy services. Despite national efforts to encourage cooperation in the interest of improving program delivery and efficiency, very often the lack of coordination results in a fragmented sector, leading to slow growth.

[90] Tonga Power Limited. Tonga Power, Powering the Sustainable Development for Our Kingdom. https://www.tongapower.to/Powering%20the%20sustainable%20development%20for%20our%20Kingdom.

The following institutions have been the drivers of energy development in Tonga:

- **Department of Energy.** This department, under the Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC),[91] takes the lead role in the planning and coordination of energy initiatives. The MEIDECC was established through a cabinet decision in 2014.
- **Tonga Energy Roadmap Committee (TERM-C).** TERM-C merged with the Energy Department in 2014, with the approval of the cabinet. It has been driving the implementation of the Tonga Energy Roadmap and oversees energy efficiency initiatives.
- **Tonga Competent Authority (TCA).** Under the Ministry of Commerce, Tourism and Labour, the TCA is mandated by the Price and Wage Control Act of 1988 (section 5) to set petroleum retail and wholesale prices on the island.[92]
- **Ministry of Lands, Survey and Meteorological Surveys (MLSMS).** This ministry is the authority for petroleum mining and exploration in Tonga, as mandated by the Petroleum Act Cap 35.
- **Tonga Power Limited (TPL).** This state-owned company is the sole provider of electricity in Tonga, as mandated by the Tonga Electric Power Board Act of 1988 (amended). A board of directors governs TPL as mandated by the Electricity Act 2007.[93]
- **Electricity Commission.** is the regulator of TPL and it draws its authority from the Electricity Act 2007.[94]
- **Renewable Energy Authority (REA).** Operating under the MEIDECC, the REA was set up through the Renewable Energy Act 2008 to administer the functions of the Renewable Energy Advisory Committee.[95]

Relevant national legislations

There is a range of national legislations and regulations, including policy instruments, that support energy development in Tonga. These legal and policy instruments are implemented by various government agencies, as is shown in Table A2.18 and Table **A2.19**.

Table A2.18: Legal Instruments in Tonga for Renewable Energy and Energy Efficiency

Title of Legal Instrument	Sector and Implementing Agency	Description
Consumption Tax Act 2003[a]	Ministry of Revenue & Customs[b]	Introduction and implementation of the Consumption Tax for all fuel sales, charged at 15%
Price and Wage Control Act 1988	Ministry of Commerce, Tourism and Labour.	Price controls for goods and services and for wage rates; ADO, petrol, kerosene, and LPG controlled goods in Tongatapu and Vava'u
Electricity Act 2007 Tonga Electric Power Board Act 2007	Electricity grid sector: TPL	Reformed the electricity sector, set up the Electricity Commission, and gave a concession contract

[91] Government of Tonga, Ministry of MEIDECC, Tonga Energy Roadmap. Tonga Department of Energy. https://tongaenergyroadmap.gov.to/?page_id=593.
[92] Government of Tonga. 2016. *Price and Wage Control Act of 1988*. 2016 Revised Edition. Nuku'alofa. https://tonga.tradeportal.org/media/PriceandWageControlAct_2.pdf.
[93] Government of Tonga. *Electricity Act 2007 (Act No. 11 of 2007)*. Nuku'alofa. http://extwprlegs1.fao.org/docs/pdf/ton110152.pdf; Tonga Power Limited. https://tongapower.to/.
[94] Government of Tonga, Electricity Commission. Policy. http://electricitycommission.to/policy/.
[95] Government of Tonga. 2008. *Renewable Energy Act 2008*. Nuku'alofa. https://ago.gov.to/cms/images/LEGISLATION/PRINCIPAL/2008/2008-0010/RenewableEnergyAct2008_1.pdf.

Electrical wiring bylaw Electrical contractor bylaws (revised 2007) Electricity (Amendment) Act 2010 (Act No. 37 of 2010)		to TPL to supply the island groups; authority to regulate electrical installations per by-laws; provides registration and permits, including certificates of completion of installation; new provision to include free importation of plant, machinery, mechanical appliances, etc., by the concessionaire for purpose of generating, distributing, or supplying electricity
Renewable Energy Act 2008	Renewable energy sector (off-grid): Department of Energy, MEIDECC	Act to regulate renewable energy use in Tonga, including the authority to establish the Renewable Energy Authority and the Renewable Energy Advisory Committee to consult on renewable energy matters
Consumer Protection Act[c] Consumer Protection (Product Safety & Labelling Standards) Regulations[d]	Energy efficiency sector: Ministry of Commerce, Tourism and Labour; joint implementation with the Department of Energy	Act to protect consumers, to establish fair trade practices, and to provide minimum energy performance and labelling standards
Tonga Energy Bill	Energy planning and coordination	A bill to develop a coherent institutional and policy framework for the energy sector

ADO = automotive diesel oil, LPG = liquefied petroleum gas, MEIDECC = Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications, TPL = Tonga Power Limited.
[a] Government of Tonga. 2003. *Consumption Tax Act 2003 (Act 29 of 2003)*. Nuku'alofa. https://ago.gov.to/cms/images/LEGISLATION/PRINCIPAL/2003/2003-0029/ConsumptionTaxAct2003_1.pdf.
[b] Government of Tonga, Ministry of Revenue & Customs. https://www.revenue.gov.to/.
[c] Government of Tonga. 2000. *Consumer Protection Act 2000 (Act 15 of 2000)*. Nuku'alofa. http://extwprlegs1.fao.org/docs/pdf/ton71129.pdf.
[d] Government of Tonga. 2016. *Consumer Protection (Product Safety & Labelling Standards) Regulations*. Chapter 40.08.1, 2016 Revised Edition. Nuku'alofa. https://tonga.tradeportal.org/media/ConsumerProtectionProductSafetyLabellingStandardsRegulations_2.pdf.
[e] Government of Tonga, Ministry of MEIDECC, Tonga Energy Roadmap. Tonga Energy Bill. https://tongaenergyroadmap.gov.to/?page_id=471.
Sources: Pacific Clean Energy Financial Potential project team; Tonga Power Limited. https://www.tongapower.to/.

Table A2.19: Policy Instruments in Tonga for Renewable Energy and Energy Efficiency

Title of Policy	Implementing Agency	Description
Renewable Energy Policy Framework 2006	MEIDECC	Policy adopted in 2006 to establish a vision and goal for sufficient renewable energy systems that will be socially, financially, economically, technically, politically, and environmentally sustainable
Tonga Energy Roadmap 2010–2020	MEIDECC	Set renewable-energy targets: 50% reduction in petroleum use and improved energy efficiency by 18%
Tonga's Second Nationally Determined Contribution 2020[a]	Department of Climate Change, MEIDECC [b]	Committed to emission reduction, a transition to 70% renewable

		electricity, and other energy efficiency measures[a]
Tonga Strategic Development Framework 2015–2025.[c]	Ministry of Finance and National Planning	Outlines the government's key priorities and plans for infrastructural improvement in energy, water, waste, and transport; among priority projects: additional solar PV system for Tongatapu and grid-connected renewable energy for the outer islands
Net Billing Policy 2013	TPL	Policy to allow self-generation and feeding into the grid.

MEIDECC = Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications, PV = photovoltaic, TPL = Tonga Power Limited.
[a] Government of Tonga. 2020. *Tonga's Second Nationally Determined Contribution 2020: Submission under the Paris Agreement*. Nuku'alofa. https://pacificndc.org/sites/default/files/2020-12/Tonga%20Second%20NDC.pdf.
[b] Government of Tonga, MEIDECC, Department of Climate Change. https://climatechange.gov.to/?p=5031.
[c] Government of Tonga, Ministry of Finance and National Planning. 2015. *Tonga Strategic Development Framework 2015–2025*. Nuku'alofa. http://www.finance.gov.to/sites/default/files/2020-09/Tonga%20Strategic%20Development%20Framework%202015-2025.pdf.
Source: The Pacific Clean Energy Financial Potential project team.

Fiscal incentives

Fiscal incentives are available to energy consumers in the form of tax reductions, grants, and subsidies to support various energy activities of households and businesses. Incentives are provided by the government to ease the costs of renewable-energy and energy-efficiency technologies entering the market, and to encourage investment in services to improve efficiency, standards, and quality. The energy incentives in Tonga are provided in monetary and nonmonetary forms (Table A2.20).

Table A2.20: Fiscal Incentives for Renewable Energy and Energy Efficiency

Type of Incentive	Purpose	Implementing Agency
Customs taxes and duties[a]	Exemptions for all equipment for electricity generation, including renewable energy[b]	Ministry of Revenue and Customs
Investment incentives in 2014–2015	Exemptions and reduced import tariffs on building materials; capital goods charged 3% duty with possible payment by installment; solar PV materials eligible as building parts and materials	Ministry of Finance and Planning
Consumption tax	Exemption of equipment used for tourism or manufacturing; possible inclusion of renewable-energy technologies (solar water heaters, solar panels, batteries) for hotels and resorts[c]	Ministry of Revenue and Customs in collaboration with Ministry of Tourism
Public financing in the form of direct grants	Renewable-energy and energy-efficiency projects directly funded by the government and development partners.	MEIDECC, Ministry of Finance and Planning
Excise tax	Reduced excise tax for fuel-efficient vehicles	Ministry of Revenue and Customs

Lifeline tariff	Subsidies totaling approximately T$1 million annually starting in 2015.	TPL
Duty tax for power generation	Exemption from excise tax on diesel for power generation	Ministry of Revenue and Customs

MEIDECC = Tonga Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications; PV = photovoltaic; T$ = pa'angan (Tongan national currency), TPL = Tonga Power Limited.

[a] Government of Tonga, Ministry of Revenue & Customs. About Tax Legislations. https://www.revenue.gov.to/Tax-Legislations.

[b] Government of Tonga. *Electricity Act 2007 (Act No. 11 of 2007)*. Nuku'alofa. http://extwprlegs1.fao.org/docs/pdf/ton110152.pdf.

[c] Government of Tonga. 2016. *The Special Order for Duty & Consumption Tax exemption Tourism & Manufacturing until 16 July 2016*. Nuku'alofa.

Source: Pacific Clean Energy Financial Potential project team.

6.2.3 Tariffs

The electricity tariff in Tonga is one of the highest in the region. A uniform tariff is charged to all electricity consumers, and it has a fuel and nonfuel component. The fuel component of the tariff is adjusted regularly to forecast fuel costs and electricity demand, taking into account previous under-recovery and over-recovery rates. The nonfuel component is adjusted for annual inflation over the tariff period, referencing consumer price index. The tariff charged to customers at the beginning of 2019/20 was $0.35 (T$0.799) per unit and was lowered to $0.32 (T$0.73) by April 2020. A lifeline tariff for residential customers consuming up to 100 kWh per month has been subsidized by the government since 2015.

6.2.4 Relevant support programmes

Loans supported by the International Union for Conservation of Nature

In 2013, the International Union for Conservation of Nature signed a memorandum of understanding with the Tonga Development Bank on building capacity for energy loans. The project aimed to reduce the impact of fossil fuel imports on Tonga's economy by encouraging private sector investment in renewable energy. Project implementation covered one year, and the loan products were primarily personal and business loans for the purchase of energy-efficient equipment and appliances, with a 30% subsidy.

Government development loans are being offered through a 5-year facility (2020-2025) funded by the government and administered by the Tonga Development Bank. The total funding for this facility is approximately $8 million (T$18 million), and will be used for low-interest (3%) loans to support economic growth in agriculture, tourism, utilities, manufacturing, education, and overseas medical services. The loans vary from T$20,000 to T$500,000, with payback period of up to 5 years, depending on the loan conditions.

The South Pacific Business Development microfinance network helps small entrepreneurs, women, and rural households get better access to finance. This initiative is a partnership between the International Finance Corporation (IFC) and the Australian government. It operates in Tonga, Fiji, Samoa, and the Solomon Islands, offering small loans with no required collateral.[96]

There are also loan facilities administered by national development banks across the region (though mainly in the Federated States of Micronesia, Marshall Islands, and Palau) from which

[96] South Pacific Business Development (SPBD). Tonga: What is the Need and Extent of Poverty in Tonga? http://www.spbdmicrofinance.com/spbd-network/tonga.

lessons can be learned about improving access to finance for energy security, energy efficiency, and renewable energy deployment.

6.3 Estimation of Demand

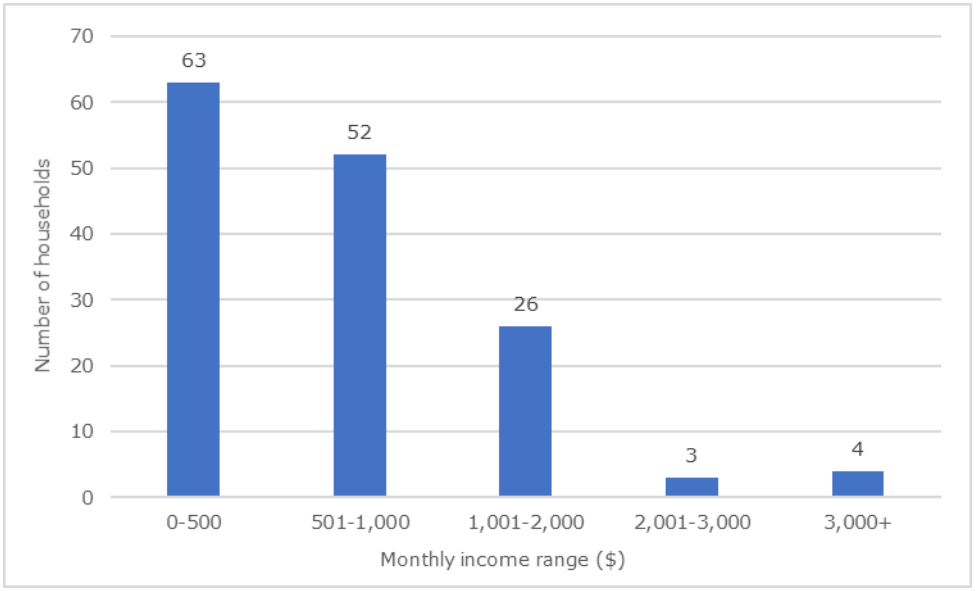
6.3.1 Income and expenditure

A household willingness-to-pay survey conducted for this study in 2021 found substantial differences between grid-connected and off-grid households when it came to income opportunities and expenditure behavior. It also found a segment of the community that had no purchasing power at all and were heavily reliant on the family and the community to meet their daily needs.

Urban grid-connected households

The survey conducted for this study found that monthly household incomes in urban areas varied between $13 and $8,800, with an average income of $791 and a median income of $629 (Figure A2.12). This result indicated an unequal distribution of wealth in which a plurality of households was in the lowest category. Of the total, 36% (54 households) were living below the poverty line and could not pay for any energy products and services. These households merit significant support to ensure that they enjoy the same benefits as the other households.

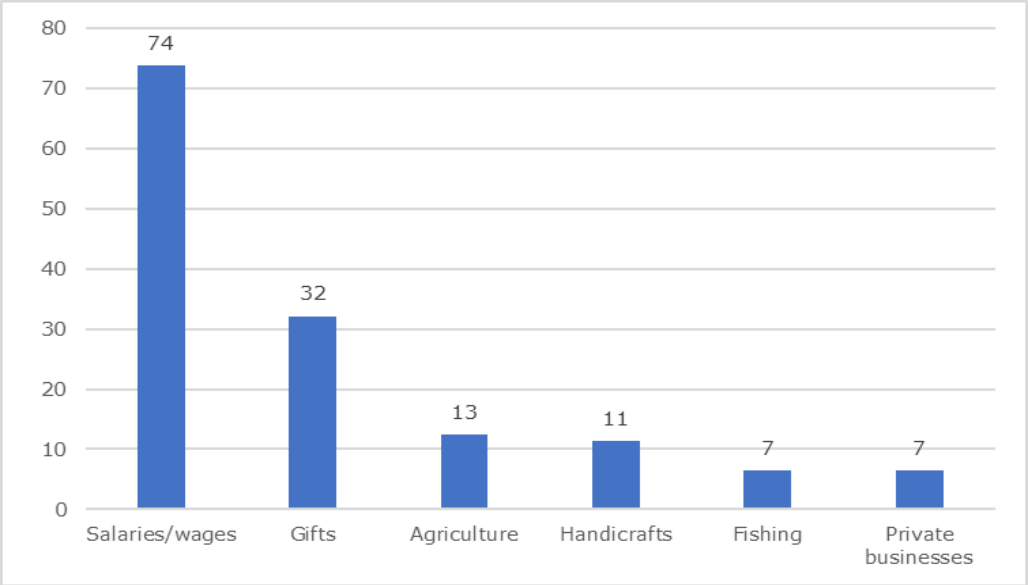
Figure A2.12: Monthly Cash Incomes in Grid-Connected Households in Tonga



Source: Survey by the Pacific Clean Energy Financial Potential project team.

Household income was influenced by various factors, such as employment, gifts and remittances, sales of handicrafts, crops, and the catch of the day (Figure A2.13). The employment level was relatively high (69%); remittances (32%) were the second-highest contributor to grid-connected household incomes; and two-thirds of the households depended on more than one income to sustain them.

Figure A2.13: Sources of Income for Grid-Connected Households in Tonga (%)



Note: Each bar in this graph indicates the percentage of grid-connected households that claimed the associated category as one of their sources of income or as their only income.
Source: Survey by the 'Pacific Clean Energy Financial Potential project team.

A financing facility would presumably work best with those in the lower segment of the grid-connected community who are employed (in the formal or informal sector), as this group would be able to repay their loans. However, these borrowers would actually belong to the high-risk category, so more creative options and solutions should be considered.

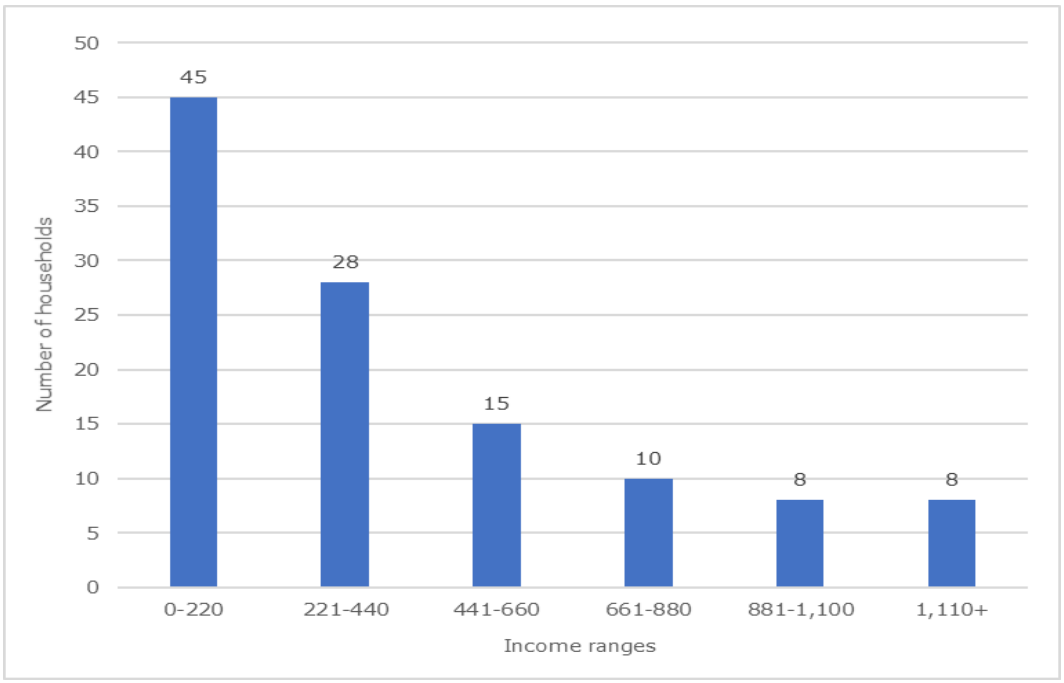
Data on spending provides an insight into household consumption behavior and priorities. Balancing income and expenditure is a skill that is very critical for sustaining household resources. Grid-connected households spend $300 to $400 of their monthly income on food, utility bills (including for electricity), transport, and other expenditures (including electricity consumption). Large households spend more on energy consumption (up to $260 per month), as they tend to use many appliances and inefficient lightbulbs.

The comparison between monthly incomes and monthly expenditures for the grid-connected households showed that 27% of them (31) did not have any savings. These households were usually larger in size (at least five members), with monthly electricity bills exceeding $44 (T$100), revealing a level of poverty in the community and the need for financial assistance.

Rural off-grid households

The monthly incomes of off-grid households varied from $31 to $3,586, with an average of $472, which was 53% higher than the median income ($308). Again, the distribution of wealth was found to be unequal, with most households earning the lowest monthly income (Figure A2.14).

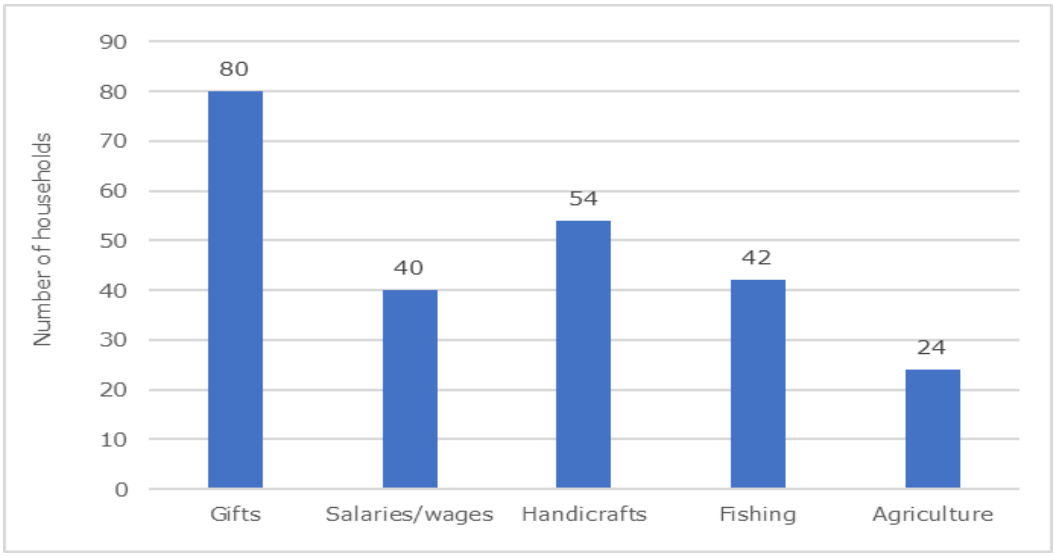
Figure A2.14: Distribution of Monthly Cash Incomes in Off-Grid Households in Tonga



Source: Survey by the Pacific Clean Energy Financial Potential project team.

Due to lack of formal employment opportunities, 70% of rural outer-island households were relying heavily on gifts (including remittances) from family members abroad as one of their sources of income. Over two-thirds were self-employed at the time of the survey, generally engaging in fishing, handicraft production, farming, and other activities to earn a living (Figure A2.3).

Figure A2.3: Sources of Income for Off-Grid Households in Tonga



Note: Each bar in this graph indicates the number of off-grid households that claimed the associated category as one of their sources of income or as their only income
Source: Survey by the 'Pacific Clean Energy Financial Potential project team.

The income data for off-grid households provided strong evidence of the need for financial assistance. Considering that household incomes are often irregular, the terms and conditions of any loans will need to be very flexible, and nonmonetary forms of repayment may have to be considered. However, it should be noted that the high level of remittances sent to rural households may dissuade them from applying for a loan, as their chances of receiving enough money to pay for an appliance may be quite high.

The spending behavior for off-grid households is somewhat similar to that of the grid-connected households in terms of allocations, but they differed significantly when it came to priorities. The outer-island rural households spent an average of $300 a month on fishing and related activities (boat maintenance, fishing gear maintenance, etc.), including interisland travel.

When incomes and expenditures were both checked, the results showed that most households were able to save, but others could not, and it was clear that the households without savings would need financial support if they ever decide to purchase solar products, equipment, and systems.

6.3.2 Appliance and equipment inventory

Urban grid-connected households

A wide range of household appliances for heating, cooling, lighting, and entertainment were found in surveyed grid-connected households (Table A2.21). The five most common household appliances were radios, TVs, refrigerators, hot kettles, and freezers. A range of lighting equipment was also observed (Table A2.22). However, more than half of the grid-connected households were still using incandescent light bulbs.

These results provide an incentive to continue with campaigns to raise public awareness of energy-efficient appliances, and to engage in market interventions such as subsidy and rebate programs.

Table A2.21: Ownership of Appliances in Grid-Connected Households in Tonga

Appliance	Number in Operation	Households Owning Appliance (%)
Fans	207	61
Radios	154	79
Televisions	158	78
Freezers	117	64
Refrigerators	136	76
Solar lighting	32	7
Kettles for hot water	135	74
Cooking tops	108	45
Air conditioners	23	8
Microwave ovens	83	45
Hot water systems	57	30
Irons, blenders, solar pumps	50	18
Total	**1,260**	

Notes:
1.The values in this table are based on 168 surveyed households.
2. A blank cell indicates that a column head does not apply.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

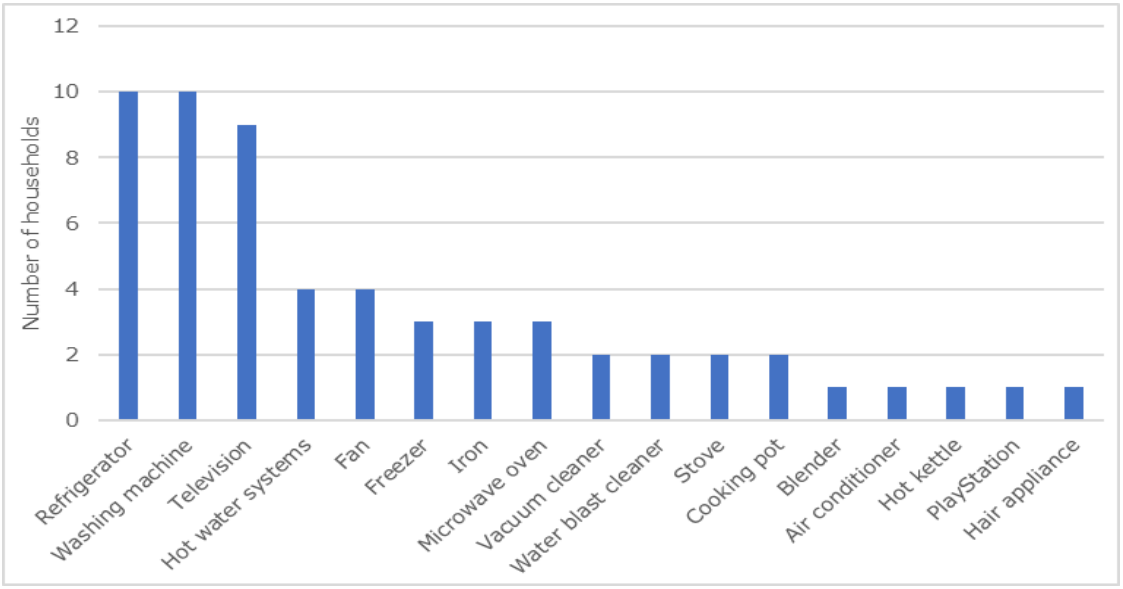
Table A2.22: Lighting Equipment in Use in Grid-Connected Households in Tonga

Type of Lighting	Number in Operation	Household Ownership (%)
Incandescent	545	95
CFLs	304	39
LFLs	432	51
LED	313	15
Total	**1,594**	

CFL = compact fluorescent lamp, LED = light emitting diode, LFL = LED flat light.
Notes:
1.The values in this table are based on 168 surveyed households.
2. A blank cell indicates that a column head does not apply.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

The appliance purchase histories of the surveyed households revealed that most appliances in operation were less than five years old, although it is interesting to note that appliances purchased 20 years before were still operational. In terms of the next appliance purchase, the most common choices were a refrigerator, washing machine, and TV, among others (Figure A2.16).

Figure A2.16: Next Planned Appliance Purchases for Grid-Connected Households in Tonga

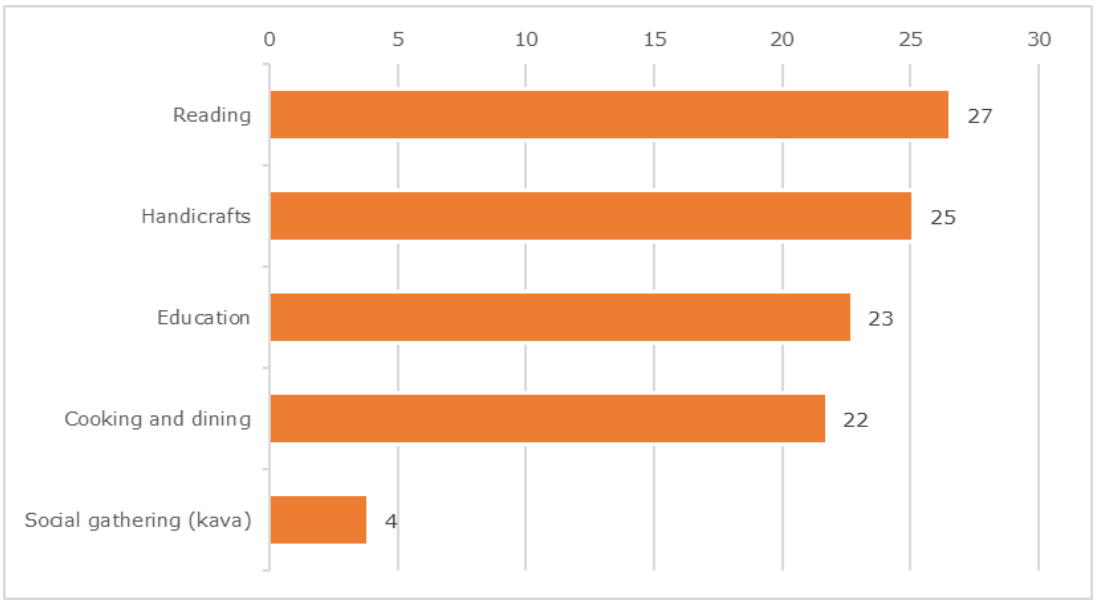


Source: Survey by the Pacific Clean Energy Financial Potential project team.

Rural off-grid households

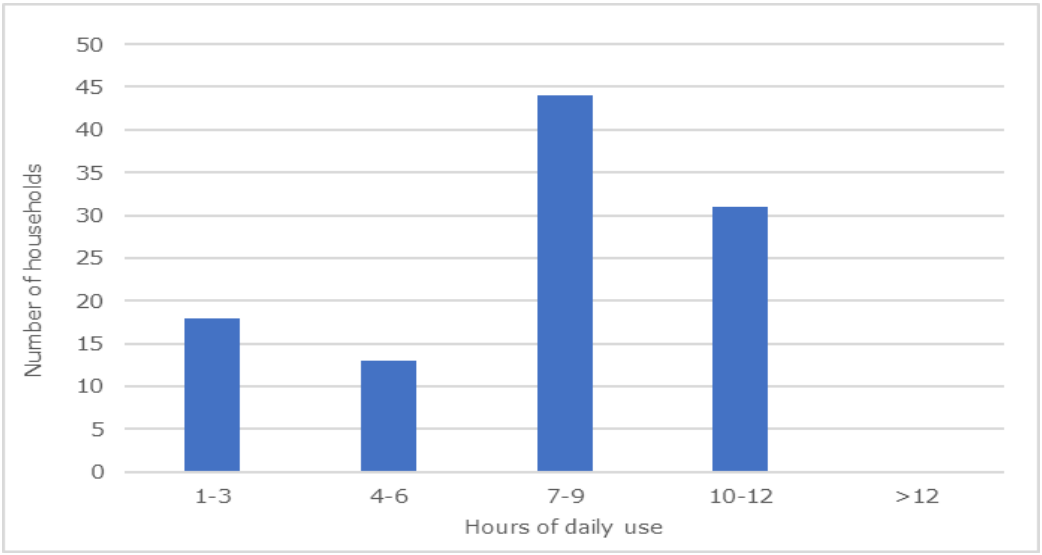
There is significantly greater demand among off-grid households for solar lanterns than for other electrical appliances or equipment (e.g., radios, fans, TVs, refrigerators, and washing machines), despite already owning other types of lighting fixtures. This demand can be further explored to determine the best way to support to these households, given that lighting apparently serves as a lifeline for outer-island rural communities (Figure A2.17 and Figure A2.18). Various mobile solar-lighting technologies can be tested with a small segment of the community. Plug-and-play systems can also be considered for testing in the outer islands.

Figure A2.17: Uses of Lighting Equipment in Off-Grid Households in Tonga (%)



Source: Survey by the Pacific Clean Energy Financial Potential project team.

Figure A2.18: Hours of Lighting Equipment Use in Off-Grid Households in Tonga

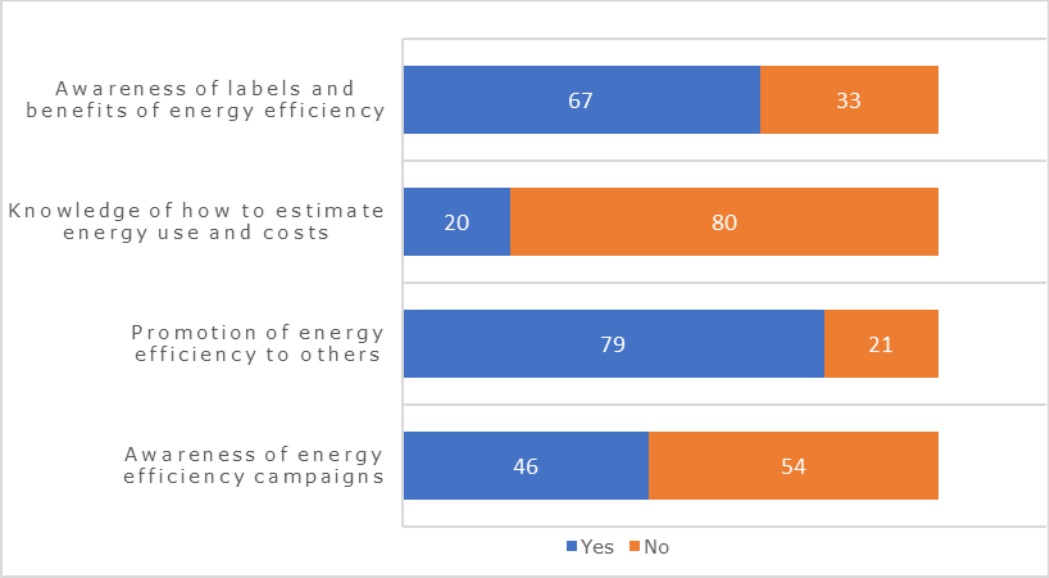


Source: Survey by the Pacific Clean Energy Financial Potential project team.

6.3.3 Awareness of energy efficiency

Awareness of the benefits of energy efficiency is relatively high (67%), and the perception of the value of energy efficiency is at a similar level among grid-connected households. However, their understanding of energy efficiency labels is extremely low (20%). Despite this, 79% are willing to promote energy efficiency to others (Figure A2.19).

Figure A2.19: Awareness of Energy Efficiency in Grid-Connected Households in Tonga (%)



Source: Survey by the Pacific Clean Energy Financial Potential project team.

Awareness amongst off-grid households of the benefits of energy efficiency is very low. There should be a nationwide campaign to raise household awareness of the economic and environmental benefits of using energy-efficient appliances. The involvement of suppliers and distributors of solar products and energy-efficient appliances would be essential for the success of such an initiative.

6.3.4 Costs of ownership

There are many factors that affect the operation of an electrical appliance, including price, running costs (e.g., electricity bills), repair and maintenance, and the cost of replacement, among others. The costs of solar products and of energy-efficient appliances offered by Tongan suppliers and distributers are shown in Table A2.23.

Table A2.23: Costs of Solar Home Systems and Energy-Efficient Appliances in Tonga

Product	Cost ($)
Mini solar home systems (E.M. Jones)	220
Mobile white goods, lighting fixtures, dryers, microwave ovens, etc. (Lords Mobile)	44–1,320
Home appliances (E.M. Jones)	440–1,760
LED tubes, fans (Dexing Hardware)	4, 7, 20
Freezers (Luna'Eva)	660

LED = light-emitting diode.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

Table A2.24 lists scenarios based on the purchase of various appliances and their cost-of-ownership implications for a household in Tonga.

Table A2.24: Comparative Estimated Costs of Ownership of Selected Appliances in Tonga

Appliance Type	Current Market Price/Payment Type	Energy Consumption (kWh/year)	Annual Cost	Expected Repair Period	Replacement/ Warranty
LG 279L refrigerator (3 stars)	$703 (T$1,598) or 3-month laybuy.	290	$93 (T$212)	Nil for first 7 years.	10-year warranty
Haier 365L top mount refrigerator (2.5 stars)	$703 (T$1,598)	440	$141 (T$321)	Nil first 2 years	2-year warranty
LG 441L refrigerator (4 stars)	$1,100 (T$2,500)	327	$105 (T$239)	Nil for first 7 years	10-year warranty
LG 668L refrigerator (3 stars)	$2,244 (T$5,100)	553	$177 (T$398)	Nil for first 7 years	10-year warranty
Fisher & Paykel 8 kg washing machine (4 stars)	$1,156 (T$2,627)	300	$96 (T$219)	Nil for first 2 years	2-year manufacturer's warranty

kg = kilogram, T$ = pa'anga (Tongan national currency).
Source: Survey by the Pacific Clean Energy Financial Potential project team.

The payment methods for purchases of white goods include: cash; hire purchase; or lay-buy for a period of 3 months, depending on the retailer's policy. It is clear from the estimates that the up-front cost of a star-rated appliance will be much higher than the running costs. The benefits of energy-efficient appliances are, in fact, the low running costs and longer warranty periods. However, given the low purchasing power of poor households, based on their savings, the up-front costs of energy-efficient appliances are very high for them; they are also very high for middle-income households. A financing facility could benefit these households, and an ongoing public awareness campaign should be an important component of such an initiative.

6.3.5 Willingness to pay

Urban grid-connected households

The responses of grid-connected households regarding their willingness to pay (WTP) more for energy-efficient appliances were mixed. Most households (71%) said that they would be willing to pay more, but when asked if they would be willing to take out a loan or pay through a hire purchase plan, 26% changed their minds and 33% were not sure if they would assume the risk (Figure A2..5). Moreover, of those who were willing to pay more, 38% had the resources to do so because their incomes were higher than the average for grid-connected households. Yet not all higher-income households gave positive responses, which means that a higher income cannot necessarily be equated with a WTP for more expensive appliances, or with a willingness to assume financial risk.

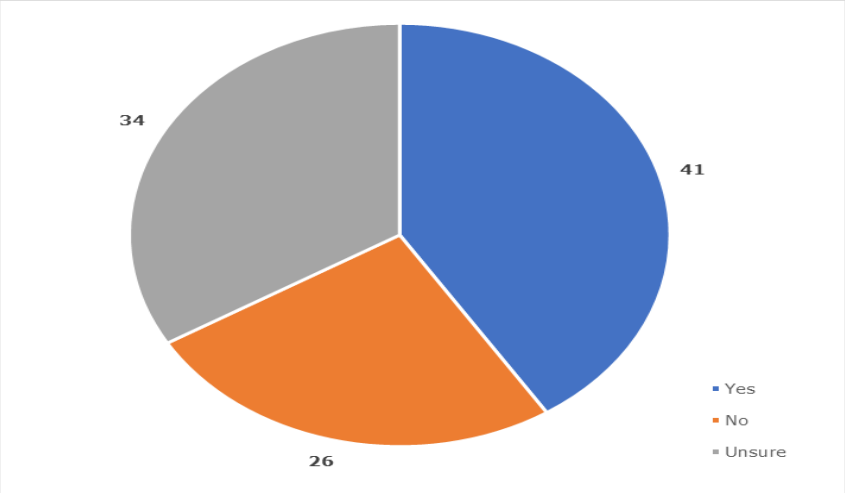
A range of acceptable price increases (in percentages) is shown in Table A2.25. The spectrum of increases is very wide, and the price increases of over 50% might not be realistic, considering the limited savings of grid-connected households. For instance, a 50% higher price for a refrigerator, freezer, or washing machine costing $1,000 in the local currency would render the appliance unaffordable for low- and middle-income households.

Table A2.25: Extent of Higher Costs Grid-Connected Households Were Willing to Pay for Energy-Efficient Appliances

Quantity of Households	1%–10%	11%–20%	21%–30%	31%–50%	51%–100%	Total
Number	24	28	28	24	21	**125**
Percentage	19	22	22	19	17	**100**[a]

[a] The percentages in this row do not actually add up to 100 due to rounding.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

Figure A2.4: Willingness of Grid-Connected Households to Take Out a Loan to Purchase Energy-Efficient Appliances (%)

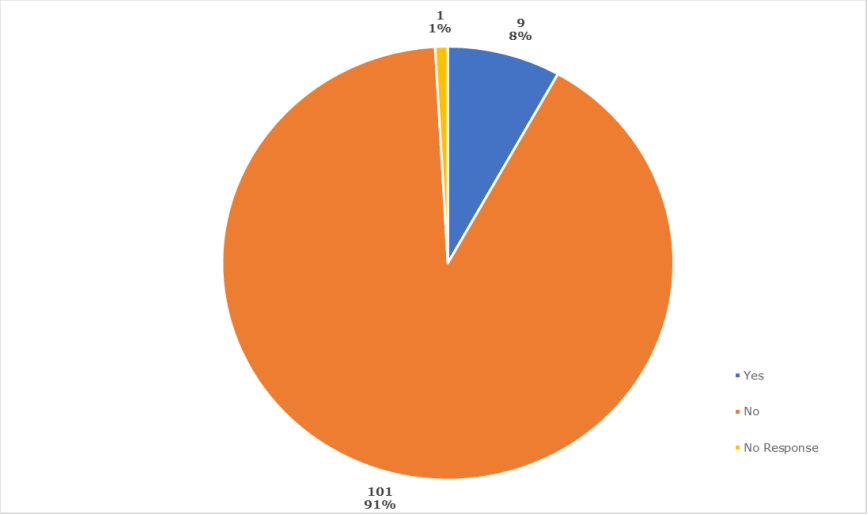


Source: Survey by the Pacific Clean Energy Financial Potential project team.

Rural off-grid households

The off-grid households' overall negative response to the idea of borrowing to pay for energy-efficient appliances was very high, at 91% (Figure A2.6). This lack of WTP reflected their lower incomes and higher dependency on remittances, as well as their long history of dependency on government grants for solar home systems (SHSs) from an outer-island electrification program.

Figure A2.5: Willingness of Off-Grid Households to Take Out a Loan to Purchase Solar Products

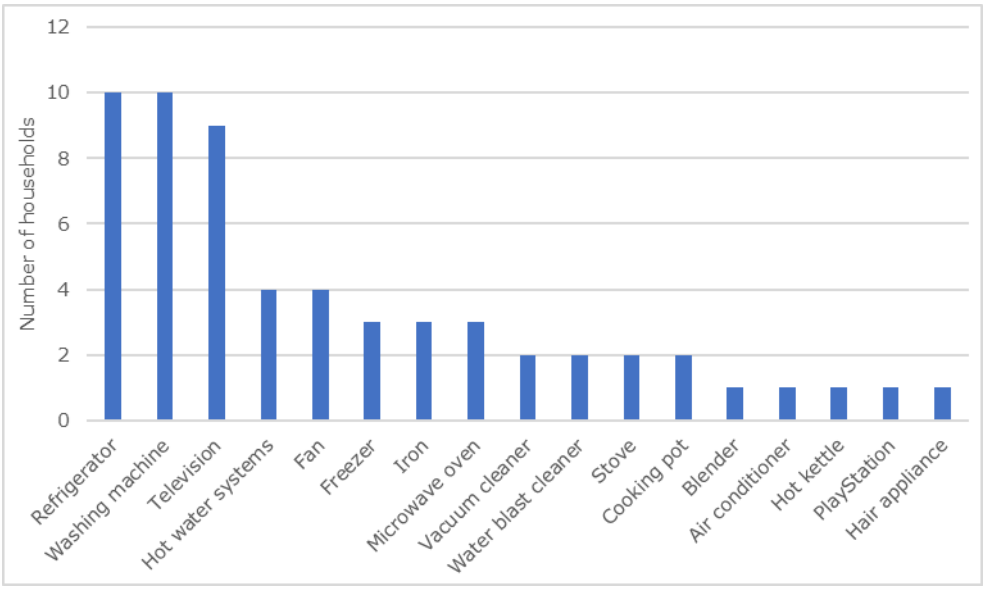


Note: The first value in each section represents the actual number of respondents, and the second represents the percentage of all respondents from off-grid households in Tonga.
Source: Survey by Pacific Clean Energy Financial Potential project team.

6.3.6 Demand forecast

The plans of grid-connected households for their next appliance purchases showed that they preferred refrigerators, washing machines, televisions, and hot water systems (Figure A2.7).

Figure A2.6: Next Planned Appliance Purchases for Grid-Connected Households in Tonga



Source: Survey by Pacific Clean Energy Financial Potential project team.

6.4 Market Overview

6.4.1 Suppliers

The number of outlets and distributors of electrical appliances and equipment is very limited in Tonga. All local and foreign electrical retailers and wholesalers must register with, and be issued a license by, the Ministry of Commerce. Foreign companies operating locally must also have an immigration permit to operate and employ foreigners, if necessary.

All qualified electricians must register with the Electricity Commission and be issued a license to practice; and this license must be periodically renewed according to its specific terms and conditions. The Electricity Commission also issues electricity bylaws and concession contracts. There are 31 registered contractors and the country's sole supplier of grid electricity, Tonga Power Limited (TPL).

All electrical appliances and renewable-energy equipment are imported, as Tonga does not have a local manufacturer of energy equipment. The prices and countries of origin of the white goods and electrical products sold at the local stores vary depending on the origin of the foreign business partners of the local suppliers (Table A2.26 and Table A2.27).

Table A2.26: Suppliers and Distributors of Renewable-Energy Products in Tonga

Supplier	Product / Support Services	Product / Service Costs/ Countries of Origin
E.M. Jones	Mini-solar home systems. Distribution only.	$220 (T$500) per system
Kingdom Energy & Electrical Services	DC 12 V/15 A charge and discharge controllers, and DC light bulbs in stock Registered electrical contractor offering all types of electrical work, including solar installations (mostly small scale to mini-grids), repair and maintenance services for solar installations, and general electrical work on both AC and DC systems	Mostly New Zealand and the PRC
JH Electrical	Lights, fittings, wires, tools, switches, switchboards, etc. Also installations, upgrades, house wiring, appliance repair, solar home systems	Varied pricing, depending on product quality; service price quotations available Origin: Australia, New Zealand, PRC
Vaitohi Enterprises	Solar batteries, by customer order	Price and charges depending on product and service type Origin: New Zealand
'Ofa Construction Limited	Contractors only; experience with renewable energy donor-funded projects; registered electrical contractors who can install whole solar-energy systems, from panels to storage installations.	Pricing depending on the type of work Origin: Japan (mainly)
Vete Electronics	Customer orders only: solar-energy systems Capable of installing solar-energy systems	Pricing subject to the type of work Origin: Australia, Fiji, Europe, New Zealand, PRC, United States

A = amperes, AC = alternate current, DC = direct current, PRC = People's Republic of China, T$ = Tongan pa'anga; V = volts.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

Table A2.27: Suppliers and Distributors of Electrical Appliances and Equipment in Tonga

Supplier / Products / Services	Customer Types / Prices	Countries of Origin
Lords Mobile White goods (freezers, refrigerators, air conditioners), LED lights, microwave ovens, dryers, irons, etc.	Households, businesses, communities, churches, schools Price range: $44–$1,320 (T$100–T$3,000)	Hong Kong, China; PRC; Singapore.
Pacific Timber & Hardware Lighting and electrical equipment (wires, switches, plugs)	Households, businesses (electrical contractors, etc.) Prices for LED lighting: $3–$35 (T$7–T$80)	Australia, Fiji, New Zealand, PRC, US
Top Tile Company LED lighting, wires, switches, plugs, electric water heaters	Households, electrical contractors, businesses Prices for LED lighting: $8–$11 (T$18–T$24)	PRC
W&D Electrical LED lighting, fans.	Households, businesses Price range for LED bulbs: $2–$5 (T$5–T$12); price range for LED floodlights: $35–$308 (T$80–T$700)	Australia, Fiji, New Zealand, PRC
Vete Electronics Four types of white goods; security systems, sound systems, TVs, radios	Households, businesses, communities Prices varying by product range; products directly ordered by customers	Australia, Fiji, New Zealand, PRC, US
Luna'Eva Hardware Store LED lighting, air conditioners, refrigerators, freezers, fans, electrical tools and equipment	Households, businesses, communities LED downlights: $9 (T$20); freezers $660 (T$1,500)	New Zealand, PRC
E.M. Jones All types of white goods, LED lights, fans, stoves, TVs, generators, electrical tools and equipment	Households, businesses LED lights: $18–$24 (T$40–T$55); other home appliances: $440–$1,760 (T$1,000–T$4,000)	Australia, New Zealand, PRC
Dexing Hardware LED lights, fans	Households, businesses LED tubes: $7 and $20 (T$15 and T$45); bulbs: $4 (T$10)	PRC
JH Electrical Lights, fittings, wires, tools, switches, switchboard, etc.; installations, upgrades, house wiring, appliance repairs	Households, businesses, electrical contractors, communities, schools Prices varying according to product quality; service price quotations available	Australia, New Zealand, PRC

LED = light emitting diode, PRC = People's Republic of China, T$ = Tongan pa'anga (Tongan national currency), TV = television, US = United States.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

6.4.2 Lending agencies

The financial institutions in Tonga comprise of 4 commercial banks, 10 licensed money exchange agencies (both inward and outward), 5 inward remittance-only agents, and 3 foreign

exchange dealers operating under a banking license.[97] All financial institutions must be registered and licensed by the National Reserve Bank of Tonga.

Business and household loans have declined during the COVID-19 period. However, total loans by nonbank financial institutions have increased by 1.1% (footnote 97). This reflects the limited access to finance in the banking sector, but it could also mean that household debt will grow.

There are five lending institutions providing loan products to businesses and households for a variety of purposes. These products also include lending for purchases of energy-efficient household appliances and renewable-energy equipment and systems (Table A2.28).

Table A2.28: Inventory of Lending Agencies and Services in Tonga

Tonga Development Bank
• Term loans are available to both homeowners and businesses that require financing for the installation of energy-efficient appliances and renewable-energy systems with energy star ratings (New Zealand Standard), such as washing machines, refrigerators, freezers, air conditioners, solar-energy systems, electric light fittings and light bulbs, and flat-screen TVs. The only suppliers of these appliances working with the Tonga Development Bank are Courts and E.M. Jones, where customers can get their invoices to submit to the bank. The loan officers ensure that the appliances to be purchased rate at least three stars and that they satisfy the energy-efficiency rating requirements (New Zealand Standard). • Under the EESL program, financing is available through personal and business loans for the purchase and installation of energy-efficient systems and home appliances, along with a subsidy amounting to 30% of the cost of the product. Since 22 December 2014, the program's funding has been provided by the IUCN.
Tonga Retirement Fund Board
• The Retirement Fund Board offers personal loans for various purchases, such as electrical appliances, solar hot-water units, and vehicles. The size of a loan is usually determined by the borrower's income; for instance, some borrowers have received up to $30,000, with a payback period of 4 years (maximum) and interest rates ranging from 6% to 16%. • The Retirement Fund Board serves mostly civil servants and public utility employees.
Bank South Pacific
Bank South Pacific's services include: • unsecured personal loans for immediate short-term needs, for a fixed interest rate of 18.5% per year; • secured personal loans, for a fixed interest trate of 14% per year; and • small business loans, for a fixed rate of 15% per year.
Australia and New Zealand Banking Group
• Personal loans are available.
Bank Negara Malaysia
• Personal loans are available.

EESL = Energy Efficiency Subsidy Loan, IUCN = International Union for Conservation of Nature.
Source: Survey by the Pacific Clean Energy Financial Potential project team.

At the other end of the spectrum are smaller lending agencies that serve the microfinance market and customers who are ineligible for bank loans. The risks are much higher in this market, but the agencies adapt to each customer's requirements by using various techniques to secure collateral and ensure repayment. This lending market accepts as collateral and/or repayment all forms of traditional crafts (e.g., mats, tapa cloth, etc.), personal property (e.g., jewelry, vehicles), agricultural produce, and even the catch of the day, among other things.

[97] National Reserve Bank of Tonga. Banking Sector Development for September 2021. http://www.reservebank.to/index.php/economic/banking.html.

A financing facility for poor and low-income households should consider easy and simple requirements and processes for poor customers who do not have cash resources but may have other valuable assets.

6.5 Opportunities for Local Operations and Management and Job Creation

6.5.1 Repair services

Repair and maintenance services are limited, and in some areas completely absent (e.g., the Ha'apai island group). The cost of repairs for households vary between $22 and $220 per month. Repair services are essential for sustaining the lifetime and service of electrical appliances. Market support will be needed to provide training opportunities and financial support to those individuals with the skills to establish a business. There are 33 registered electricians in the labor market, but most of them are contractors who work on construction sites. The market survey found suppliers who provided maintenance services for renewable-energy systems, but very few of them offer repair services for household appliances such as refrigerators, freezers, and air conditioners. In the outer islands, repair services are non-existent.

As for rural off-grid households, the existing solar equipment is serviced regularly by local island technicians hired by the Department of Energy, and households pay a minimum fee for this service.

Opportunities to strengthen the local O&M market should involve incentives and possibly subsidies for young skilled entrepreneurs to help them set up repair shops. Funding should be made available through the banking system (e.g., Tonga Development Bank) or through nonbank lending agents.

6.5.2 Capacity needs

There is a general shortage of skilled electricians and technicians who can repair refrigerators, washing machines, air conditioners, and freezers. This skill is an industry-specific one, so local retailers and suppliers of these appliances will need help in establishing a twinning arrangement with the manufacturers (e.g., Fisher & Paykel) to provide further training to local technicians when new technologies enter the market.

In terms of ongoing training, the Tonga Institute of Higher Education provides programs for trade-related skills in electrical, plumbing, and technical trades. The funding of new programs and scholarships to broaden the enrollment register of skilled technicians would benefit from a targeted financing facility. Special attention and opportunities should be given to female trainees.

6.6 Development Partners

Tonga's energy sector development has grown exponentially over the past decade due to significant support by development partners through bilateral and multilateral arrangements. Development partners have collaborated to improve efficiency of project delivery. The following electricity sector projects are examples of ongoing development and collaboration between the Government of Tonga and its Development Partners to improve energy service access, enhance energy efficiency, and improve service provision in the electricity sector (Table A2.29).

Table A2.29: Past and Ongoing Energy Projects in the Electricity Sector funded by Tonga's Development Partners

Project	Objectives / Activities / Locations / Cost / Funding	Development Partners
Tonga Renewable Energy Project [a]	Support for the TERM's achievement of its 50% renewable energy target, reduction of emissions by 13,616 tons annually, saving of 4.17 million liters of fuel per year Total cost: $53.2 million Funding: GCF, $29.9 million; ADB, $12.2 million; GoT, $5.60 million; TPL, $3 million	ADB, GCF, DFAT.
Outer Island Renewable Energy Project [b]	Installation of solar power (1.32 MWp) on nine outer islands; grid-connected systems in 'Eua, Ha'apai, and Vava'u; and mini-grid systems in 'Uiha, Nomuka, Ha'afeva, and Ha'ano Total cost: $6.8million Funding: DFAT, $4.5million; ADB, $2 million; GoT, $300,000	ADB, DFAT
Nuku'alofa Network Upgrade Project [c]	Upgrade and modernization of the electricity network in the Nuku'alofa area to reduce losses, increase access, and provide safe and reliable electricity supply to 8,472 households and businesses in the greater Nuku'alofa area Total cost: NZ$20.3 million Funding: NZ$11 million, MFAT; NZ$9.3 million, ADB	ADB, MFAT
6MW IPP Project[d]	Power purchase agreement with Sunergise Ltd to produce power at three sites in the Western District of Tongatapu Island (2.3 MW from each site), and then sell it back to the grid for period of 25 years	Private funding
Our Renewable Energy Plants[e]	Maama Mai solar farm (1.32 MW), Popua, Tongatapu, 2012 Funding: NZ$7.9 million	NZAID
	Mata 'o e La'a solar farm (1 MW), Vaini, Tongatapu, 2015 Funding: $15 million	Government of Japan
	La'a Lahi solar farm (420 kW), Neiafu, Vava'u, 2013 Funding: $4.7 million	Government of the United Arab Emirates
	Ha Masani solar farm (550 kW), Ha'apai, 2016 Funding: $15 million	OIREP collaboration among ADB, DFAT, EU, Second Danish Cooperation Fund

	Huelo ‘o e Funga Fonua solar farm (200kW), ‘Ohonua, ‘Eau, in 2012 Funding $2.9 million	OIREP, DFAT
	Singyes Solar, IPP (2 MW), Matatoa, Tongatapu, 2011 Funding: $4.4 million, 25-year term	Private funding
	Ii ‘o Manu Mataongo wind farm (1.375 MW), 2018 Funding: $20 million	Government of Japan

ADB = Asian Development Bank, DFAT = Department of Foreign Affairs and Trade (Australia), EU = European Union, GCF = Green Climate Fund, GoT = Government of Tonga, IPP = independent power producer, kW = kilowatt; MFAT = Ministry of Foreign Affairs and Trade (New Zealand), MW = megawatt, MWp = megawatt-peak, NNUP = Nuku’alofa Network Upgrade Project, NZAID = New Zealand Aid Programme, NZ$ = New Zealand dollar; OIREP = Outer Island Renewable Energy Project, TERM = Tonga Energy Road Map, TPL = Tonga Power Limited, TREP = Tonga Renewable Energy Project.

[a] Tonga Power Limited. Tonga Renewable Energy Project. https://tongapower.to/TREP%20Project.

[b] Tonga Power Limited. Outer Island Renewable Energy Project. https://tongapower.to/OIREP.

[c] Tonga Power Limited. Nuku’alofa Network Upgrade Project. https://tongapower.to/Nuku%27alofa%20Network%20Upgrade%20Project.

[d] Tonga Power Limited. 6MW IPP Project. https://tongapower.to/6MW%20IPP%20Project.

[e] Tonga Power Limited. Our Renwable Energy Plants. https://tongapower.to/Clean%2C%20Green%2C%20Sustainable%20Power%20for%20Tonga.

Source: The Pacific Clean Energy Financial Potential project team.

7 VANUATU

7.1 Country Context

7.1.1 Macroeconomic overview

Demographics

The Republic of Vanuatu consists of more than 80 islands. Its population in 2020 was estimated at 290,000, dispersed across 65 islands. Three-quarters of the population lives in rural areas. Vanuatu is divided into six provinces, each with its own elected provincial government. The provinces are divided into municipalities, with municipal council boundaries usually aligning with individual islands, and these have local government responsibilities. The two largest urban centers are Port Vila, on the island of Efate, with a population of around 47,000; and Luganville, on the island of Espiritu Santo, with a population of around 18,000.

Urbanization is progressing slowly in Vanuatu, with 24% of residents living in urban areas. The urban population is growing slightly faster than the rural population (2.6% vs. 2.3%).[98] Population density overall is 22 people/km^2, but it is higher in the provinces with large urban populations, such as Shefa Province (where Port Vila is located), which has a density of 65 people/km^2. Around 11% of households were assessed as living in poverty in 2010. There is evidence of malnutrition among children, with 29% showing stunted growth.[99]

Gross Domestic Product

Vanuatu has enjoyed steady economic growth since the mid-2000s. GDP growth rose from 3.5% to 4.2% during 2016-2019. GDP per capita in 2019 was $3,058, higher than the GDP per capita of most Pacific Island Countries, almost twice of Kiribati's GDP per capita, but only two-thirds of Fiji's. Vanuatu's continuous progress has led to its graduation from least developed country (LDC) status on 4 December 2020.[100] Economic growth has traditionally been driven by tourism, public spending on infrastructure, the private sector (notably the construction industry), and aid flows. For Vanuatu, fish accounted for less than 3% of total exports during 2014-2019 and 3.6% in 2020. The increase in the value of fish exports from $0.3 million in 2019 to $1.7 million in 2020 is indicative of expanding Vanuatu's fishing sector from its relatively low base.[101]

The rural economy is engaged in subsistence farming and in limited production of copra, beef, cocoa, and kava for export.[102] However, Vanuatu's economy is fossil fuel-dependent; import of fossil fuels accounted for 9% of GDP in 2019.

Disaster resilience

Vanuatu ranks as one of the most vulnerable countries in the world with regards to natural disasters and the effects of climate change (World Risk Index score of 49.74).[103] Vanuatu is located along the tropical cyclone track and on the Pacific Ring of Fire, which means frequent

[98] Government of Vanuatu, National Statistics Office. 2017. *Vanuatu: 2016 Mini Census Report: Volume 1*. Port Vila, Vanuatu.
[99] Government of Vanuatu, National Statistics Office. 2014. *Vanuatu - Demographic Health Survey 2013*. Port Vila.
[100] UNCTAD. 2020. Vanuatu Graduates from Least Development Member Status. 4 December. https://unctad.org/news/vanuatu-graduates-least-developed-country-status.
[101] Government of Vanuatu, National Statistics Office. 2021. *2020 Vanuatu International Merchandise Trade*, Port Vila.
[102] ADB and the Government of Vanuatu. 2021. *Asian Development Bank Member Fact Sheet: Vanuatu*. N.p. https://think-asia.org/bitstream/handle/11540/13571/van-2020.pdf?sequence=1.
[103] United Nations University, 2021. *World Risk Index report (2020).* Tokyo.

earthquakes and tsunamis. Vanuatu suffered an average of 24 cyclones per decade since 1969/1970 and has experienced two category 5 cyclones (the highest intensity on the scale) since 2017. These events have severely impacted the country's infrastructure. Vanuatu is expected to average $48 million per year in losses due to earthquakes and tropical cyclones.[104] The vulnerability to economic and environmental disasters remains a permanent challenge and a threat to the country's structural economic transformation (footnote 100), thus, the country needs to improve its disaster and climate resilience programs. Vanuatu's economy contracted by 9.8% in 2020 because of the impacts of COVID-19 and Tropical Cyclone Harold, which hit the country in April 2020.[105]

7.1.2 Energy resources

Dependence on fuel imports

Vanuatu has no indigenous fossil fuel resources. The country imported 58.7 million liters of fossil fuel in 2019, equivalent to 24% of its total imports and 9% of its GDP.[106] Diesel-based power generation reached 76.6% of total power generation, consuming 33% of all imported diesel.[107]

Indigenous energy resources

Vanuatu does have good renewable energy resources, with development in its early stages (24.4% of total electricity production in 2019). There is some potential for hydropower development on various islands in Vanuatu, mostly mini-grid or microgrid sites, although a few utility-scale sites have been found. The main obstacles to further hydropower development include long distance from hydropower sites to the villages, heavy rains that accompany the cyclones, and the low O&M capacity in the villages. Like most PICs, Vanuatu has a substantial potential for electricity generation from solar PV systems. Annual sunshine hours are very high, at around 2,000-2,300 hours per year and solar insolation is estimated at about 6 kWh/m^2/day, based on satellite data.

Locally produced copra oil is used for electricity production in limited amounts in Port Vila and Malekula. The use of copra oil fluctuates with the variations in diesel and copra prices. During 2014-2016, it was relatively high, with a peak of just over 1 million liters in 2015. Production dropped to zero in 2017 due to the lack of a commercially reliable supply chain for copra oil, but it picked up again in 2018 and 2019, to nearly 320,000 liters per year (footnote 107). Utilities, especially Union Electrique du Vanuatu (UNELCO), are recommending the use of copra oil due to its benefits to the local coconut industry.[108]

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[104] World Bank, 2011. Pacific: Catastrophe Risk Assessment and Financing Initiative - *Vanuatu Country Risk Profile*. Brussels.

[105] ADB. 2021. *Asian Development Outlook 2021: Financing a Green and Inclusive Recovery.* Manila. https://www.adb.org/sites/default/files/publication/692111/ado2021.pdf.

[106] Government of Vanuatu, Department of Energy; Government of Vanuatu, National Statistics Office.

[107] Government of Vanuatu, Department of Energy; Government of Vanuatu, Utilities Regulatory Authority (URA). 2020. *Electricity Fact Sheet 2014–2019*. Port Vila. http://ura.gov.vu/attachments/article/97/Electricity%20Fact%20Sheet%202014%20-%202019%20-Final.pdf.

[108] UNELCO. Copra Oil: UNELCO is Developing the Production of Electricity from Renewable Sources with Local Rources. https://www.unelco.engie.com/en/commitments/objectives-on-renewable-energy/copra-oil.

7.2 Sector Overview

7.2.1 Sector performance

Problems

Vanuatu's energy sector faces three major challenges: low energy access and quality, vulnerability to fuel prices, and limited private sector participation. This is aggravated by a lower-than-average quality of the grid and of generation ratios (load factor, capacity factor, and availability factor). Under the business-as-usual (BAU) scenario, Vanuatu's consumption of imported petroleum products is expected to grow by 50% by 2030. This would reduce Vanuatu's energy security, worsen its balance of payments, expose local consumers to high and volatile energy costs, and increase greenhouse gas (GHG) emissions and other forms of pollution. Increasing energy efficiency is one of the main solutions to these problems, but despite the potential savings, consumers often fail to seek out energy-efficient appliances and equipment. The reasons include a lack of awareness of the benefits of energy efficiency, limited willingness on the part of consumers to change their behavior, and financial constraints. Vanuatu also has a range of other barriers that pose challenges to the uptake of energy efficiency, including technical, geographical, logistical, and legal barriers.

Energy access

Statistics from the ADB show that 64% of the population in Vanuatu had access to electricity in 2019. Further details gleaned from the updated National Energy Road Map (NERM) and provided by the Vanuatu National Statistics Office show that the percentage of those with access was boosted by households located in or near concession areas. At the national level, only 38% of households reported having electricity (from the main grid, solar energy, or from their own generators) as a main source of lighting. Outside the key urban areas (Port Vila and Luganville), under 20% of households had access to a main grid.[109]

Sector performance

In Vanuatu, electricity generation, transmission, and supply activities are not unbundled. The sector is organized under four private sector contracts that operate stand-alone island grids serving the urban areas of Port Vila, Luganville, Malekula Island, and Tanna Island. Rural areas and the outer islands are served by off-grid solutions, including solar lamps and chargers, solar home systems (SHSs), small diesel and petrol generators, and solar micro-grids and mini-grids.

Several factors contribute to the lack of private sector participation in Vanuatu. Three identified ones are the small size of the electrical systems under concession, the cross-subsidy mechanism in tariffs, and the insufficient regulatory and institutional framework for public–private partnerships and independent power producers (IPPs). The extent of energy demand in the four concession areas is small (Efate and Espiritu Santo) or very small (Tanna and Malekula), and this dampens the interest of investors. The application of the cross-subsidy mechanism in tariffs distorts the market and deters small businesses from using more electricity for fear of paying exorbitant electricity prices. A more integral regulatory and institutional approach towards public-private partnerships and IPPs is needed to promote them more effectively and provide clear and stable incentives to investors.

[109] Government of Vanuatu, National Statistics Office. Socio-Economic Atlas for Vanuatu, Section C. Household Living (Dwelling) Conditions. https://vnso.gov.vu/images/Special_Report/Vanuatu_Socio-Economic_Atlas/Household_Living_Dwelling_Conditions.pdf; Government of Vanuatu. 2016. *Updated Vanuatu National Energy Road Map 2016–2030*. Port Vila. https://www.nab.vu/sites/default/files/documents/NERM2016-30.compressed.pdf.

The concession in Efate (Port Vila) is operated by UNELCO, which is 51% owned by ENGIE and 49% by the Vanuatu National Provident Fund (VNPF). This concession, which expires in 2031, is the largest power system of the country. As of 2019, it was serving 15,407 customers in the city of Port Vila and several sections of the Efate Island (around 70% of the population living on the island). Total annual production of electricity in this concession is 66.04 GWh/year, with a peak demand of 12.40 MW. The generation capacity in this concession area includes: 20.80 MW from diesel generator sets, 3.80 MW from wind turbines, and 2.45 MW from solar PV energy systems. In terms of grid capacity, the concession has 270 km of transmission lines and 333 km of distribution lines. Tariff setting for this concession is not done by the Utility Regulatory Authority (URA), but by UNELCO, a private company that follows the specific provisions established in the concession contract. Recent experience suggests that UNELCO is unwilling to accommodate rooftop solar energy systems. UNELCO has the exclusive right to sell electricity within its concession area, although self-supply is allowed by law. Recent examples, such as the attempts by resorts to install their own solar PV systems while remaining connected to UNELCO's grid, suggest that UNELCO is reluctant to distribute electricity from solar PV systems.

Vanuatu Utilities & Infrastructure (VUI) operates the grid and the diesel and hydropower generation assets of Luganville, on Espiritu Santo Island, under a concession contract signed in June 2019 and expiring in 2040. VUI is a private utility that is a wholly owned subsidiary of the US-based construction company Pernix Group, Inc. As of 2019, this concession is the second largest in Vanuatu and was serving 3,941 customers in sections of Espiritu Santo (Luganville and Port Olry), Maewo, Vanua Lava, and Ambae islands. The annual production of electricity in this concession is 11.98 GWh/year, with a peak demand of 2.21 MW. The generation capacity in this concession area is 4.32 MW, of which, 3.08 MW is from diesel generator sets, 1.2 MW from hydropower plants, and 40 kW from solar PV systems. In terms of grid capacity, the concession has 80.9 km of transmission lines and 92.3 km of distribution lines.

The Department of Energy temporarily operates the grids of Tanna and Malekula islands until new concessions are procured. These concessions have been operated by UNELCO until July 2020 when the concession contracts expired. The concession on Malekula Island was serving 1,203 customers as of 2019. The annual production of electricity in this concession area is 1.05 GWh/year, with a peak demand of 250 kW. The generation capacity is 710 kW, of which, 690 kW comes from diesel generator sets and 20 kW from solar PV systems. In terms of grid capacity, the concession has 38 km of transmission lines and 33 km of distribution lines.

The concession on the island of Tanna was serving 1,510 customers as of end 2019. The annual production of electricity in this concession is 1.39 GWh/year, with a peak demand of 220 kW. The generation capacity in this concession area is 720 kW, of which, 690 kW is from diesel generator sets and 30 kW from solar PV systems. In terms of grid capacity, the concession has 22.4 km of transmission lines and 28.7 km of distribut*ion lines.*

Electricity generation

In 2019, for the country as a whole, 76.6% of grid-connected electricity generation was from diesel, providing 61.61 GWh of electricity. This was a small decrease compared with previous years: 63.31 GWh in 2017 and 62.40 in 2018. Total grid-connected electricity production in 2019 consisted of hydro (9.7%), wind (7.7%), solar (4.3%), and copra oil (1.8%). Year-on-year increases in 2018-2019 was 40.9% for wind, 13.5% for solar, and 2.2% for hydro, while diesel decreased by 1.27%. Renewable thermal generation using copra oil contributed an additional 1.8% to the energy mix in the concession areas.

Generation and grid capacities suffer delayed maintenance and lack of modernization by the undercapitalized utilities. UNELCO estimates that $5 to $10 million will be needed to extend and upgrade Port Vila's grid over the next 5-7 years, and $30 to $40 million to modernize the generation capacity and to prepare the system to integrate a larger share of renewables. UNELCO's tariff includes Vt500 million (just under $5 million) in annual charges dedicated to investments for a five-year period. However, this is much lower than what is needed to expand and modernize the grid.[110]

There is scope for private sector investment in mini-grids. The Department of Energy is working closely with development partners and with the URA to increase Vanuatu's electrification rate of about 35 percent. The Department plans to develop several mini-grids from a priority list of more than 30. The operation of these mini-grids will either be bundled up with existing concession contracts or their construction and operation will be tendered out to new private sector investors, with the Government of Vanuatu contributing equity. While the implementation approach and financing mechanisms are yet to be decided, the URA's assistance - an independent and well-resourced regulator - will strengthen the Department's ability to meet its electrification target.

Expected investments

Vanuatu's updated energy road map proposes 68 actions to achieve all the NERM objectives. Of these 68 actions, 19 were already in progress at the time of publication of the updated NERM (2016), and another 22 were designated as having the highest priority and slated to begin in 2016. The timeline for the remaining 27 actions depended on the availability of funding and government staff time. The estimated budget for implementing these actions amounts to at least $250 million during 2016-2030, with funding to come from a mix of government, donor, private sector, and other fund sources.[111]

In preparation for the concessional arrangements, the Department of Energy prioritized six investment projects for ADB support, at an estimated total of $30 million, and are consistent with both the NERM and with the upcoming rural electrification master plan funded by the New Zealand Ministry of Foreign Affairs and Trade. The six projects are:

- $15 million investment to install 7.6 MWp solar power in combination with energy storage in Efate's grid by 2025;
- $2 million investment to install the first renewable energy project in the Tanna grid by 2015, including a 300kWp–500 kWp solar power project backed with power storage;
- $4 million project to install five mini-grids with an average capacity of 100 kWp solar PV energy, each in combination with energy storage at several locations on Malekula Island;
- $1 million project (cost excluding civil works) to install 20 pico-hydro power plants and a microgrid across the country (with the plants ranging from 5 kW to 20 kW, reaching a total expected installed capacity of 150 kW); and
- $4 million investment to install a 500 kWp–1,000 kWp grid-connected floating solar PV system backed by battery storage on the shores of the Espiritu Santo Island; and
- $4 million investment for installing bi-directional smart meters and transformer substations with remote management to modernize and automize the grids of Port Vila and Luganville.

[110] ADB. 2021. *Regional: Capacity Building and Sector Reform for Renewable Energy Investments in the Pacific*. Technical Assistance Consultant's Report. Manila (49450-010).

[111] Government of Vanuatu. 2016. *Updated Vanuatu National Energy Road Map 2016–2030*. https://www.nab.vu/sites/default/files/documents/NERM2016-30.compressed.pdf.

7.2.2 Policy framework

National Energy Road Map

Vanuatu's first NERM, published in October 2011 and endorsed in 2013, defined the government's strategy and corresponding targets for 2013-2020. In 2016, the NERM was updated to reflect new developments in the economy, especially in the energy sector, and to extend the targets to 2030. The updated NERM focuses on five priorities: accessible energy, affordable energy, secure and reliable energy, sustainable energy, and green growth. Other policy documents with a strong influence on Vanuatu's energy sector strategy include: the updated version of Vanuatu's first Nationally Determined Contribution (NDC), issued in 2016 and updated in 2020,[112] which set targets for emission reductions, renewable energy, and energy efficiency; the Vanuatu Infrastructure Strategic Investment Plan (VISIP),[113] which includes lists of ongoing and proposed energy projects, including investments in energy infrastructure and highlights six priority actions in the energy sector; and the National Sustainable Development Plan (NSDP),[114] which includes targets relating to sustainable infrastructure and energy access.

The NERM describes a wide range of potential benefits from an increased use of renewable energy. These include: (i) enabling economic and social development by making energy more affordable for households and business; (ii) increasing electricity access, thereby helping to improve productivity and product quality and thus raise the incomes of rural island people; and (iii) directly creating opportunities for local employment by reducing Vanuatu's reliance on imported diesel oil. Regarding the third item, the NERM mainly identified opportunities in rural communities, in industries such as coconut oil production and the distribution and maintenance of solar energy systems.

Energy Efficiency Act

The Energy Efficiency Act of 2017 established technical standards for refrigerators, air conditioners, and lighting products sold in Vanuatu. These standards are based on the Australia and New Zealand minimum energy performance standards and were developed with assistance from the Pacific Community. The Department of Energy approves applications for the importation of compliant products and equipment. Compliant products are registered online in the Pacific Appliance Database, which provides information to importers, retailers, and the general public. However, the level of awareness still needs to be improved, so that people understand the economic benefits of purchasing energy-efficient appliances.

Targets

The Government of Vanuatu is aiming for a strong increase in electricity access. In and near the concession areas, access was expected to increase from 62% in 2015 to 100% in 2030. However, analysts forecast an increase to 56% by 2030. The target for electricity access in off-grid areas was an increase from 9% in 2015 to 100% in 2020. The projected increase, however, is to 55% by 2030. A third target concerns improving electricity access for public institutions (health and education) through grid-based or off-grid solutions. This target was an increase from 54% in 2015 to 100% in 2020, but the projected increase is to 74% by 2030. Additional targets concerned increases in the use of efficient cooking stoves and modern

[112] Government of Vanuatu. Vanuatu's First Nationally Determined Contribution (NDC) (Updated Submission 2020). https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Vanuatu%20First/Vanuatu%E2%80%99s%20First%20Nationally%20Determined%20Contribution%20(NDC)%20(Updated%20Submission%202020).pdf.

[113] Government of Vanuatu. n.d. *Vanuatu Infrastructure Strategic Investment Plan 2015–2024*. https://www.gov.vu/images/publications/VISIP%202015-2024%20Report.pdf

[114] Government of Vanuatu. Vanuatu 2030. https://www.gov.vu/index.php/resources/vanuatu-2030.

cooking fuels, such as liquefied petroleum gas (LPG) or biogas,[115] and in the number of mini-grid renewable-energy systems installed in rural communities (to 14% by 2030).[116]

Vanuatu is also aiming to increase the share of grid-based electricity obtained from renewable sources. The target was an increase from 29% in 2015 to 100% by 2030,[117] but that share only reached 30.8% by 2018. Technology-specific targets include a doubling of installed wind capacity to 5.5 MW by 2025; the installation of a 10 MW grid-connected solar PV system by 2025 and the addition of another 10 MW by 2030; the commissioning of a first-stage 4 MW geothermal plant by 2025 and the second-stage 4 MW by 2030; and the replacement of fossil fuels by coconut oil in electricity generation.

Vanuatu's main target for energy efficiency is a reduction by at least 10% in total energy demand between 2015 and 2030, compared with the BAU projection. Additional targets were set at the subsectoral level, formulated as the percent savings in energy consumption over the BAU projections. The target for electricity sector end-use efficiency is 13.5% for 2030; for land and marine transport, the target is 10%. For biomass end-use efficiency (for cooking and drying), the target is 14% by 2030. Total potential savings by 2030 are valued at $335 million. A separate target was also set for improving diesel generation efficiency, aiming at a 20% increase from 2010 to 2030. Current progress has fallen short of the target, however, so the expected increase by 2030 is only 5%.

7.2.3 Tariffs

The URA monitors the VUI concession and sets tariffs for consumers in Luganville under an agreement with that city. As the concession contract with UNELCO for Port Vila had been signed before the URA's creation, the tariff for Port Vila was not set by the URA but by UNELCO, following the specific provisions established in the concession contract. Prices in the UNELCO concession are adjusted monthly. Pacific power benchmarking data shows that the prices in Port Vila are comparatively low for domestic consumers with low levels of consumption (50 kWh) but are among the highest in the region for domestic consumers with higher levels of consumption (200 kWh) and for commercial customers. At the same time, the distribution and O&M costs are among the lowest in the region. A benchmark of power tariffs in the region confirms that electricity tariffs in Vanuatu are, overall, among the highest in the region: In 2018-2019, the tariff for households was $0.72 per kWh (compared with the regional average of $0.36 per kWh and median of $0.31 per kWh); for commercial consumers, it was $0.41 per kWh (compared with the regional average of $0.41 per kWh and median of $0.40 per kWh). For industrial consumers, the tariff was $0.41 per kWh (compared with the regional average and median of $0.41 per kWh), and for the government, the tariff was $0.41 per kWh, compared with the regional average of $0.48 per kWh and median of $0.40 per kWh.

7.2.4 Relevant support programmes

Vanuatu Rural Electrification Project

The Department of Energy aims to promote the use of renewable energy and to expand access to electricity service to public institutions, businesses and more importantly, to the three-quarters of the population that are dispersed across the country's rural off-grid areas. The flagship project coordinating these efforts is the World Bank-funded Vanuatu Rural Electrification Project (VREP). VREP subsidized 50% of the cost of very small "plug and play" SHSs for lighting and phone charging for remote households, aid posts, and not-for-profit community halls located in remote off-grid areas. This stage has been completed.

[115] These targets are defined in the updated NERM.
[116] The target for mini-grid renewable-energy systems is defined in the NSDP.
[117] These targets are confirmed by Vanuatu's Nationally Determined Contribution and by the NSDP.

The objective of the VREP Stage II is to continue promoting the increased use of renewable energy and expanding access to electricity service in the remote off-grid areas of Vanuatu. There are three components to the project. The first is the provision of SHSs and microgrid systems in the rural areas of Vanuatu. This component supports the expansion of access to reliable electricity service in rural Vanuatu through the installment of SHS and microgrid configurations in areas where mini-grid configurations would not be economically viable, and which are not earmarked for mini-grids under this or any other donor or government project, as they would not be the least-cost solution. SHSs and microgrids have been made available to rural households and public institutions. This component has targeted some 37 public institutions and 8,400 rural households, which equates to approximately 42,000 people.

The second component is the construction of mini-grid systems in rural areas of Vanuatu. This component has supported the expansion of access to reliable electricity service for rural communities through the design, supply, installation, and commissioning of mini-grid systems. The project has financed the construction of five mini-grids, based on initial cost estimates. Finally, the third component comprises technical assistance and project management. This component addresses three key areas of the project, the first focusing on the vendor registration model for component one, the second focusing on the owners' engineers for component two, and the third focusing on project management. VREP II currently subsidizes 33% of the larger SHSs, microgrids, and mini-grids in rural communities. VREP II projects are also eligible to receive a low-interest loan for 50% of project cost from the National Green Energy Fund (NGEF).

7.3 Estimation of Demand

7.3.1 Income and expenditure

Urban grid-connected households

The 2010 Household Income and Expenditure Survey (HIES) found that 60% of workers in the informal economy were engaged in subsistence work, including 99% of workers living in the rural areas. The 2010 HIES estimated that the average monthly household income was VT83,800 per month (approx. $750), with incomes higher in urban areas (VT97,500) than in rural areas (VT79,500). Around 68% of income was in the form of cash (90% urban, 59% rural).[118] The average monthly income for residents of informal settlements in Port Vila was significantly lower, estimated at $103.

Rural off-grid households

Outside the capital, incomes were much lower, with many households in the outer islands living largely outside the cash economy. The main source of cash income is the sale of produce, but the lack of transportation options (particularly by sea, with cost and unreliability the major impediments) limit these opportunities. Household appliances and even the monthly electricity bill are often unaffordable. Due to poverty in the rural areas, a large proportion of the population consumes electricity within the level for the subsidized lifeline tariff (60 kWh/ month), since they cannot afford to pay for more electricity.

7.3.2 Appliance and equipment inventory

Urban grid-connected households

Energy demand surveys conducted in 2017 for the Pacific Community in grid-connected households in Port Vila and Luganville, found that 80% of the surveyed households had a refrigerator and/or freezer to preserve their food. About 48% of households had both and 12%

[118] Vanuatu National Statistics Office. 2011. *Vanuatu Household Income and Expenditure Survey 2010*, Port Vila

had neither. With regards to comfort, about 80% of households had fans, at least 31% had air conditioning, and at least 50% had a washing machine. Regarding entertainment, 80% of households had at least one TV (footnote 75). The Pacific Community survey also revealed that 42% of households had purchased a major appliance within three years prior to the survey, and that many households had bought more than one appliance. Appliances most purchased by the respondents were: refrigerators (65%), TVs (59%), freezers (45%), washing machines (29%), and air conditioners (9%). Regarding lighting equipment, long fluorescent tubes and compact fluorescent lamps (CFLs) were the most commonly used lighting fixtures by close to 80% of households. LED lighting was found in 15% of households, though this percentage may have increased since the survey, as the cost of LED lighting has dropped considerably in the past years.

Rural off-grid households

With regards to the off-grid population, a survey[119] carried out in 2016, revealed that almost all households owned at least one solar lighting device. Families use lighting mainly for reading, studying, cooking, and socializing. The average duration of solar lighting use per day was seven hours.

7.3.3 Awareness of energy efficiency

The term "energy efficient" was apparently widely understood and 73% of the surveyed households associated a high star rating with a positive outcome. Almost all the survey respondents stated that they recognized Australia and New Zealand's energy star labelling, and most associated the stars with the correct message. However, the majority were not sure or did not know how to use the labelling to estimate their energy consumption and costs. A majority of the surveyed households plan to use the labels to purchase appliances in the future and a third plan to use the label information to determine the total cost of ownership (footnote75).

7.3.4 Costs of ownership

The total costs (without applicable subsidies from government programs) of some solar products listed by approved vendors are shown in Table A2.30.

Table A2.30: Costs of Solar Products Listed by Approved Vendors in Vanuatu, April 2020

Solar Product	Cost ($)
150Wp SHS, 343Wh, 12V battery, DC load, 20A PWM controller, board	740
150Wp SHS, 326Wh, 12V battery, AC load, 20A PWM controller, board	925
275Wp SHS, 618Wh, 12V battery, DC load, 15A MPPT controller, board	1,310
275Wp SHS, 504Wh, 12V battery, DC load, 30A MPPT controller, board	1,335
275Wp SHS, 587Wh, 12V battery, AC–DC load, 15A, MPPT controller, board	1,445
275Wp SHS, 499Wh, 12V battery, AC load, 30A, MPPT controller, board	1,600
275Wp SHS, 592Wh, 12V battery, DC load, 15A, MPPT controller, board	1,710
275Wp SHS, 562Wh, 12V battery, AC-DC load, 15A, MPPT controller, board	1,840
550Wp SHS, 1,010Wh, 24V battery, DC load, 30A, MPPT controller, board	2,650
550Wp SHS, 1,173Wh, 24V battery, AC load, 20A, MPPT controller, board	3,300
550Wp SHS, 1,125Wh, 24V battery, AC load, 20A, MPPT controller, board	4,225

[119] H. Wade, J. Salong, and P. Johnston. 2016. *Report Two: Site Visit and Survey Report: Ability and Willingness to Pay for Electricity and Estimated Electricity Demand for Emae, Makira, Mataso and Aneityum Islands*. Government of Vanuatu and GIZ. https://doe.gov.vu/images/docs/workshop-materials/Workshop%20on%20Renewable%20Energy%20based%20Off-Grid%20Master%20Plan%20for%20small%20remote%20islands%20-%20Site%20Visit%20&%20Survey%20Report.pdf.

550Wp SHS, 1,177Wh, 24V battery, AC-DC load, 20A, MPPT controller, board	6,610
1,100Wp SHS, 2,347Wh, 24V battery, AC-DC load, 35A, MPPT controller, board	6,408
1,100Wp SHS, 2,353Wh, 48V battery, AC-DC load, 35A, MPPT controller, board	9,720
1,960Wp microgrid, 3,648Wh, 48V battery, AC, 2x60A, MPPT controller, board	9,085
2,800Wp microgrid, 5,990Wh, batteries, AC, MPPT controller, board	12,375
3,240Wp microgrid, 6,080Wh, batteries, AC, MPPT controller, board	14,340
3,920Wp microgrid, 7,196Wh, batteries, AC, MPPT controller, board	16,350
3,960Wp microgrid, 7,819Wh, batteries, AC, MPPT controller, board	20,910
4,950Wp microgrid, 10,421Wh, batteries, AC, MPPT controller, board	27,600

AC = alternating current, DC = direct current, MPPT = maximum power point tracker, PWM = pulse-width modulation, SHS = solar home system, V = volt, Wh = watt-hour, Wp = watt-peak.
Source: Pacific Clean Energy Financial Potential project team.

7.3.5 Willingness to pay

Urban grid-connected households

The latest survey carried out in Port Vila and Luganville indicated that more than half of respondents (59%) were not sure what other appliance they will purchase in the future, but TVs were the most likely, followed by washing machines, freezers, air conditioners and refrigerators. No surveys were carried out in the last five years to understand the willingness to pay (WTP) from Vanuatu's urban population for more energy efficient appliances.

Rural off-grid households

In the rural population segment, the GIZ survey revealed that people in off-grid areas (no mini-grids) gave top priority to the purchase of solar lighting units, radio and phone chargers. Their WTP is very low, estimated at half the real cost of basic solar home systems. The survey concluded that pico-solar systems can provide the high priority services to the bulk of households and solar home systems to community installations such as schools, health centers or other community services.

7.3.6 Demand forecast

The GIZ survey revealed that the priority energy services indicated by the rural population in off-grid areas were energy for their radios, mobile phone charging, and lighting. Rural towns with mini-grids indicated priority for energy service for their TVs, refrigerators/freezers and washing machines. Other energy services desired were access to energy for electric tools, blenders, toasters, iron, sound systems, and fish finders. Up to 83% of the rural households own at least one mobile phone, usually charged through solar chargers.

7.4 Market overview

7.4.1 Suppliers

There are private solar retailers, electrical shops and hardware outlets in Port Vila and Luganville. These businesses sell solar home systems, solar products and household appliances to the whole country. Vanuatu's Department of Energy has established an approval procedure to solar retailers that want to sell solar products to government financed programs. Government supported programs can only purchase equipment from those approved vendors (

Table A2.31). All refrigeration, air conditioning and lighting equipment imported to Vanuatu must comply with Australian and New Zealand minimum energy performance standards.

Table A2.31: Suppliers and Distributors of Renewable-Energy Products in Vanuatu

Vendor	Location
Solar Retailers	
Energy4All	Port Vila, Efate Island
Greentech	Port Vila, Efate Island
Rapid Electrical	Port Vila, Efate Island
Pacific Communication Solution	Port Vila, Efate Island
Electrical Shops	
Vate Electrics	Port Vila, Efate Island
South Pacific Electrics	Port Vila, Efate Island
Rapid Electrics	Port Vila, Efate Island
Hardware Outlets	
Wilco Hardware	Port Vila, Efate Island
Port Vila Hardware	Port Vila, Efate Island
Vila Distribution	Port Vila, Efate Island

Source: Pacific Clean Energy Financial Potential project team.

7.4.2 Lending agencies

The National Green Energy Fund

To assist the achievement of renewable energy penetration targets, Vanuatu's Parliament created the National Green Energy Fund (NGEF) in 2018 as a state-owned entity under the Department of Energy. The main purpose of the NGEF is to mobilize and channel revolving financial resources through loans to households, communities and businesses to access renewable energy and energy efficient products. Funded by the state, the NGEF's capital budget is about VT500 million ($4.38 million) for 2020-2025, from which, the Council of Ministers approved VT230 million. The revenues derived from its financial activities are expected to bring additional funds into the Fund. The initial focus of the NGEF will be on electricity access, mainly in off-grid areas, use of renewable energy and energy efficient appliances. NGEF supports all these projects with concessional loans for 50% of project cost at 6% annual interest. Term of loan is 1 to 5 years (5 years for larger projects), and exceptionally up to 7-8 years. For eligible VREP II projects, this concessional loan is an additional support to the 33% grant received by VREP. The beneficiary pays upfront only 17% of the purchasing cost. Costs of the solar systems are usually 70% of the total project cost (which includes wiring, installation, led lighting and appliances). According to NGEF, the subsidy of 33% is still low for the population in the outer islands of Vanuatu. Since its beginning of operations, NGEF has funded about 70 projects, most of them between 2020 and 2021. However, this number is still far from the ambitious target established for the VREP II.

NGEF's first project approved in 2019 amounted to VT1.9 million ($17,000) to finance projects through the Luganville Electricity Concession. A solar refrigeration system was installed at the Futuna Fish Market by an approved supplier. The Department of Energy implemented the project with the support of the Cooperatives Department. Fishermen in Futuna now store their fish safely before sale in a solar-powered refrigeration system. Also, two schools were provided with a solar system, including wiring, LED lighting, laptops and printers.

In 2020, the NGEF signed MOUs with the Departments of Education and Tourism to provide schools and tourism operators with access to finance for renewable energy products. In

January 2021, the NGEF confirmed the allocation of VT190,105,260 ($1.7 million) to provide renewable solar energy to schools located in disperse off-grid areas in the provinces of Sanma and Torba. NGEF also plans to finance solar energy systems to replace diesel generators used by telecommunication operators, drinking and irrigation water pumping stations, and hospitals and health centers.

Between 2020 and 2021, 70 projects were funded - about 40 were microgrids (1 kW to 5 kW) and the rest were solar home systems of up to 1 kW. Twenty projects were funded in 2020 for VT17.9 million ($160,000) and 50 projects in 2021 for VT53.5 million ($480,000). Beneficiaries in 2020 included 16 cooperative and 4 schools. Beneficiaries in 2021 included 27 schools, 8 cooperatives, and 1 area council. NGEF has also funded three solar pumps for schools. All these projects include wiring, installation, LED lighting and some appliances, such as freezers for cooperatives, and printers and computers for schools. A rural butchery was awarded financing for a grinding machine and a meat slicing machine.

Cooperatives (which can be a group of households) have also benefitted from NGEF. The cooperative needs to be registered in the registry of cooperatives to become a legal entity and have a savings account to show eligibility for the loans. NGEF has signed an MoU with the Department of Cooperatives to supervise and audit the operations of registered cooperatives. Members pay back through their cooperative accounts and the cooperative pays back to NGEF.

Examples of costs and loans provided through NGEF are:

- Solar refrigeration system for Futuna (1st project) received a loan for VT800,000 ($7,000) for 50% of the equipment and 100% of transport, wiring, installation and LED lighting.
- A 3.3 kWp solar system for VT1,250 million loan, equivalent to 50% of the total cost.
- A microgrid for a secondary school with two 5kWp systems in a school (10 kWh/day) received a loan for VT4.1 million ($36,000). This loan covered 50% of the solar system, 100 % of wiring and installation, and 100% of LED lighting. The cost of the 2 solar systems alone is VT5.1 million ($45,000). Repayment for the loan was agreed as two annual payments (March and September) for VT491,000 each payment ($4,400) for five years.
- One of the awarded loans was to a cooperative with seven members for a solar home system for each member. One of the cooperative members got a 5 kWp system, the other six got 1.1 kWp of solar freezer + LED lighting. Total loan was about VT3.3 million ($29,000). Current price of a solar freezer is in the range of VT700,000 - VT800,000 ($6,000 to $7,000).

National Bank of Vanuatu

The National Bank of Vanuatu (NBV) is the largest bank in Vanuatu with 29 branches and agencies across the country and is the only commercial bank with branches outside the largest cities. Clean energy lending is integrated in the NBV's current programs for building or renewing houses. The "IsiHaos" program lends money for building one of their six designed houses, all resilient to extreme weather and cyclones. Each *IsiHaos* type is inclusive of a 3,000-litre fiberglass water tank, an underground waterwell, and a solar power system. *IsiHaos* is available through very low interest housing loans set by NBV. All construction and renovation works are done by individuals or companies registered with the Bank. Engineers usually follow technical standards from Australia and New Zealand for the solar home systems.

Micro-finance services

Alternative methods such micro finance services are being implemented in the country through microfinance agencies that provide small and short-term lending for solar home systems.

Some of the agencies active in the micro finance sector in Vanuatu are VanWoods, the South Pacific Business Development (SPBD) Microfinance Ltd, and NBV.

Challenges for Clean Energy Loan Products

a) **Eligibility to loans -** All loans approved by NGEF require applicants to present collaterals. NGEF prefers to use the applicant's Provident Fund assets as collateral, and will take physical assets, such as real state, as collateral if the Provident Fund is insufficient. The unemployed, people with informal employment, and self-employed who do not have the benefits of the Provident Fund are ineligible. To partially address this challenge, the NGEF has signed a MoU with the Department of Cooperatives to guarantee loans made to cooperative societies. In Vanuatu, any society of at least seven persons can register as a cooperative. Fishermen cooperatives or even household cooperatives, have applied successfully for NGEF loans. As the regulatory regime is already established for cooperatives, they have a relatively short loan preparation process and approval.
b) **Low income of the population -** The low income of the population and community institutions is a large obstacle to clean energy loan products in Vanuatu. A large number of households, schools and cooperatives do not apply for NGEF loans because their incomes do not allow them to pay for the already subsidized cost of solar equipment (33% subsidy received by VREP II). NGEF considers that subsidy to the cost of solar products should probably be between 50% to 60% to make the clean energy loans attractive to the population and achieve sufficient market penetration of these products.

7.5 Opportunities for Local Operations and Management and Job Creation

7.5.1 Repair services

A major barrier in off-grid areas is the limited technical capacity and insufficient O&M support given by vendors. There is a lack of skilled technicians in the country to design, install, operate, and troubleshoot rural off-grid systems. Vendors' guarantees usually last less than two years. Past and ongoing solar programs have been severely constrained by insufficient technical support in the outer islands. Even though there are available training and certification programs in the country, the lack of monetary incentives and low payment capacity of communities discourage qualified technicians from serving the needs of the outer islands. Rural electrification programs in Vanuatu must be rethought to strengthen adequate and prompt O&M services to consumers in the outer islands.

7.5.2 Capacity needs

Technical skills and capacities in Vanuatu are fairly sufficient but would need reinforcement. To ensure higher success, training should be conducted locally. Local training initiatives could involve industry people as part time trainers. A few trainings and knowledge transfer initiatives in the past are:

- The Vanuatu Institute of Technology offers technical courses and on its website is indicating further courses will be developed. Its Electrical Engineering Technology Department, currently offers programs in electrical wiring and is developing a range of other programs in the electrical engineering field.
- In 2018, GIZ funded the preparation and supply of training material for off-grid systems to the Pacific Vocational Training Centre (PVTC).
- Other educational and research centres, such as the National University of Vanuatu, does not seem to offer technical courses, but is focused on economics, tourism, hospitality and social science courses.

7.6 Development partners

Multiple development partners are operating in Vanuatu and supporting renewable energy development in the country. The institutions most active in the RE sector are as follows:

a) The World Bank manages the VREP II which will focus primarily on RE hybrid mini-grids and solar home systems.
b) The Asian Development Bank is actively promoting hydropower development on Santo, Malekula (Brenwei) and RE mini-grids.
c) The Japan International Cooperation Agency is also active on Espiritu Santo and is looking to expand current hydropower projects.
d) The New Zealand Ministry of Foreign Affairs and Trade is collaborating with the World Bank and providing funding for VREP II.
e) The Australian Department of Foreign Affairs and Trade is active in Vanuatu supporting capacity-building activities in multiple sectors.
f) The United Arab Emirates has been supporting installations of new solar PV capacity and solar-hybrid mini-grids.
g) The European Investment Bank is active in the region and provides funding for private and public renewable energy projects.

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