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World Small Hydropower Development Report 2022

Pacific Island Countries and Territories

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Pacific Island Countries and Territories

Countries: Fiji, French Polynesia, Federated States of Micronesia, New Caledonia, Papua New Guinea, Samoa, Solomon Islands, Vanuatu

INTRODUCTION TO THE REGION

The national electricity sectors of the Pacific Island Countries and Territories (PICTs) are characterized by a high degree of geographical fragmentation, including the fragmentary nature of major electricity grids as well as the prevalence of micro-grids and off-grid generation. Despite this, management of the electricity sectors is centralized across most of the countries in the region included in the present Report, with public utilities and state-owned companies operating the major grids and generating capacities in Fiji, French Polynesia, New Caledonia, Papua New Guinea, Samoa and Solomon Islands. Vanuatu and the Federated States of Micronesia (FS of Micronesia) are exceptions to this pattern. In Vanuatu, the national grid is managed by two private companies, while in the FS of Micronesia the sector is split between four public utilities companies based on the four federal divisions of the country. Although electricity access is generally high throughout the region, difficult geography complicates extending full electricity access in some countries, particularly in Vanuatu and Papua New Guinea. The FS of Micronesia, New Caledonia, Solomon Islands and Vanuatu are heavily dependent on fossil fuels for electricity generation, while the energy mixes of other PICTs nations are fairly diversified, with renewable energy sources (RES) playing an increasingly important role. Alongside hydropower and solar power, generation from biomass is common in the region, while Papua New Guinea is actively developing geothermal power.

Hydropower is a major energy source across most of the PICTs region. In Fiji and Papua New Guinea, hydropower is one of the leading sources of electricity generation, although installed capacities of thermal power are higher in both countries. In French Polynesia, New Caledonia and Samoa, hydropower forms a significant share of total generation but plays a supplementary role overall. In the FS of Micronesia, Solomon Islands and Vanuatu, the contribution of hydropower to generation is relatively minor.

An overview of the electricity sectors of the countries in the PICTs region is provided in Table 1.

Table 1. **Overview of the Pacific Island Countries and Territories**

Country	*Total population (million people)*	*Electricity access, total (%)*	*Electricity access, rural (%)*	*Total installed capacity (MW)*	*Electricity generation (GWh/year)*	*Hydropower installed capacity (MW)*	*Hydropower generation (GWh/year)*
Fiji	1	96	94	366	1,061	128	559
French Polynesia	0.3	100	100	300	694	49	160
FS of Micronesia	0.1	83	79	29	64	1	1
New Caledonia	0.3	100	100	1,022	3,233	78	305
Papua New Guinea	9	60	57	1,084	2,087	258	877
Samoa	0.2	100	100	62	171	16	55
Solomon Islands	0.7	73	72	68	98	0.4	1
Vanuatu	0.3	67	58	33	82	1	N/A
Total	-	-	-	**2,964**	-	**531**	-

Source: *WSHPDR 2022*[1]

Note: Data in the table are based on data contained in individual country chapters of the *WSHPDR 2022*; years may vary.

REGIONAL SMALL HYDROPOWER OVERVIEW

The majority of countries in the PICTS region, including Fiji, FS of Micronesia, Samoa, Solomon Islands and Vanuatu, do not have an official definition of small hydropower (SHP). In French Polynesia, New Caledonia and Papua New Guinea, SHP is defined as hydropower plants with an installed capacity of up to 10 MW.

A comparison of installed and potential SHP capacities in the PICTs region is provided in Table 2.

Table 2. **Small Hydropower Capacities by Country in the Pacific Island Countries and Territories Region (MW)**

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed capacity (≤10 MW)*	*Potential capacity (≤10 MW)*
Fiji	Up to 10 MW	11.3	43.2	11.3	43.2
French Polynesia	Up to 10 MW	48.6	98.0	48.6	98.0
FS of Micronesia	N/A	N/A	N/A	0.7	9.0
New Caledonia	Up to 10 MW	13.0	100.0	13.0	100.0
Papua New Guinea	Up to 10 MW	41.0	153.0	41.0	153.0
Samoa	N/A	N/A	N/A	15.5	22.0
Solomon Islands	N/A	N/A	N/A	0.4	11.0
Vanuatu	N/A	N/A	N/A	1.3	5.4
Total	-	-	-	**131.8**	**441.6**

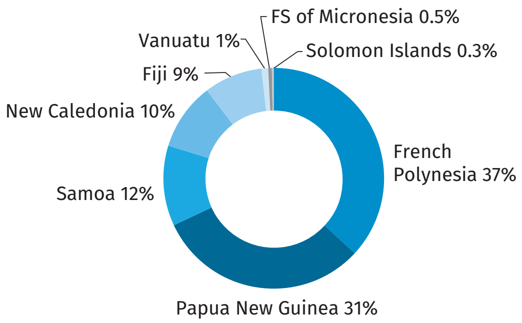
Source: *WSHPDR 2022*[1]

The installed capacity of SHP up to 10 MW in the PICTs region is 131.8 MW, while the potential capacity is estimated at 441.6 MW. Relative to the *World Small Hydropower Development Report (WHSPDR) 2019*, the installed capacity has increased by nearly 15 per cent due to the commissioning of several new SHP plants across the region, with Papua New Guinea accounting for the largest share of the increase. In other countries of the region, installed SHP capacity has seen moderate increases or remained the same. The potential capacity for SHP up to 10 MW has increased by nearly 7 per cent, largely due to a re-evaluation of available data on SHP potential in Fiji.

SHP occupies a significant share of the overall installed hydropower capacity in the PICTs region, accounting for 100 per cent of all hydropower capacity in French Polynesia, the FS of Micronesia, Samoa, Solomon Islands and Vanuatu. This tendency is explained in part by the relatively small overall size of the electricity sector in many countries of the region, but also by specific characteristics of local geography that limit large hydropower development, including the absence of major rivers on smaller islands. Along with other RES, SHP provides additional advantages to island countries as a source of localized electricity generation not requiring the extension and maintenance of centralized grids, as well as a hedge against fluctuations in global fossil fuel prices to which island economies are particularly vulnerable. At the same time, SHP development in the PICTs is constrained by a number of factors common to the region, including geological conditions and the vulnerability of available water resources to climate change. There is also significant opposition to hydropower development from environmental groups and local communities, in part due to the important role of tourism in the region's economy.

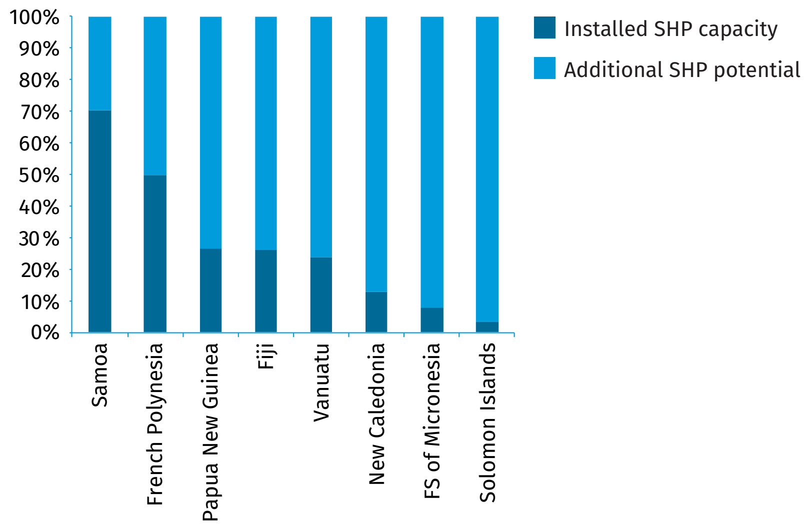
The share of regional installed capacity for SHP up to 10 MW by country is displayed in Figure 1, while the share of total SHP potential utilized by the countries is displayed in Figure 2.

Figure 1. **Share of Regional Installed Capacity of Small Hydropower up to 10 MW by Country in The Pacific Island Countries and Territories Region (%)**



Source: *WSHPDR 2022*[1]

Figure 2. **Utilized Small Hydropower Potential up to 10 MW by Country in The Pacific Island Countries and Territories Region (%)**



Source: *WSHPDR 2022*[1]

The total installed capacity for SHP up to 10 MW in **Fiji** was 11.3 MW in 2021, while potential capacity is estimated at 43.2 MW, indicating that 26 per cent has been developed. Little development of SHP has taken place in the country in recent years, with the last new plant commissioned in 2017 and ongoing projects focusing on the refurbishment of existing plants rather than the construction of new ones.

In **French Polynesia**, there are 16 SHP plants up to 10 MW with a total installed capacity of 48.6 MW. The potential capacity is estimated at 98 MW, indicating that French Polynesia has utilized approximately 50 per cent of its SHP potential. Although the country's SHP capacity has seen only slight increases over the last decade, the Hydromax Project, a 2018 government initiative to promote sustainable hydropower development, has led to the construction of a new SHP plant as well as upgrades to two previously-existing SHP plants.

The FS of Micronesia have 0.7 MW of installed capacity for SHP up to 10 MW, while the potential capacity is estimated at 9.0 MW, indicating that approximately 8 per cent has been developed. The country's installed SHP capacity has remained constant over the last decade. Most hydropower potential in the country is located in the state of Pohnpei, which also hosts the country's only SHP plant. The FS of Micronesia are building a new 2.5 MW SHP plant on the Lehnmesi River, scheduled to be completed by 2023.

In **New Caledonia**, the installed capacity of SHP up to 10 MW was approximately 13 MW at the end of 2020, while the potential capacity is estimated at approximately 100 MW. This indicates that 13 per cent of the known SHP potential has been developed so far. Recent developments in the SHP sector have included the completion of the 3 MW Paalo plant, the first new SHP plant in the country in three decades.

Papua New Guinea has 41 MW of installed capacity for SHP up to 10 MW, while the potential is estimated at 153 MW, indicating that approximately 27 per cent of existing SHP capacity has been developed. With the launch of two new SHP plants, the number of existing SHP plants in PNG had reached 11 as of 2020. Under the Town Electrification Investment Programme, Papua New Guinea is planning to rehabilitate and increase the capacity of some of its existing SHP plants. Ongoing SHP projects in the country include the 3 MW Ramazon plant scheduled to be completed by 2023 and another 10 MW project undergoing feasibility studies.

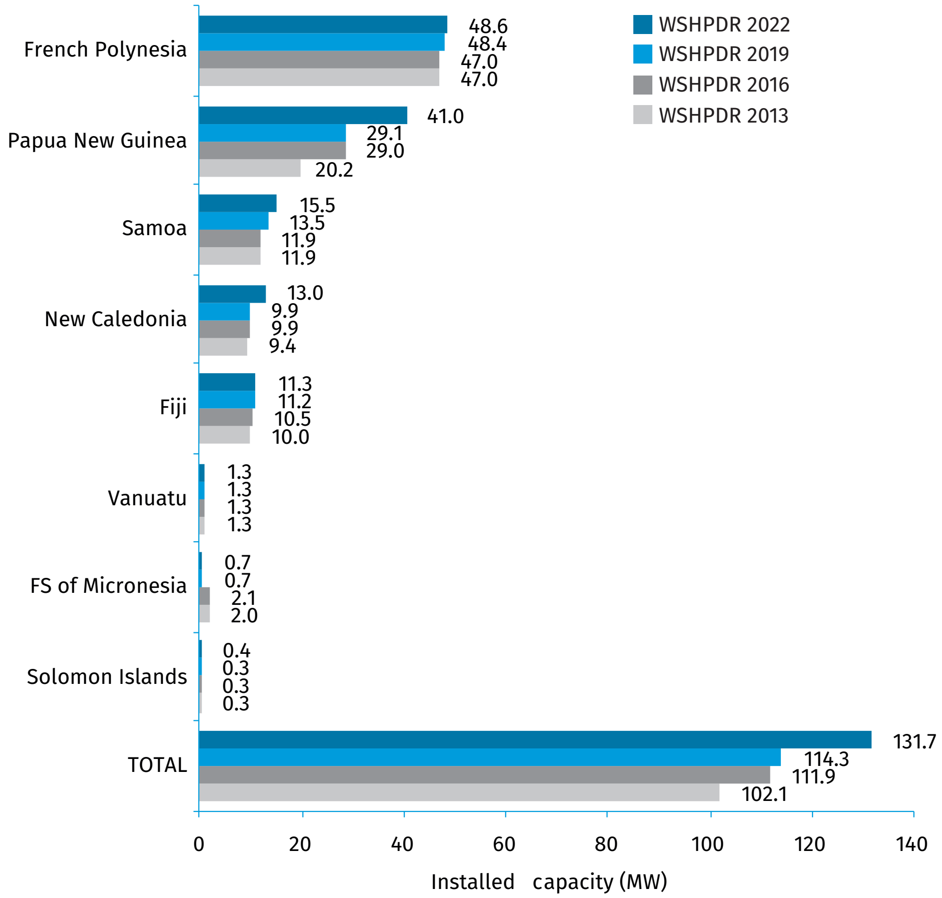
In **Samoa**, the installed capacity for SHP up to 10 MW is 15.5 MW, and the total potential capacity is estimated at 22 MW, indicating that approximately 71 per cent has been developed. SHP plants once supplied more than 85 per cent of the country's electricity, but the share of SHP in the country's energy mix has declined in parallel with growing electricity demand. In recent years, the Renewable Energy Development and Power Sector Rehabilitation Project, funded by multiple governments and international organizations, helped rehabilitate and reconnect 4.69 MW of SHP capacity to the grid. Despite the high financial costs incurred during the rehabilitation process, hydropower remains the most cost-effective source of electricity generation in Samoa.

In **Solomon Islands**, the installed capacity of SHP plants is 361 kW, whereas the potential capacity is estimated at 11 MW, indicating that approximately 3 per cent has been developed. There are 13 hydropower plants in the country, with capacities up to 150 kW. A number of SHP projects, including the 30 kW Beulah micro-hydropower plant, are under development or in the planning stages.

The installed capacity for SHP up to 10 MW in **Vanuatu** is 1.3 MW and the potential capacity is estimated at 5.4 MW, indicating that approximately 24 per cent has been developed. There are existing plans in the country to construct 13 new micro-hydropower plants with a total capacity of 1.5 MW. However, any potential SHP sites in Vanuatu require multi-year monitoring prior to construction to adequately assess both the hydropower potential of the site as well as the risk of flood damage.

Changes in the installed capacities for SHP up to 10 MW of countries in the PICTs region compared to the previous editions of the *WSHPDR* are displayed in Figure 3.

Figure 3. **Change in Installed Capacity of Small Hydropower up to 10 MW from *WSHPDR 2013* to *WSHPDR 2022* by Country in The Pacific Island Countries and Territories Region (MW)**



Source: *WSHPDR 2022*,[1] *WSHPDR 2013*,[2] *WSHPDR 2016*,[3] *WSHPDR 2019*[4]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

While there is significant undeveloped SHP potential in **Fiji**, one of the key challenges for SHP development in the country has been sourcing finance for projects, particularly for smaller developers, as the SHP sector in Fiji is heavily dependent on international financing. Land disputes with property owners are another important barrier, particularly when construction impacts multiple land holdings. On the other hand, Fiji benefits from a strong tradition of hydropower development and the Government has demonstrated commitment to the development of RES, including hybrid plants combining hydropower with other RES.

Barriers to SHP development in **French Polynesia** include competition with the local tourism economy and limitations on construction in protected areas. Enablers include significant untapped SHP potential, the commitment of the Government to energy transition and easier access to financing from France due to the status of French Polynesia as an overseas collectivity of France and the Government's ongoing partnership with the French Development Agency.

In **the FS of Micronesia**, barriers to SHP development include competition between water users for access to freshwater resources as well as the need for technical and financial assistance. At the same time, much of the country's SHP potential remains untapped and SHP can offer a solution for the extension of electricity access to remote off-grid communities.

In **New Caledonia**, major barriers to SHP development include a lengthy preparatory and bureaucratic process for SHP projects, environmental constraints and difficulties in utilizing land within protected areas. The main enabler for SHP development in the future is the Government's plan for a significant enlargement of hydropower capacity, which has already resulted in the construction of one new SHP plant.

In **Papua New Guinea**, barriers to SHP development include high investment costs, insufficient geological and hydrological data and high sediment load in the country's rivers. At the same time, the National Energy Policy for the years 2017–2027 prioritizes ongoing hydropower development and the country's considerable undeveloped SHP potential offers extensive opportunities for future projects. SHP in Papua New Guinea additionally enjoys access to funding from a variety of sources.

Barriers to SHP development in **Samoa** include lack of monitoring data on water resource potential, low accuracy and reliability of project data, decreasing load factors of SHP plants due to climate change and consequent water scarcity, the difficulty of repairing plants in case of damage and local resistance to the construction of SHP plants. Enablers include the available undeveloped potential, policy focus on RES development, availability of funding and incentives in the form of feed-in tariffs (FITs) and local experience in SHP development and rehabilitation.

In **Solomon Islands**, a key obstacle to SHP development is the lack of a standardized acquisition process for land for SHP projects. Additional obstacles include the lack of incentives for investment in SHP as well as technical challenges posed by geological conditions. At the same time, the SHP potential of Solomon Islands remains mostly untapped and the country benefits from the availability of funding for SHP projects from a variety of sources.

In **Vanuatu**, barriers to SHP development include the lack of appropriate sites near population centres, the complexity of electricity transmission and transportation of materials across a multitude of small islands, the high costs of feasibility studies, limited technical expertise and the lack of technical standards for SHP. At the same time, the need for extending full electricity access through micro-grids and off-grid generation contributes to interest in future SHP development in the country and could be financed through climate change-related funds provided by international aid agencies and private entities.

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Fiji

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KEY FACTS

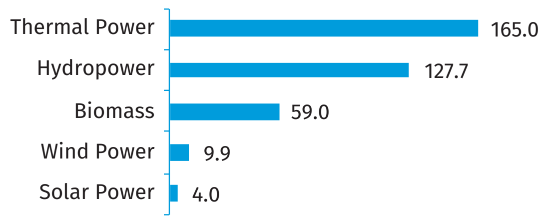
Population	902,906 (2021)[1]
Area	18,270 km^2 [2]
Topography	Fiji is a small island nation with 322 islands, out of which 100 are inhabited. The larger islands are volcanic in origin, while smaller uninhabited islands are mainly coral islands. The largest island is Viti Levu and the second largest island is Vanua Levu. The highest point in Fiji is Mount Tomanivi which is 1,324 metres above sea level.[2]
Climate	Fiji experiences two main climates. The summer months are from November to April, with an average temperature of 30°C during the day and remaining above 20°C at night. The period from November to April is usually wet and hot with possibilities of tropical cyclones. During the winter months from May to October, the climate is marginally drier and cooler, with temperatures dropping by only 2 4°C compared to the summer months.[3]
Climate Change	Climate change is a reality in Fiji, with the Fiji Meteorological Services reporting higher temperature recordings in the last decade (2011–2019). Fiji has also been experiencing more intense tropical cyclones and severe flash flooding in recent years. Coastal erosion and seawater intrusion due to sea level rise (approximately a 6 mm increase per year) has forced many communities to relocate to higher grounds.[4,5]
Rain Pattern	From October to May, Fiji receives significantly higher precipitation compared to the months of June to September. The cyclone season in Fiji is from November to April and corresponds to high rainfall. The average annual rainfall between 1981 and 2017 was 1,981 mm. However, the rainfall is not equally distributed over space and time, resulting in frequent draughts and floods.[6]
Hydrology	On Viti Levu, the main river systems are the Rewa, Navua, Sigatoka and Ba. The Rewa is navigable for 113 kilometres, while in some parts of interior Viti Levu, the Sigatoka provides the main means of transport.[7]

ELECTRICITY SECTOR OVERVIEW

There are two types of electricity generation systems in Fiji: grid-connected and off-grid. The sole utility compan, Energy Fiji Ltd. (EFL), operates the grids in the three largest islands. Independent power producers (IPPs) provide electricity supply to the national grid using biomass. There are grid-connected solar photovoltaic (PV) systems (mostly on the rooftops of commercial buildings), making up approximately 4 MW of total installed solar power capacity in 2018.[8] There was a total of 365.6 MW of installed capacity in Fiji in 2018, of which EFL had approximately 302 MW in its generation portfolio. Of the total, 165.0 MW was from industrial diesel oil (IDO) and heavy fuel oil (HFO) generators, 127.7 MW from hydropower and 9.9 MW from wind power (Figure 1).[9] There is also biomass power generation, however, data on installed capacity for 2018 is not available. As of 2017, IPPs had 59 MW of installed capacity of biomass power generation.[10]

Biomass power generation in the country mainly comes from the IPPs Fiji Sugar Corporation (FSC), Tropik Woods Industry Limited (TWIL) and Nabou Green Energy Limited (NGEL). FSC has three mills (Lautoka, Labasa and Ba), with each mill having its own cogeneration plant of 5 MW, 24 MW and 9 MW, respectively. TWIL is a sawmill that produces electricity from its 9 MW power plant.[10] NGEL, commissioned in 2017, uses wood residue and fast-growing Gliricidia Sepium and invasive African Tulips to power its 12 MW biomass power plant.[11]

Figure 1. **Installed Electricity Capacity by Source in Fiji in 2018 (MW)**

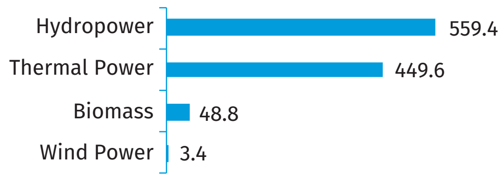


Source: Prasad & Raturi[8] Energy Fiji Limited,[9] Hussain,[10] NGEL[11]

Note: Data for biomass capacity from IPPs are from 2017.

In 2019, 1,061.2 GWh of electricity was supplied to the national grid. Of the total, 559.4 GWh was from hydropower, 449.6 GWh from combusting IDO and HFO, 48.8 GWh came from biomass and 3.4 GWh from wind power (Figure 2).[12]

Figure 2. **Annual Electricity Generation by Source in Fiji in 2019 (GWh)**

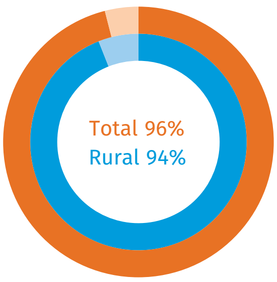


Source: EFL[12]

Note: Grid-connected solar power generation is not considered in the source document.

Off-grid systems provide electricity in remote locations on larger islands and maritime islands where EFL grids cannot reach. Sources for off-grid electricity generation are diesel generators, solar power home systems, micro-grid solar/diesel/battery hybrid and pico- or mini-hydropower systems. The Fiji Department of Energy (DoE) under the Rural Electrification Policy is responsible for ensuring that non-grid connected communities and households have access to some form of electricity.[13] According to the 2017 census, almost 78.5 per cent of the households are connected to the national grid, while almost 17.5 per cent of households have access to off-grid electricity (Figure 3). The remaining 4 per cent of the total Fijian households do not have access to electricity, which comprises 6 per cent of rural households and 2 per cent of urban households.[13] For the villages that are using diesel generators, electricity is only available for 3–4 hours in the evenings.

Figure 3. **Electrification Rate in Fiji in 2017 (%)**



Source: FBoS[13]

Four villages (Namara, Tukavesi, Solevu and Nakoro) in Fiji have solar/diesel/battery hybrid systems. As for diesel generators, there are some sites that have a stand-alone diesel generator, while other sites have hybrid diesel generators with a solar home system or a diesel generator with access to the EFL grid. For sites only with operational diesel generators: Western division has 90.5 kVA in total, Northern Division has 876.5 kVA, Eastern division has 1,326.5 kVA and Central division has 129 kVA. From 2008 to 2019, 13,776 solar home systems (SHS) were installed in remote areas in Fiji.[14]

According to the 2016 Rural Electrification Policy, the Government will pay for the capital cost of rural electrification projects.[15] Three years after commissioning, the off-grid electrification projects is handed over to the community members once they are trained in operation and maintenance. Minor maintenance cost is borne by the community. However, in case of major maintenance work, the responsibility lies with the DoE. The village is responsible for paying for their fuel usage from off-grid diesel generation.

The DoE through its Rural Electrification Unit is responsible for liaising with rural communities concerning their electricity needs and supplying electricity in the form of solar home systems, hybrid systems, small hydropower (SHP) and diesel generators. The grid electricity is supplied by EFL. It is a limited liability company where the Government owns 51 per cent of the shares, domestic customers own 5 per cent and the remaining 44 per cent has recently been sold to a Japanese power company.[16] EFL is responsible for the planning, generation, transmission and distribution and retail of grid electricity. It supplies grid-connected electricity to four islands: Viti levu, Vanua Levu, Ovalau and Taveuni, with each island having its own generators and electricity network. None of the islands have an interconnected grid network. Viti Levu has the largest grid network with peak demand of 172 MW and 252 MW of available capacity, of which almost 50 per cent is from renewable sources.[9]

The country's largest hydropower plant (80 MW), located in Viti Levu, receives water from the Nanuku and Wailoa Rivers. A 41.7 MW run-of-river plant is located at the Sigatoka River headwaters. Vanua Levu has two grids (Labasa and Savusavu) where Labasa has 7.6 MW of peak demand and 11.10 MW of available capacity, all of which comes from diesel generators. Meanwhile, Savusavu has 2.3 MW of peak demand and 4.5 MW of available capacity, with 0.8 MW being from hydropower and the rest from diesel generation. Ovalau has 1.8 MW of peak demand and 2.3 MW of available diesel generators, while Taveuni has 0.4 MW of peak demand that is met by 0.7 MW of hydropower and 1.6 MW of diesel generators.[9]

Fiji has a new Electricity Act 2017 which provides power to an independent body to act as a regulator for the electricity sector. The Fijian Competition and Consumer Commission (FCCC) has been given the responsibility of being that regulator. However, due to its technical and capacity constraints, EFL still holds some regulatory responsibility.[17] The FCCC is an independent body; one of its roles is to determine the minimum electricity export tariff to be paid to IPPs as well as the tariff rate customers pay for electricity used. The minimum electricity export tariff is set at 0.3308 FJD/kWh (0.16 USD/kWh) for electricity sold to the national grid if IPPs are generating 24/7/365.[18]

The electricity demand tariff depends on the customer category: domestic, small business tariff (commercial), maximum demand tariff (industrial) and others (primary and secondary schools, places of worship and streetlights).[18] Domestic customers pay either a base rate or a reduced rate if they consume less than 100 kW per month or earn less than or equal to FJD 30,000 (USD 14,754). The commercial tariff is applicable if the maximum demand is less than 75 kW. Industrial customers are charged and categorized based on their maximum demand (Table 1). For primary and secondary schools, the first 200 kWh are subsidized by the Government, paying 0.1285 FJD/kWh (0.063 USD/kWh), and the school pays 0.2116 FJD/kWh (0.10 USD/kWh).[17]

Table 1. **Electricity Tariffs in Fiji**

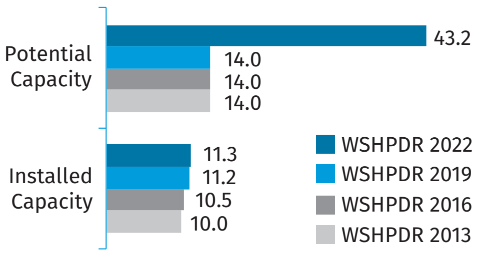
Customer category	*Consumption band*	*Final electricity price (FJD (USD) per kWh)*
Domestic	base rate	0.3401 (0.17)
	< 100 kWh/month	0.1767 (0.087)
Commercial	< 14,999 kWh/month	0.4099 (0.19)
	> 14,999 kWh/month	0.4294 (0.21)
Industrial	75-500 kW in demand	0.2781 (0.14)
	500-1,000kW in demand	0.3026 (0.15)
	> 1,000 kW in demand	0.3270 (0.16)
Other	Places of worship & street lights	0.3401 (0.16)
	Primary and secondary schools	0.2116 (0.10)

Source: Energy Fiji Limited[17]

SMALL HYDROPOWER SECTOR OVERVIEW

There is no official definition of SHP in Fiji. The definition used for this chapter is up to 10 MW. Fiji has grid-connected as well as off-grid SHP plants. The installed capacity of SHP was 11.3 MW in 2021 (Table 2). Since the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity of SHP in the country has changed by 0.1 MW due to a new estimate of the capacity of the Wainikasou plant, while estimates on the economic potential capacity have increased due to access to a new feasibility study based on geospatial analysis and a cost-benefit analysis, revealing 31.9 MW of untapped potential plus the existing capacity, making the total potential 43.2 MW (Figure 4).[12,21,22,23]

Figure 4. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Fiji (MW)**



Source: EFL,[12] *WSHPDR 2013*,[19] *WSHPDR 2016*,[20] WSHPDR 2019,[21] UNFCCC,[22] JICA,[23] DoE,[24] EquatorInitiative[25]

Table 2. **List of Operational Small Hydropower Plants in Fiji**

Name	*Location*	*Capacity (kW)*	*Head (m)*	*Plant type*	*Operator*	*Launch year*
Wainikasou	Viti Levu	6,600	116	Run-of-river	EFL	2004
Vaturu	Viti Levu	3,000	321	Run-of-river	EFL	2006
Wainique	Savusavu	800	–	Run-of-river	EFL	1992
Somosomo	Taveuni	700	590	Run-of-river	EFL	2017
Bukuya	Interior of Ba, Viti Levu	100	–	Run-of-river	Village+ DoE + UNDP	1989
Muana	Vanua Levu	48	–	Run-of-river	Village+ DoE	1999
Kadavu village	Kadavu Island	23	24.6	Run-of-river	Village+ DoE	1994
Nasoquo	Viti Levu	4	–	Run-of-river		1984
Vatukarasa	Viti Levu	3	–	Run-of-river		1993
Buca (under maintenance))	Vanua Levu	0.025	183	Run-of-river	Village + DoE	

Source: EFL,[12] UNFCCC,[22] JICA,[23] DoE,[24] EquatorInitiative[25]

Table 3 shows two plants that were operational previously but currently are awaiting or undergoing maintenance. For the Buca hydropower project, according to the Fiji Department of Energy, there are plans to upgrade its capacity from 25 kW to 125 kW.

Table 3. **List of Ongoing or Planned Small Hydropower Rehabilitation Projects in Fiji**

Name	*Location*	*Capacity (MW)*	*Head (m)*	*Plant type*	*Developer*	*Stage of development*
Nagado/Vaturu	Viti Levu	2.8	321	Run-of-river	EFL	Restoration works
Buca	Vanua Levu	0.025	183	Run-of-river	Village + DoE	Refurbishment

Source: EFL,[12] DoE[24]

A study by the Japan International Cooperation Agency (JICA) has identified 37 potential hydropower sites.[23] These sites were ranked based on their cost-benefit analysis, environmental impact and technical feasibility, until the list was narrowed down to nine priority sites for investment. Another 2009 report of the DoE has also identified potential SHP sites in Fiji. From the 20 sites selected and ranked for long-term monitoring (2–3 years). The methodology for ranking these plants depended on technical feasibility and economic feasibility, using a supply and demand analysis. As a result of this ranking, six sites were identified as feasible in that study.[26] The sites listed in Table 4 are the nine sites that make up the economic potential used in Figure 4 (31.9 MW). They are ranked in order of priority and are all from the more recent JICA study.

Table 4. **List of Small Hydropower Plants Available for Investment in Fiji**

Name	*Location*	*Potential capacity (MW)*	*Head (m)*	*Type of site (new/ refurbishment)*	*Priority rank*
No. 8 Mba 1U/S	West Viti Levu	9.2	74.7	New	AA
No. 29 Waivaka	South Viti Levu	7.4	176.5	New	AA
No. 14 Naboubuco	Central Viti Levu	2.7	96.9	New	A
No. 24 Nakavika	South Viti Levu	2.6	45.7	New	C
No. 26 Wainavadu	South Viti Levu	2.5	97.04	New	A
No. 28 Waisoi	South Viti Levu	2.1	190.0	New	A
No. 35 Waievu	South Vanua Levu	2.0	76.1	New	AA
No. 31 Saquru	East Vanua Levu	2.0	254.1	New	A
No. 7 Nabiaura	West Viti Levu	1.4	216.9	New	AA

Source: JICA[23]

Grid-connected SHP plants are operated and maintained by the EFL. Off-grid SHP plants are operated and maintained by the DoE for the first three years after commissioning. After three years, the project is handed over to the community after proper training has been done regarding operation and maintenance.

RENEWABLE ENERGY POLICY

The National Development Policy of Fiji aims for 100 per cent of electricity generation to be from renewable sources by 2036, while by 2021, 100 per cent of the population was envisioned to have access to electricity.[27] Fiji is committed to reducing its greenhouse gas (GHG) emissions and thus in the Nationally Determined Contributions (NDC) Implementation Roadmap has set short- and medium-term plans to increase efficiency in the transport and electricity sector and increase the renewable energy share in electricity generation.

The country's NDC target is a 30 per cent reduction in GHG emissions by 2030 when compared to the business-as-usual scenario. Of the 30 per cent, 10 per cent is unconditional, meaning that Fiji is committed to reducing the emissions, while the remaining 20 per cent is conditional on the availability of finance and enabling policies for emissions reduction.[28] Of the 30 per cent reduction in emissions, 20 per cent should come from replacing IDO and HFO generators with renewable energy generation. A further 10 per cent of emissions reduction should come from energy efficiency measures implemented in the electricity demand and transport sector. Similarly, in its Low-Emission Development Strategy (LEDS) 2018–2050, the country shows commitment to reaching net-zero emissions by mid-century.[29]

The National Climate Change Policy 2012 is a document that provides guidelines for different sectors on the impact of climate change and, through planning and implementation programmes, prepares for climate change adaptation and mitigation.[30] Mitigation is to be addressed via assessment and utilization of renewable sources such as hydropower, marine energy, wind power, etc. This document highlights that hydropower will be adversely affected by climate variance, (especially low rainfall) and mentions that deforestation is to be minimized during dam construction. The National Adaptation Plan 2018 supports the SDG 7 Affordable and clean energy for all through its infrastructure section that highlights hydropower and other renewable energy output under new climatic conditions.[31]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

At the time of writing of this chapter, the DoE was investigating potential SHP projects using contour maps from the Lands Department.[32] The DoE undertakes the installation of SHP projects with the assistance of external contractors. EFL approval is only given if required standards have been followed and if the power plant is safe to operate. Before the commencement of any SHP project, an environmental impact assessment (EIA) is carried out and clearance from the Department of Environment is required.

COST OF SMALL HYDROPOWER DEVELOPMENT

The average cost of a grid-connected SHP plant is approximately 3,000 FJD/kW (1,475 USD/kW) and the generation cost (i.e., operations and maintenance cost) is 1.8 FJD/MWh (0.89 USD/MWh).[33] However, the installation of the Somosomo hydropower plant, a joint project between the DoE and the Government of China, cost approximately 30,000 FJD/kW (14,754 USD/kW).[34]

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

There are no dedicated financial mechanisms for SHP projects in Fiji at the time of writing. Zero duty is charged on import of renewable energy-related equipment. A five-year tax holiday, which provides exemption for all non-VAT taxes, is also available to developers investing in renewable energy generation projects.[35] SHP projects received funding from development project finance in the past.

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Climate change is impacting the rainfall pattern in Fiji. During periods of droughts, there is low output from hydropower plants, while now frequent category five tropical cyclones can damage power infrastructure such as transmission and distribution lines.[5]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Fiji currently has 11.3 MW of SHP installed capacity from operational plants, with an additional 2.8 MW of SHP capacity undergoing maintenance or upgrading and 19.1 MW of planned projects since 2009.[26] There is significant potential, but sourcing finance is always a challenge for smaller utility companies and IPPs.

The following points summarize the main barriers to SHP development in Fiji that have been identified:

- One of the major barriers is the land issue. For SHP projects, a significant land area is needed, from the water source (weir) to the power plant. The path where the pipe(s) are laid out for penstock can cover three to four different mataqali's (traditional land), which makes negotiations with landowners difficult.
- According to the DoE, landowners interpret land agreements differently during the "talanoa" (discussion) sessions between DoE staff and themselves. The DoE suggests that it is best to have the agreement in writing or to use land that does not deal with direct involvement of landowners, i.e., use the native land leased by the Government.
- There is a strong need for enhanced and continuous capacity development of the DoE staff regarding various aspects of SHP development.
- IPPs need access to financing and support from donors and other entities like ADB, UNDP, GEF, GCF, etc.

The following points summarize the main enablers for SHP development that have been identified:

- The ambition of the Government to achieve 100 per cent renewable electricity generation by 2036 and universal access to electricity requires development of new energy resources, including SHP.
- EFL has significant experience in developing and operating hydropower projects over the past four decades. It is well-placed to increase the renewable energy component in its grid by investing into new SHP projects.
- There is also potential to develop pumped-storage hydropower plants, which can be run in combination with solar/wind power plants.

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French Polynesia

Davy Rutajoga, International Center on Small Hydro Power (ICSHP)

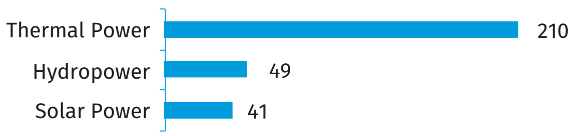
KEY FACTS

Population	282,534 (2020)[1]
Area	4,167 km^2 [2]
Topography	The archipelagos of French Polynesia are the Tuamotu Archipelago, Society Islands, Marquesas Islands, Tubuai Islands and Gambier Islands. The Society Islands account for two fifths of the total land area and are the most westerly. Resulting from the emergence of underwater volcanoes, the islands are made of eroded volcanic cones that cut up into high volcanic peaks and deep valleys. The highest peak is Mount Orohena, culminating at 2,241 metres.[3]
Climate	The climate in French Polynesia is tropical, warm and humid. The cool and dry season lasts from May to October with some variations from island to island. In Papeete, the average annual temperature is 26°C with an average high of 33°C in March and an average low of 21°C in October. In the southern Tubuai Islands, the climate is cooler with an average annual low temperature of 18°C. Humidity is high all year long.[3]
Climate Change	The islands of French Polynesia are affected by global warming. Sea level rise, increased erosions, rainfall irregularities and frequent extreme climatic events have been observed. The average annual temperature has increased by 1.1°C since the 1950s and is expected to increase further. Sea level rise is of great concern in French Polynesia, with levels projected to rise by 80 centimetres by the year 2100.[4,5]
Rain Pattern	French Polynesia experiences a warm and rainy season from November to April, with December being the wettest month. Precipitation is abundant on most islands, with the exception of northern Tuamotu and the Marquesas Islands. Coastal areas experience an average rainfall of 3,050 mm.[3]
Hydrology	Water resources are abundant and groundwater is used extensively, though availability varies according to the topography of the island. They are abundant in highly elevated islands and limited on the atolls.[6]

ELECTRICITY SECTOR OVERVIEW

The main sources of electricity in French Polynesia are thermal power and hydropower, accounting for 71 per cent and 23 per cent, respectively, of the total electricity generation, which amounted to 694 GWh in 2019. Solar power generation amounted to 40 GWh, or 6 per cent of the total generation in the same year (Figure 1).[7]

Figure 1. **Annual Electricity Generation by Source in French Polynesia in 2019 (GWh)**

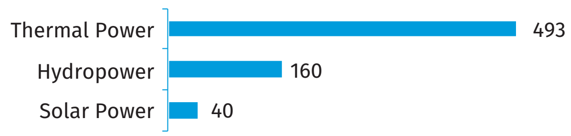


Source: IRENA[7]

French Polynesia is dependent on non-renewable thermal energy for most of its electricity needs. However, plans have been formulated by the Government to transition to renewable energy, with a set goal of a 75 per cent share of renewable energy in the generation mix by 2030.[8]

´In 2020, French Polynesia had 300 MW of installed electricity capacity, of which thermal power and hydropower represented 70 per cent and 16 per cent, respectively. Solar power accounted for 41 MW, or 14 per cent, of the total installed capacity (Figure 2).[7]

Figure 2. **Installed Electricity Capacity by Source in French Polynesia in 2020 (MW)**



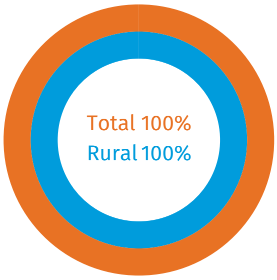
Source: IRENA[7]

As French Polynesia is composed of multiple islands, the production and consumption of electricity varies depending on the population, remoteness and installation of plants. The main electricity utility company in the islands is the Electricité de Tahiti (EDT ENGIE) and its subsidiary Marama Nui, which operates hydropower plants in Tahiti and the

Marquises. As French Polynesia is an overseas collectivity of France, EDT ENGIE is connected to the French multinational utility company ENGIE, which promises to help bring about the development of clean energy in the islands.[9]

In 2020, 100 per cent of the rural and urban population of French Polynesia had access to electricity (Figure 3).[10]

Figure 3. **Electrification Rate in French Polynesia in 2020 (%)**



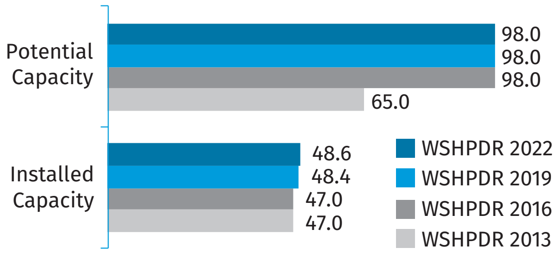
Source: World Bank[10]

Electricity tariffs in French Polynesia in 2019 were between 0.17 USD/kWh for low consumption and 0.37 USD/kWh for high consumption.[11]

SMALL HYDROPOWER SECTOR OVERVIEW

French Polynesia defines small hydropower (SHP) as hydropower plants that have an installed capacity of up to 10 MW. There are currently 22 operational SHP plants in French Polynesia with a total installed capacity of 48.6 MW (Table 1), a 0.2 MW increase from the installed capacity reported in the *World Small Hydropower Development Report (WSHPDR) 2019*. This increase is due to the construction of a 220 kW SHP plant in Maroto as part of the Hydromax Project, a 2018 project that aimed to optimize hydropower without any negative impact on the environment.[12,13] The estimated SHP potential in French Polynesia is 98 MW, similar to the estimates in the *WSHPDR 2019* (Figure 4).

Figure 4. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in French Polynesia (MW)**



Source: EGT ENGIE,[12] *WSHPDR 2019*,[13] *WSHPDR 2013*,[14] *WSHPDR 2016*[15]

There are 16 SHP plants in Tahiti, distributed across five valleys: Vaihiria, Vaite, Faatautia, Titaaviri and Papenoo. The Papenoo valley alone accounts for 60 per cent of the total hydropower production in Tahiti. There are a further six SHP plants in the Marquesas Islands found in Hiva Oa and Nuku Hiva.[12]

Table 1. **List of Existing Small Hydropower Plants in French Polynesia**

Name	*Locations*	*Capacity (MW)*
Papenoo	Tahiti	28.4
Faatautia	Tahiti	7.5
Vaihiria	Tahiti	4.9
Titaaviri	Tahiti	4.1
Vaite	Tahiti	2.5
Hiva Oa and Nuku Hiva	Marquesas Islands	1.2
Total		**48.6**

Sources: EGT ENGIE,[12] High Commission of the Republic in French Polynesia[16]

RENEWABLE ENERGY POLICY

Although French Polynesia is an overseas collectivity of France and is thus led by France in most areas, it is autonomous on matters of handling climate change and formulating mitigation and adaptation strategies. This includes renewable energy policies and programmes.

In 2015, the Government of French Polynesia launched the Energy Transition Plan (ETP) and set a target of increasing the share of renewable energy in the islands' generation mix to 75 per cent by 2030. In order to achieve this goal, the Hydromax Project was developed. This project aimed to increase the generating power of hydropower plants, while minimizing negative environmental impact. As part of the Hydromax Project, a new SHP plant was constructed as well as the capacity of the SHP plants in Titaaviri and Papenoo was increased. The ETP is supported by the French Development Agency (AFD), which is providing a funding of USD 450,000.[8,16,17]

In 2019, the Energy Code of French Polynesia was updated to include a ban on the construction of new fossil fuel-powered plants or any non-renewable power plants. It also stipulates that no refurbishments of non-renewable energy power plants can be funded by the Government. Funding can only be given towards the construction or refurbishment of renewable energy power plants.[18]

French Polynesia is a member of the Pacific Centre for Renewable Energy and Energy Efficiency (PCREEE) and as such is committed to the improvement of access to modern, affordable and reliable energy services, energy security and mitigation of negative externalities of the energy system by promoting renewable energy and energy efficiency investments, markets and industries.[19]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

The main legislation and regulation documents in French Polynesia concerning hydropower projects are:

- The Energy Code of French Polynesia (Country Law No. 2019-27 of 2019);
- Law No. 2013-27 of 2013 on the Guiding Principles of the Energy Policy of French Polynesia.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

In general, SHP provides a sound contribution to French Polynesian society. The development of new SHP projects is hampered mainly by:

- Most water resources, including waterfalls, are highly touristic, which is the backbone of the economy. The construction of dams and hydropower plants in the vicinity of these sites could potentially deter tourists from visiting;
- Many of the valleys with hydropower potential are often inhabited by protected species and contain archaeological sites.

Enablers for SHP development in French Polynesia include:

- Untapped SHP potential that presents opportunities for development;
- The Energy Transition Plan (ETP), which considers hydropower development a priority;
- The Government is committed to the development of renewable energy, notably through its membership in the PCREEE;
- Partnership with AFD would be beneficial as France manufactures hydropower plant equipment;
- High financing potential as French Polynesia is a collectivity of France and thus could benefit from the country's internal financing mechanisms for development projects.

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Federated States of Micronesia

International Center on Small Hydropower (ICSHP)

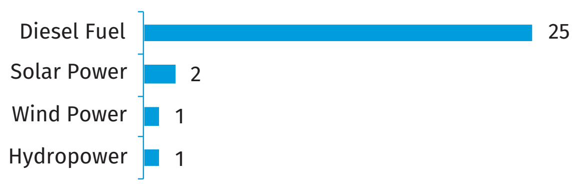
KEY FACTS

Population	116,255 (2021)[1]
Area	702 km^2 [2]
Topography	The 607 islands of the Federated States of Micronesia include mountainous islands of volcanic origin and coral atolls. The country is divided into four states each composing a region of several islands. Kosrae in the east is mostly mountainous with two high peaks, Fenkol (634 metres) and Matanti (583 metres). Just west is Pohnpei that has the highest elevations in the country and the highest peak, Mount Totolom at 791 metres. Chuuk contains 14 significant islands of rugged terrain and several low-lying atolls. Yap is the south-easternmost state with a peak elevation of 178 metres at Mount Tabiwol. The outer islands of all states are mostly coral atolls.[2]
Climate	The Federated States of Micronesia has a wet, tropical climate. The average temperature is 27°C and varies little throughout the year. The wet season is long, between April and December, while the dry season is short, during January to March.[3]
Climate Change	As a country of islands, climate change effects such as sea level rise and coastal erosion and flooding are of particular concern. These are already being experienced and expected to accelerate into the coming decades. Additionally, extreme storms such as typhoons are becoming more intense and more frequent. Ocean acidification is also weakening the country's coral reefs and atolls, which serve as barriers to the main islands.[4]
Rain Pattern	Micronesia experiences plentiful precipitation ranging between 3,000 mm per year on some islands and up to 9,000 mm on others. Pohnpei is considered by some as the wettest place in the world with its average annual rainfall at 9,000 mm. Rainfall can happen all year round but is heaviest between April and December. The country is at high risk of typhoons and tropical storms each year around July.[2,4]
Hydrology	Due to having the highest elevations, the state of Pohnpei has the most rivers, approximately 40 of them, which flow all year long. Similarly, in Kosrae, almost all streams and rivers flow all year long, including the Finkol, Innem and Okat. The islands of Chuuk have just a few permanent rivers, including the Wichon and Kiepw. Conversely, the few rivers of Yap tend to stop flowing during the dry season. Outer islands lack streams and rivers, with the only source of fresh water being rain and groundwater.[2,5]

ELECTRICITY SECTOR OVERVEW

As of 2020, the total installed capacity across the Federated States of Micronesia (FSM) was 29 MW. Of this, diesel fuel accounted for 25 MW (86 per cent), solar power for 2 MW (7 per cent) and the remaining 7 per cent was split between wind power for 1 MW and hydropower for 1 MW (Figure 1).[6] Imported diesel fuel has historically been the most important energy source for the country, although renewable energy has been incorporated within the last few years. Plans to increase the overall installed capacity in the country have been underway with the financial support of international entities. Between 2019 and 2024 there are several ongoing and planned projects with investments amounting to USD 109.50 million from the World Bank, the Asian Development Bank, the European Union, Japan, the United States and the United Nations Development Programme. These projects include numerous solar power projects, both on the national grid and the creation of mini-grids, a few diesel fuel plant projects, one hydropower project and one wind power project.[7]

Figure 1. **Installed Electricity Capacity by Source in the Federated States of Micronesia in 2020 (MW)**



Source: IRENA[6]

In 2019, total electricity generated in the FSM was 64 GWh. Diesel fuel generated 60 GWh (94 per cent), solar power 3 GWh (5 per cent) and hydropower 1 GWh (1 per cent) (Figure

2).[6] Thus, renewable energy accounted for 6 per cent of electricity generation in 2019. According to the country's Energy Master Plan, renewable energy generation goals included 9 per cent by 2018 and 30 per cent by 2020, indicating that actual renewable energy generation fell short of the goals.[7]

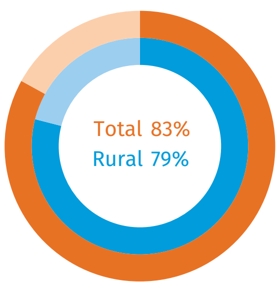
Figure 2. **Annual Electricity Generation by Source in the Federated States of Micronesia in 2019 (MW)**

Source: IRENA[6]

The country consists of four states: Chuuk, Kosrae, Pohnpei and Yap. Each state has their respective publicly-owned utility company: Chuuk Public Utility Corporation (CPUC), Kosrae Utilities Authority (KUA), Pohnpei Utilities Corporation (PUC) and Yap State Public Service Corporation (YSPSC). They are each vertically integrated and the only electricity and water company in their states. The companies are overseen by their respective utility board made up of members appointed by their state governments. All four companies are members of the greater Pacific Power Association that associates all utility companies in the 22 pacific island countries to share technical assistance and expertise amongst them.[8]

The overall electrification rate of Micronesia is 83 per cent, which includes an urban electrification rate of 97 per cent and a 79 per cent rural electrification rate (Figure 3).[9] Rates vary greatly across the four states with Chuuk having the lowest rate, under 30 per cent, while the other three states have rates between approximately 70 and 100 per cent.[10] Electrification of Chuuk is highly prioritized by the state and ongoing projects include installing a number of separate mini-grids in remote areas of several of its islands as well as installing over 500 solar panels on individual homes across the state. The country aims to have universal access to electricity by 2027.[7]

Figure 3. **Electrification Rate in the Federated States of Micronesia in 2020 (%)**



Source: World Bank[9]

Electricity tariffs are proposed by the state utility company and approved by its utility board. Each state has their own tariff rates that are calculated depending on the cost of diesel fuel per gallon with rates varying for different types of users or usage.[11] Current electricity tariff rates in Chuuk, Pohnpei and Yap are detailed in Table 1. Current rates in Kosrae are unavailable.

Table 1. **Electricity Tariffs in the Federated States of Micronesia**

Utility Company	*Type of Consumer*	*Usage*	*Tariff (USD/kWh)*
CPUC	Residential		0.4478
	Commercial		0.4778
	Government		0.4978
PUC		< 7,000 kWh	0.6225
		> 7,000 kWh	0.6225 + USD 9 per kW demand
YSPSC*	Residential	< 50 kWh	0.3712
		50–250 kWh	0.4242
		> 251 kWh	0.4507
	Commercial	< 1,000 kWh	0.4507
		> 1,000 kWh	0.5303
	Government		0.7863

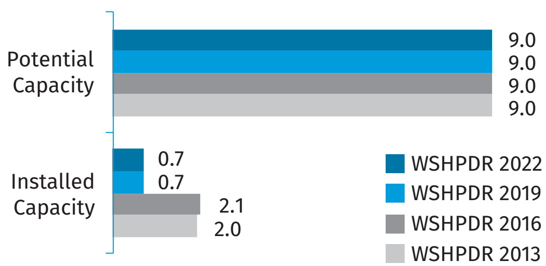
Source: CPUC,[11] PUP,[12] YSPSC[13]

Note: *Values for Yap Island proper, outer island rates differ.

SMALL HYDROPOWER SECTOR OVERVIEW

There is no official definition of small hydropower (SHP) in the FSM, therefore, this chapter uses the standard definition up to 10 MW. The total installed capacity of SHP is 0.725 MW, while the total potential is 9 MW, indicating that approximately 8 per cent of possible SHP has been developed in the country. Compared to the *World Small Hydropower Development Report (WSHPDR) 2019,* both installed and potential capacities have remained the same (Figure 4).

Figure 4. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in the Federated States of Micronesia (MW)**



Sources: World Bank,[10] *WSHPDR 2019,*[5] *WSHPDR 2016,*[14] *WSHPDR 2013*[15]

Due to river properties, the hydropower potential in the country is mostly limited to the state of Pohnpei. The only hydropower plant in the country is the 725 kW Nanpil plant in the state of Pohnpei. This plant was originally built in the 1980s with 2.1 MW, but during a rehabilitation process in 2014, only 725 kW was reinstalled due to the conflicting water demand of the same reservoir.[10] More recently, a site on the Lehnmesi River has been identified for a 2.5 MW SHP project. Within the Renewable Energy Development Project funded by the Asian Development Bank, plans to construct this plant are underway and envisaged to be completed by 2023. The project is valued at approximately USD 2 million.[7]

RENEWABLE ENERGY POLICY

A defined National Energy Policy (NEP-2012) is in place, with each of the four states having specific action plans. In April 2018, the country launched its Energy Master Plan. The NEP-2012 defined the national goal of improving the livelihoods of all citizens with affordable, reliable and environmentally friendly energy. The policy specifically promotes sustainable, social and economic development through the provision and utilization of cost-effective, safe, reliable and sustainable energy services. It set a goal to reach a 30 per cent renewable energy share by 2030.[16]

The NEP-2012 is in line with the objectives of Sustainable Energy for All Initiative (SE4ALL) and Agenda for Change in poverty reduction, sustainable growth, clean energy and improving resilience to natural disasters and climate change. All these development objectives can be achieved and accelerated through reinforced cooperation and partnership between the country and its development partners. The plan highlights the importance of external investments and public-private partnerships in the sector. However, no legal framework or financial incentives, such as feed-in-tariffs, to encourage investment in the electricity sector have been developed as of yet.[16]

The Energy Master Plan of 2018 discusses the expansion of capacities and energy security for the country. It calls for over USD 300 million in investments for the installation of numerous schemes, mostly of solar power, the rehabilitation of the distribution network and bringing electricity to unserved communities, many with the use of mini-grids. The plan foresees a 47 per cent share of renewable energy by 2024 if all projects in the plan were to be implemented before that time. As per reports from the 2022 Research and Development Conference for the Energy Sector, many of these projects are ongoing, but project completions are not clearly announced.[7]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Barriers to the development of SHP include:
- The country lacks extensive freshwater supply and there is therefore a conflict between water demand and the use of hydropower, as shown in the case of the current Nanpil SHP plant;
- For the development of hydropower, technical and financial assistance is needed, including site-specific hydrology data, funding and site-specific impact assessments covering river flow, land inundation and the general environment.[5]

Enablers for the development of SHP include:
- Most of SHP potential is untapped leaving technical opportunity for development;
- Access to electricity in the country is not universal and SHP development in remote areas can bring electricity to communities that have been without;
- Currently, fossil fuels account for 94 per cent of electricity generation. SHP could be used to achieve the goal of 30 per cent renewable energy by 2030.

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New Caledonia

Bastian Morvan, Department of Industry, Mines and Energy; and International Center on Small Hydro Power (ICSHP)

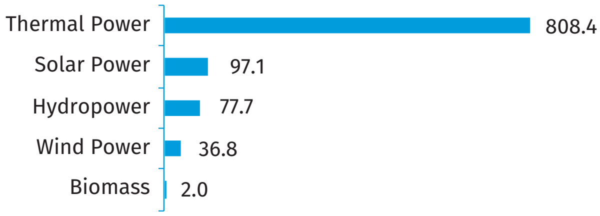
KEY FACTS

Population	271,960 (2020)[1]
Area	19,103 km[2]
Topography	New Caledonia consists of a group of islands: the island of New Caledonia, where the capital Nouméa is located, the Loyalty Islands, the Bélep Islands, the Île des Pins and a number of uninhabited islets. The island of New Caledonia is by far the largest in the country, measuring 50 kilometres in width and 500 kilometres in length. The island's eastern and western halves are separated by rugged mountains that run north-south. Most of the southern third of the island is characterized by a plateau, which rises to 1,617 metres at Mount Humboldt. Mount Panié, the highest peak in New Caledonia, rises to 1,628 metres above sea level and is located in the north-east of the main island.[2]
Climate	The climate is subtropical and is influenced by annual changes in the position of the subtropical high-pressure belt and bass intertropical pressures. There are two main seasons and two inter-seasons: a hot and humid hurricane season (November–April), a transitional season (April–May), a cold season with westerly winds (May–September) and a dry season with constant trade winds (September–November). The average annual temperature ranges between 22°C and 24°C. In the south of the island of New Caledonia, temperatures can exceed 30°C. The lowest temperature recorded in the capital city, Nouméa, is 13°C, while in the north temperatures as low as 5°C have been recorded.[2,3]
Climate Change	Due to the country's topography, the marine environment is most impacted by climate change, with coral reef degradation occurring as a result of successive bleaching events. In 1996, the corals of New Caledonia experienced severe bleaching with the coral mortality rate rising as high as 80 per cent. Rising sea levels also pose a threat to the beaches and coastal ecosystems of New Caledonia as estuaries and low-lying islands are likely to be particularly flooded, especially during tropical storms. Between 1980 and 2099, the air temperature in New Caledonia is expected to increase by 1.8-2.1°C and precipitation is projected to decrease by 5–8 per cent.[4,5]
Rain Pattern	Precipitation happens throughout the year and ranges from less than 1,000 mm on the west coast of the main island to more than 3,000 mm on the east coast. Rainstorms are particularly common on the east coast. There are two particularly rainy periods, from December to March and from July through August. September through November are the driest months.[2]
Hydrology	The longest river in the country is the Diahot, which flows northwards on the main island for approximately 100 kilometres along the western escarpment of the Mount Panié. There are also numerous streams descending from the central mountain chain. They tend to flood rapidly after rainfall and dry out in dry weather.[2]

ELECTRICITY SECTOR OVERVIEW

In 2019, the total installed capacity of New Caledonia was 1,022 MW.[6] Thermal power dominates the country's energy mix, accounting for 79 per cent of total installed capacity in 2019. Solar power is the most developed renewable energy source, accounting for almost 10 per cent of the total installed capacity, followed by hydropower at less than 8 per cent, wind power at less than 4 per cent and biomass at 0.2 per cent (Figure 1).[6]

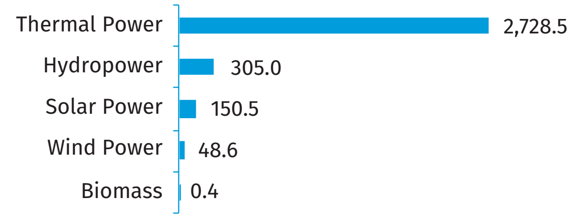
Figure 1. **Installed Electricity Capacity by Source in New Caledonia in 2019 (MW)**



Source: DIMENC[6]

Electricity generation in 2020 reached 3,233 GWh, with 84 per cent coming from thermal power, 9 per cent from hydropower, almost 5 per cent from solar power, 2 per cent from wind power and 0.01 per cent from biomass (Figure 2).[7]

Figure 2. **Annual Electricity Generation by Source in New Caledonia in 2020 (GWh)**



Source: DIMENC[7]

Since 1995, 100 per cent of the population in Caledonia, both in rural and urban areas, have had access to electricity.[8] Electricity consumption in 2020 totalled 3,165.8 GWh, of which only 753.1 GWh (24 per cent) was for public consumption from the grid. The remaining 2,412 GWh (76 per cent) was used by the metallurgical and mining industry.[7] Thus, the electricity sector in New Caledonia is inextricably linked to industry, particularly nickel extraction and processing, providing electricity to the three major nickel plants - Koniambo Nickel SAS, Doniambo of the Société Le Nickel (SLN) and Vale Nouvelle-Calédonie (VNC).[9]

Aside from the metallurgical sector, the electricity sector is made up of the New Caledonian Energy Company (ENERCAL), the country's largest electricity producer, accounting for 50 per cent of electricity production and with 80 per cent produced from renewable energy sources. ENERCAL owns the grid concession and the majority of hydropower plants in the country. The Government has mandated ENERCAL with managing the country's transmission network. It buys electricity from other power producers and transports it to industrial customers or to the distributing companies EEC-Engie and ENERCAL itself.[10]

The transport network belongs to the Government of New Caledonia, which has entrusted its management (operation and maintenance) to ENERCAL.[11] The country has six grids: one on the main island and five on smaller islands. The transmission network in the island of New Caledonia consists of 560 kilometres of 150 kV lines, 650 kilometres of 33 kV lines and 16 substations.[12]

The Department of Industry, Mines and Energy of New Caledonia (DIMENC) is the government agency responsible for the development and enforcement of the regulatory framework for the electricity sector, overseeing electricity prices and executing the technical control of electricity lines in order to ensure a balance between the electricity demand and supply.[13]

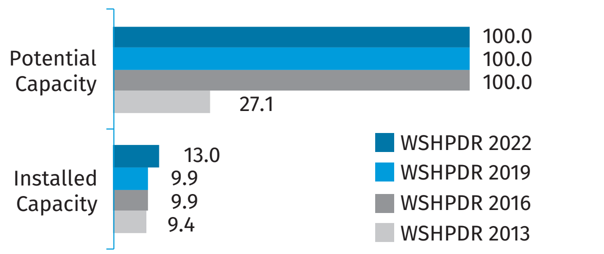
Electricity tariffs are defined on a trimestral basis by the Government and are published in the Official Journal of New Caledonia. The tariff system is uniform across the country, with prices varying depending on the type of consumption. As of January 2022, the electricity tariffs were 31.4 CFP/kWh (0.30 USD/kWh) for residential consumers and 22.01 CFP/kWh (0.21 USD/kWh) for industrial and commercial consumers.[7]

SMALL HYDROPOWER SECTOR OVERVIEW

In New Caledonia, small hydropower (SHP) is defined as hydropower plants with a capacity up to 10 MW. SHP plants are further classified into the categories of pico-hydropower (below 500 kW), micro-hydropower (from 500 kW to 2 MW) and SHP (from 2 MW to 10 MW).[14]

As of the end of 2020, the installed capacity of SHP in New Caledonia was 12.98 MW, while potential capacity is estimated at approximately 100 MW.[15,16,17] Thus, approximately 13 per cent of the known SHP potential has been developed so far. Compared to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity has increased by 3 MW as a result of the commissioning of the new Paalo plant, whereas the potential estimate has remained unchanged (Figure 3).

Figure 3. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in New Caledonia (MW)**



Source: ENERCAL,[15] Government of New Caledonia,[16] *WSHPDR 2016*,[17] *WSHPDR 2013*,[18] *WSHPDR 2019*[19]

As of November 2021, there were 12 hydropower plants in operation in New Caledonia, out of which 11 were SHP plants with installed capacity ranging from 0.02 MW to 7.20 MW (Table 1). Four hydropower plants - Yaté, Néaoua, Thu and Paalo - are connected to the grid. The Yaté hydropower plant, with a capacity of 68 MW, is the only large hydropower plant in New Caledonia. It was commissioned in 1958, has four Francis turbines of 17 MW each and a 40 km^2 reservoir with a storage capacity of 310 million m^3. Approximately 90 per cent of electricity generated by this plant is consumed by the SLN metallurgic plant and only 10 per cent is used for public distribution. The Néaoua SHP plant was launched in 1982, has a reservoir with a capacity of 1.75 million m^3 and two turbines of 3.6 MW each. Electricity generated by the plant is fed into the grid for public consumption. The Thu plant was commissioned in 1990 and is a run-of river plant with one Pelton turbine of 2.2 MW. The most recently commissioned hydropower plant in New Caledonia is the Paalo SHP plant with a capacity of 3 MW, which was launched in December 2020 to supply the entire island of New Caledonia via the island's transport network.[15] Until the commissioning of the Paalo plant the country's SHP capacity remained unchanged for almost three decades.

Table 1. **List of Operational Small Hydropower Plants in New Caledonia**

Name	*Location*	*Installed capacity (MW)*	*Plant type*	*Operator*	*Launch year*
Néaoua	Houaïlou	7.20	Reservoir	ENERCAL	1982
Thu	Houaïlou	2.20	Run-of-river	ENERCAL	1990
Paalo	Pouébo	3.00	Run-of-river	ENERCAL	2020
Borendy	Thio	0.18	Run-of-river	ENERCAL	1987
Ouégalé	Pouébo	0.13	Run-of-river	ENERCAL	1991
Kouaré	Thio	0.08	Run-of-river	ENERCAL	1983
Caavatch	Hienghène	0.05	Run-of-river	ENERCAL	1984
Pouébo (Janisel)	Pouébo	0.05	Run-of-river	ENERCAL	1983
Wadiana	Yaté	0.04	Run-of-river	ENERCAL	1982
Ouaté	Pouembout	0.02	Run-of-river	ENERCAL	1984
Katricoin	Moindou	0.03	Run-of-river	N/A	1983
Total		**12.98**			

Source: ENERCAL,[15] Government of New Caledonia[16]

The remaining eight SHP plants are classified as micro-hydropower and range in capacity from 0.02 MW to 0.18 MW. They are of a run-of-river type and are not connected to the grid, providing electricity to the isolated areas of the main island. In 2020, these eight plants generated 3.7 GWh of electricity, while the larger SHP plants generated 20.2 GWh.[7]

The total potential of SHP in New Caledonia is estimated to be between 100 MW and 250 MW.[17] The Research and Development Institute (IRD) has recommended that the focus in hydropower development in New Caledonia should be made on reservoir plants rather than on run-of-river plants due to the country's relatively steep relief and precipitation patterns.[14,17]

RENEWABLE ENERGY POLICY

Renewable energy is seen as a way to reduce the country's dependency on fossil fuel imports. In 2016, New Caledonia adopted the Energy Transition Plan (Energy Transition Scheme of New Caledonia), which set the following three objectives to be achieved by 2030:

- Decrease primary energy consumption by 20 per cent (including the mining and metallurgical sector) and final energy consumption by 25 per cent (excluding the mining and metallurgical sector);
- Achieve 100 per cent of public electricity consumption from renewable energy as well as 100 per cent of electricity generation on the islands from renewable energy sources;
- Decrease emissions in the residential and tertiary sectors by 35 per cent, in the mining and metallurgical sector by 10 per cent and in the transportation sector by 15 per cent.[20]

The transitional energy mix is expected to keep relying on thermal power for the base load, but also optimize stable renewable energy sources (hydropower, biomass), develop intermittent renewable energy sources (solar and wind power) as well as develop energy storage solutions. Thus, among renewable energy sources, hydropower is planned to see 74 MW of additional capacity by 2030, including 44 MW from reservoir-based hydropower and 30 MW from run-of-river plants. Thus, total hydropower capacity in the country is planned to reach 151.4 MW by 2030.[20,21]

The Energy Transition Plan recognizes that the development of renewable energy sources in New Caledonia requires improving the local technical and economic capacity as well as developing auxiliary services in order to stimulate demand and investment in the renewable energy sector. To support the implementation of this plan, the French Development Agency (AFD) Nouméa, partnered with the Caledonian Energy Agency (ACE) in June 2020 and has so far invested EUR 233 million (USD 264 million) into the energy transition of New Caledonia and completed several renewable energy projects as well as supported actions carried out by local communities.[22]

Another measure covered in the plan is the decentralization of electricity production and the promotion of self-generation.[9] Since 2016, four government orders have allowed self-generation from solar power for household, professional and community use. The objective is to encourage self-consumption, with possible resale of the surplus at a price of 15 CFP/kWh (0.14 USD/kWh). [23]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The major barriers to SHP development in New Caledonia include:

- Projects take a long time to develop, requiring numerous environmental studies and permits;
- Environmental constraints increase production costs;
- Protection by law of indigenous lands, which represent most of the land of New Caledonia and where acquisition of land and water rights is not allowed.

The key existing enabler for SHP development in New Caledonia is the Government's prioritization of the development of renewable energy sources, including hydropower. By 2030, installed hydropower capacity is projected to double, reaching a total of 151.4 MW, including 39.4 MW of run-of-river hydropower. The Government of New Caledonia launched the Paalo SHP plant with a capacity of 3 MW as part of the efforts towards achieving this target.

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Papua New Guinea

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KEY FACTS

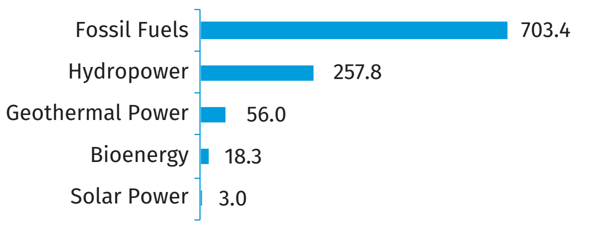
Population	8,776,119 (2019)[1]
Area	462,840 km² [2]
Topography	Papua New Guinea (PNG) consists of the eastern half of New Guinea, the Bismarck Archipelago, and small offshore islands and atolls. A mountainous zone called the Highlands extends from the west to the south-east of the island of New Guinea and occupies its central area. The highest summit is Mount Wilhelm reaching 4,509 metres above sea level.[3]
Climate	PNG has a hot, humid tropical climate. Seasonal temperature variation is limited, however, regionally temperature varies more significantly. In the lowlands, the annual temperature ranges from 23°C to 32°C. Cooler conditions prevail in the Highlands.[3] The El Niño Southern Oscillation (ENSO) also affects climate variability, which brings drought conditions, especially in the drier areas of PNG.[4]
Climate Change	PNG is one of the countries highly at risk of climate change and natural disasters. Warming of approximately 0.8–0.9°C has occurred between the 1900–1917 and 2000–2017 periods. Under the highest emissions scenario, by 2090, the temperature in PNG is expected to increase by approximately 3.6°C. As an island country, PNG faces the threat of the sea level rise, which by the end of the 21st century can reach up to 10 centimetres across the South Pacific region.[5]
Rain Pattern	Annual precipitation in most areas of PNG exceeds 2,500 mm, with the heaviest rainfall occurring in the highlands.[4] On the southward-facing slopes of the Highlands, the precipitation is extremely heavy, often exceeding 7,600 mm per year. However, the rainfall at Port Moresby, the capital, is less than 1,300 mm per year.[2]
Hydrology	The Fly, Purari and Kikori Rivers flow southwards into the Gulf of Papua. The Sepik, Markham and Ramu Rivers flow northwards into the Pacific Ocean. The longest river is the Sepik (1,126 kilometres) originating from the Victor Emmanuel Mountains. The Fly River forms a 1,200 kilometre-long river system with the Ok Tedi and Strickland Rivers, creating the largest river network in PNG.[6] However, because of the heavy rainfall and geologic instability of many areas, the rivers carry high sediment loads, which affects hydropower development.[3]

ELECTRICITY SECTOR OVERVIEW

The total installed electricity capacity of Papua New Guinea (PNG) in 2020 was approximately 1,084 MW. This comprised 748.4 MW from fossil fuel-fired power plants and 335.1 MW from renewable energy. Hydropower is the major renewable energy source in PNG accounting for 25 per cent (258 MW), followed by geothermal power accounting for 5 per cent (56 MW) (Figure 1).[7,8]

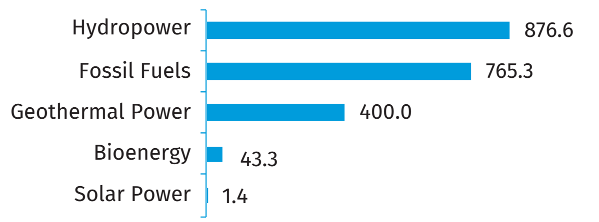
Total generation in 2019 stood at 2,087 GWh, of which renewable energy sources accounted for 1,321 GWh (63 per cent), including 42 per cent from hydropower, 19 per cent from geothermal power and 2 per cent from bioenergy (Figure 2).[7] In the Independent Power Producer (IPP) Policy, PNG set a target to achieve 100 per cent generation from renewable energy sources by 2050.[9]

Figure 1. **Installed Electricity Capacity by Source in Papua New Guinea in 2020 (MW)**



Source: IRENA[7]

Figure 2. **Annual Electricity Generation by Source in Papua New Guinea in 2019 (GWh)**

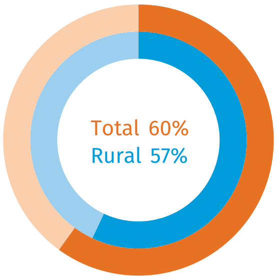


Source: IRENA[7]

PNG Power Ltd (PPL) is a state-owned entity that is in charge of electricity generation, transmission, distribution and retail services for PNG consumers.[10] It operates three major grid systems in the country, namely, the Port Moresby System, the Ramu System and the Gazelle Peninsula System, as well as several mini-grid systems, mostly powered by diesel generation sets and supplying electricity to small towns and rural areas.[11] In some locations electricity is also supplied by such independent producers as churches, mines, industrial and agricultural enclaves, which provide electricity to nearby areas.[12]

In total, approximately 60 per cent of the population has access to electricity. In rural areas, 57 per cent of the population has access to electricity, while the percentage is almost 84 per cent in urban areas (Figure 3).[13] The National Development Strategic Goals state that the electricity supply must cover 70 per cent of households by 2030 and 100 per cent by 2050.[14]

Figure 3. **Electrification Rate in Papua New Guinea (%)**



Source: World Bank[13]

The Asian Development Bank (ADB) aids the energy projects of PNG through an active portfolio of USD 240 million and proposed investments of a further USD 493 million. These projects aim to extend the electricity distribution network and improve the renewable energy supply in urban areas. The Town Electrification Investment Programme approved in 2010 is one of the energy projects in PNG funded by ADB. The first tranche of funding (2010–2021) covers the construction of 150 kilometres of 66 kV transmission lines connecting Bialla and Kimbe and the 3 MW Divune hydropower plant. The second tranche (2017–2022) covers the construction of the 3 MW Ramazon hydropower plant in the Autonomous Region of Bougainville, the rehabilitation of the 18 MW Yonki Toe of Dam hydropower plant in Eastern Highlands Province and the 10 MW Warangi hydropower plant in East New Britain Province. This project will also support the development of the renewable energy policy framework and provide environment-friendly investment for off-grid areas.[15]

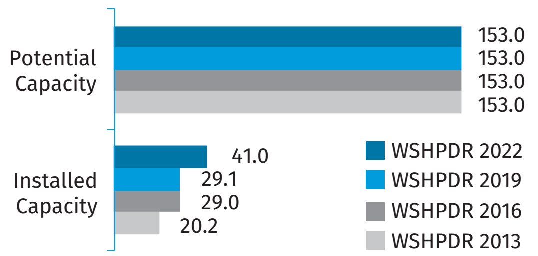
Another recent project including hydropower development is the Energy Utility Performance and Reliability Improvement Project (EUPRIP) approved by 2021. It will be supported by USD 30 million from the International Bank for Reconstruction and Development (IBRD) financing blended with reimbursable grants from the Global Infrastructure Fund (GIF) and possibly other funding sources. Upgrading PPL infrastructure is the major component of the project and will cost USD 15.8 million. Moreover, USD 3.8 million of funding will be provided for technical assistance for the development of the 80 MW Naoro-Brown run-of-river hydropower project, development of a suitable gas-to-power project in the Southern Highlands, investment in network expansion and assessment of the rehabilitation potential of existing hydropower plants.[16]

The high reliance on diesel generator sets leads to high electricity tariffs.[11] Independent Consumer and Competition Commission (ICCC) is the regulator responsible for setting the electricity tariffs. In 2018, the electricity tariff stood at 0.70 PGK/kWh (0.22 USD/kWh) for general consumers and at 1.00 PGK/kWh (0.31 USD/kWh) for industrial consumers. [20] However, in March 2018, PPL proposed to the Government to reduce tariffs by 50 percent to make electricity affordable and also to achieve the Government's electrification targets.[17]

SMALL HYDROPOWER SECTOR OVERVIEW

Although large hydropower is important to the energy mix of PNG, small hydropower (SHP) can also reduce the use of expensive diesel generators. The definition of SHP in PNG is up to 10 MW. The installed capacity of SHP in PNG is 41 MW, while the potential is estimated to be 153 MW. This indicates that approximately 27 per cent has been developed. Compared to the *World Small Hydropower Development Report (WSHPDR) 2019*, the potential remained unchanged, whereas the installed capacity increased as a result of the launch of two new SHP plants (10 MW Rouna 3 and 1.9 MW Divune) (Figure 4).

Figure 4. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Papua New Guinea (MW)**



Source: VisionRI,[12] *WSHPDR 2013*,[18] *WSHPDR 2016*,[19] *WSHPDR 2019*[20]

As of 2020, 11 SHP plants were operating in PNG (Table 1). Both the Warongoi and Rouna 3 SHP plants have the capacity of 10 MW. Under the Town Electrification Investment Programme, the Warangoi plant will be rehabilitated to increase its generation and extend the operational lifetime to 25 years.[21] In 2019, unit 2 of the Rouna 3 plant was out of operation because of a system failure and power surge. After repairing and maintenance works, the Rouna 3 (both unit 1 and unit 2) was back in full operation and has already supplied electricity to the main grid.[22]

The Divune run-of-river plant funded by ADB is already supplying 1.9 MW to Popondetta (planned to reach 3 MW).[23] Moreover, PPL oversees the construction of the 3 MW Ramazon hydropower plant, which is to be completed in 2023 and reduce 19,040 metric tonnes CO_2e per year.[24] Another 10 MW PNG FP Bauune hydropower project is in the stage of feasibility investigation.[11]

PNG has abundant untapped hydropower resources. The total estimated hydropower (large- and small-scale) potential of PNG is approximately 15,000 MW, with a considerable potential in the Purari River in Western Province, the Brown River and the Vanapa River catchment in the Central Province, the Gumini River in Milne Bay and Kimadan River in New Ireland Province.[14,22,25] The SHP potential has been estimated at approximately 153 MW from more than 79 sites.[26] No further feasibility studies of SHP potential have been carried out. However, according to the national electrification roll-out plan, the World Bank is funding a feasibility study to assess hydropower potential.[11]

Table 1. **List of Existing Small Hydropower Plants in Papua New Guinea (MW)**

Name	*Capacity (MW)*	*Owner*	*Area supplied*
Warongoi (1979)	10.00	PPL	Gazelle Peninsula
Rouna 3	10.00	PPL	National Capital District
Baiune/ Bulolo	5.70	PNG Forest Products	PNGFP and town of Wau (Morobe)
Rouna 1	5.50	PPL	National Capital District
Yuk Creek	2.40	Ok Tedi Mining Limited	Ok Tedi Mine and communities in North Fly District
Divune	1.90	PPL	Popondetta
Sinnumu Set	1.50	PPL	National Capital District
Lake Hargy	1.50	PPL	Bialla
Tolukuma	1.50	Tolukuma Mines	Mine supply
Ru Creek	0.80	PPL	Kimbe
Sohun	0.20	PG	Namatanai
Total	**41**		

Sources: VisionRI,[12] Department of Public Enterprises & Department of Petroleum and Energy[14]

RENEWABLE ENERGY POLICY

The Government's Vision 2050 directs that by 2050, renewable energy should supply all electricity in the country.[11] However, so far there is no comprehensive renewable energy policy proposed in PNG and specific policy interventions need to be promoted and developed to achieve the Vision 2050 goal. In line with the PNG Vision 2050, the target of the National Energy Policy 2017–2027 is to provide accessible, reliable, sustainable and affordable energy. The policy identifies the need to harness renewable energy sources to accelerate electrification in off-grid and rural areas through policy interventions, increased investment, specialized business entities and appropriate technologies.[25]

The Papua New Guinea Development Strategic Plan, 2010–2030 (PNGDSP) predicts that development of hydropower resources could support electricity-intensive industries, such as aluminium melting, as well as export of additional electricity to Australia and Indonesia. While the PNGDSP foresees further hydropower development to meet future demand, there is no clear implementation plan to realize the existing potential.[27]

In order to support the development of SHP, several actions need to be undertaken by the Government:

- The promotion of investment in the infrastructure for new SHP projects and SHP rehabilitation projects;
- The provision of adequate financial resources for carrying out feasibility studies of potential SHP sites;
- Creation of a hydrological database for hydropower development;
- The mitigation and addressing of competing stakeholder interests (landowner issues);
- Promoting stakeholder participation in all power infrastructure projects.[25]

The specific policy and legislation for feed-in tariffs (FITs) will be set in the Renewable Energy Policy, which is to outline strategies for the development of each renewable energy source and incentives for their development.[25]

COST OF SMALL HYDROPOWER DEVELOPMENT

The 10 MW Warongoi hydropower project had a total cost of approximately USD 6.00 million and was funded by ADB.[28] The 3 MW Rouna 3 hydropower project cost PGK15.6 million (USD 4.5 million) and was funded by the Government of Japan.[29]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The key barriers to SHP development in PNG include:

- PNG rivers have quite high sediment load, resulting in turbine silting and high operation and maintenance costs;
- High initial investment costs;
- Insufficient geological and hydrological data to support the development of SHP.[25]

Enablers for SHP development in PNG include:

- Significant hydropower potential;
- Availability of funding from various sources;
- The available and clear strategies set out in the National Energy Policy 2017–2027.

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Samoa

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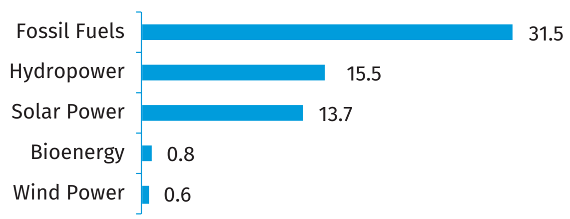
KEY FACTS

Population	202,506 (2020)[1]
Area	2,840 km^2[2]
Topography	Samoa consists of nine islands, of which four are inhabited.3 The terrain of the larger islands consists of narrow coastal plains with volcanic, rocky, rugged mountains in the interior.4 The highest point in Samoa is Mount Silisili, at 1,858 metres above sea level, which is a volcano located approximately at the centre of Savaii Island.[5]
Climate	There is relatively little seasonal variation in temperature in Samoa. The mean annual temperature ranges between 26°C and 31°C. Humidity is usually high, averaging 80 per cent or above. There are two major distinct seasons: the hot and wet season, which lasts from November to April, and the cool and dry season, which starts in May and ends in October. Night temperatures are cooler during the dry season when south-east trade winds dominate.[6]
Climate Change	Samoa has experienced warming of approximately 0.6°C between 1980 and 2018. Under the highest emissions scenario, temperature increase in Samoa is projected to reach 2.7°C by the end of the century. The number of hot days and hot nights has increased significantly. Samoa has already witnessed sea level rise of 5.2 millimetres each year and it is projected to continue to rise over the 21st century and increase by a total of 7–17 centimetres by 2030. Extreme rainfall can cause dangerous flooding, as has already been observed in parts of Samoa.[7]
Rain Pattern	Annual mean rainfall in Samoa ranges from 3,000 mm to 6,000 mm. Approximately 70 per cent of the mean annual rainfall is observed during the hot and wet season. The windward side (south and south-east) of the main islands receives more rainfall than the rain-shadowed side (mainly north and north-west).[6]
Hydrology	Similar to many other island nations, Samoa has uniquely fragile water resources.[7] All the rivers in the country are shallow and limited in length. The longest river is the Vaisigano. However, there is some potential for hydropower development on both the Upolu and Savaii Rivers.[3]

ELECTRICITY SECTOR OVERVIEW

The total installed electricity capacity of Samoa in 2020 was approximately 62 MW. This comprised 31.5 MW from fossil fuel-fired power plants and 30.5 MW from renewable energy. Hydropower is the major renewable energy source in Samoa with a capacity of 15.5 MW. The capacity of solar power is 13.7 MW and there is 0.6 MW from onshore wind power and 0.8 MW from biogas (Figure 1).[8,9,10]

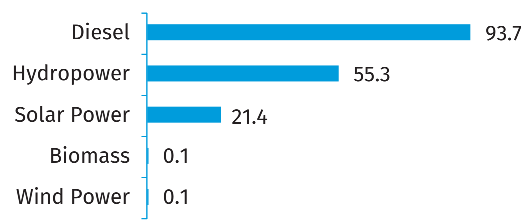
Figure 1. **Installed Electricity Capacity by Source in Samoa in 2020 (MW)**



Source: IRENA,[8,9] ADB[10]

Total generation in 2020 stood at 171 GWh and was mainly from diesel (55 per cent), while almost 80 GWh (45 per cent) was generated from renewable energy sources (Figure 2).[11] Currently, Samoa is heavily reliant on imported diesel for generation. However, under the United Nations Framework Convention on Climate Change, the Nationally Determined Contribution (NDC) of Samoa set a target to achieve 100 per cent generation from renewable energy sources by 2025.[12]

Figure 2. **Annual Electricity Generation by Source in Samoa in 2020 (GWh)**



Source: SBS[11]

Since 2016, the electrification rate in Samoa has been at approximately 100 per cent, both in rural and urban areas.[13] Approximately 95 per cent of households in Samoa have access to grid electricity and the rest are connected to small diesel generators or solar power systems.[10]

The Electric Power Corporation (EPC) is the state-owned utility company of Samoa which is mandated to generate, transmit, distribute and sell electricity. The EPC supplies electricity to nearly every household, business, community and government institution in Samoa.[14] Currently, EPC operates eight hydropower plants (one in Savaii), solar power plants at Apolima Island, Tuanaimato, Vaitele, Tanugamanono and Salelologa Savaii, a wind power plant at Vailoa Aleipata and diesel power plants at Fiaga Upolu and Salelologa Savaii.[15] The EPC is advancing a programme to reduce reliance on imported fuels and increase the use of renewable energy resources.[12] From 2015 to 2020, 31 GWh of renewable energy generation (18 per cent of total generation) was added by EPC.[16]

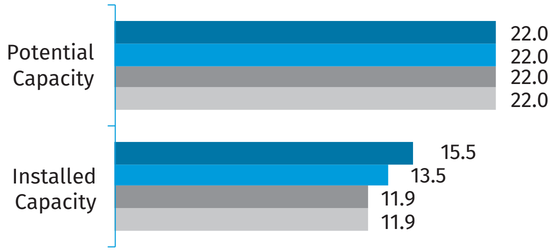
Since the Electricity Act of 2010 came into effect, the Electricity Regulator has the responsibility to review and approve tariff change proposals. Over several years, the tariff structure and the rates changed and improved continually. Compared with the electricity price in 2015, in 2020 the average electricity tariff saw a 26 per cent reduction.[16] The tariff classes were adjusted between 2020 and 2021, with the category of induction meter consumers and cash power consumers being replaced by a new tariff structure based on the post-paid and pre-paid categories. In 2022, the EPC was permitted to charge post-paid consumers 0.0063–0.0067 WST/kWh (0.0023–0.0025 USD/kWh) and 0.52–0.63 WST/kWh (0.0019–0.0023 USD/kWh) for pre-paid consumers.[17] For very large users (top 100), EPC aims to develop a new basis for setting fixed charges according to peak electricity demand.[14]

SMALL HYDROPOWER SECTOR OVERVIEW

In Samoa, there is no official definition of small hydropower (SHP). For this chapter, the standard definition of up to 10 MW will be used.

The total installed capacity of all SHP plants in Samoa is 15.5 MW.[10] The potential capacity is estimated at 22 MW.[6] Compared to the results of the *World Small Hydropower Development Report* (*WSHPDR*) *2019*, the installed capacity increased by 2 MW due to the addition of a third generator to the Taelefaga SHP plant. At the same time, no new studies have been conducted, therefore, the potential capacity remained unchanged (Figure 3).

Figure 3. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Samoa (MW)**



Source: ADB,[10] *WSHPDR 2019*,[18] *WSHPDR 2013*,[19] *WSHPDR 2016*[20]

All hydropower plants existing in Samoa are small-scale (Table 1). The 1.05 MW Alaoa hydropower plant built in 1959 was the first SHP plant to come into operation in the country. Later on, another four hydropower plants were constructed: the 4 MW Taelefaga plant on the Afulilo Dam, 3.5 MW Lalomauga plant, 1.9 MW Samasoni plant and 1.74 MW Fale ole Fe'e. In the 1990s these SHP plants supplied more than 85 per cent of the country's electricity. However, with time, because of growing electricity demand, their share in total electricity generation declined.[21]

The Asian Development Fund, Clean Energy Fund under the Clean Energy Financing Partnership Facility, European Union and Government of New Zealand funded the Renewable Energy Development and Power Sector Rehabilitation Project in Samoa, which started in 2013 and was completed in 2021. This project rehabilitated the Alaoa, Fale ole Fe'e and Samasoni SHP plants damaged by Cyclone Evan in 2012. In 2017, a total of 4.69 MW of SHP capacity was reconnected to the grid: 1.05 MW from the Alaoa plant, 1.74 MW from the Fale ole Fe'e plant and 1.90 MW from the Samasoni plant. Another outcome of this project was the addition of another 3.30 MW of new SHP capacity to the grid: 0.46 MW Tafitoala-Fausaga plant, 0.16 MW Faleata plant, 0.68 MW Fuluasou plant and another 2.00 MW generator at the Taelefaga SHP plant.[10]

Table 1. **List of Existing Small Hydropower Plants in Samoa**

Name	*Location*	*Capacity (MW)*
Taelefaga	Upolu	6.00
Lalomauga	Upolu	3.50
Samasoni	Upolu	1.90
Fale ole Fe'e	Upolu	1.74
Alaoa	Upolu	1.05
Fuluasou	Upolu	0.68
Tafitoala-Fausaga	Upolu	0.46
Faleata	Savaii	0.16

Source: ADB[10]

The 0.16 MW Faleata SHP plant was installed in 2019 on the island of Savaii. It can produce 500 MWh per year, which is approximately 4 per cent of the annual electricity demand of Savaii, and provides electricity to nearly 800 families on the island.[22] Another recently launched project is the 0.46 MW run-of-river Tafitoala-Fausaga SHP plant in the south of Upolu Island, upstream of the villages of Tafitoala and Fausaga. The plant generates approximately 1,820 MWh annually.[23] In 2020, the bid for another SHP project, 750 kW Tiapapata plant, was launched.[24]

EPC continues investing in the development of hydropower in the country. However, in 2020 electricity generation from hydropower decreased by 16 per cent, or 8 GWh, compared to the previous year, because of the need for repair and maintenance of the damaged key plants. Although high financial costs are incurred for rehabilitation of the hydropower fleet, hydropower generation remains the most cost-effective source at 0.002 WST/kWh (0.0007 USD/kWh) and accounts for a significant share of electricity generation in the country.[16]

RENEWABLE ENERGY POLICY

The Government's vision for the energy sector is to ensure access to reliable, affordable and environmentally friendly energy for all, as outlined in the 2007 Samoa National Energy Policy (SNEP). The objectives for the sector include increasing the share of generation from renewable energy sources to 20 per cent by 2030, which had been achieved before 2014.[25] Further, the Strategy for the Development of Samoa (SDS) 2016/17–2019/20 identified quality energy supply based on renewable energy sources as a key strategic outcome. In this strategy, renewable energy development was defined as the main focus in the energy sector from 2016 to 2019. Some of the specific objectives set were to increase renewable energy investment and reach 100 per cent generation from renewable energy sources by 2017.[26] However, the existing installed capacity was insufficient to support this goal. Therefore, the updated target set in the NDC of Samoa report is to achieve 100 per cent electricity generation from renewable energy by 2025 as well as to reduce greenhouse gas emissions.[27]

The Samoa Energy Sector Plan (SESP) 2017–2022, which, in line with the SDS, outlines measures for improved access to quality energy supply, identified the following key issues to be addressed in the renewable energy sector:

- Increase the share of renewable energy (hydropower, solar power, wind power) in the overall energy mix;
- Increase public awareness about the benefits of renewable energy and improved energy efficiency;
- Strengthen partnerships among stakeholders for knowledge and experience sharing;
- Develop local capacity;
- Develop a centralized database of renewable energy projects;
- Provide a legislative and regulatory framework for the expansion of renewable energy capacity.[12]

To support electricity generation from renewable energy sources, in 2017 the Office of the Regulator introduced a feed-in tariff (FIT) policy. The payment levels are differentiated by technology type, project size, resource quality and project location. This policy allows power producers to sell electricity generated from renewable energy sources to the off-taker at a pre-determined rate for a set period.[28]

COST OF SMALL HYDROPOWER DEVELOPMENT

The 0.46 MW Tafitoala-Fausaga plant and 0.16 MW Faleata plant projects had a combined capital value of USD 6.54 million, with a 70 per cent of the total being civil works costs and 30 per cent mechanical and electrical costs.[22] In 2018, a USD 6.07 million grant was allocated for building a 0.68 MW SHP plant at Fuluasou. Further, the Renewable Energy Development and Power Sector Rehabilitation Project cost was USD 10.73 million for the rehabilitation of SHP plants.[10]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The key barriers to SHP development in Samoa are:

- Lack of monitoring data on water resource potential;
- Low accuracy and reliability of available data on projects;
- Decreasing load factors on existing hydropower plants due to climate change and, in part, the removal of vegetation in the catchments;
- Hydropower plants can be damaged by natural disasters and it remains difficult to repair and replace the components because of the unreliability of the Pacific shipping delivery;
- Resistance of communities to hydropower development on local river systems.[19,29]

Enablers for SHP development in Samoa include:

- Available undeveloped potential;
- Policy focus on renewable energy development;
- Availability of funding from various sources as well as FITs;
- Experience in SHP development and rehabilitation.

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Solomon Islands

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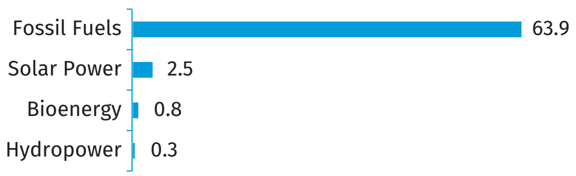
KEY FACTS

Population	686,878 (2020)[1]
Area	27,990 km^2 [2]
Topography	Solomon Islands consist of 992 islands, of which 147 are inhabited. The terrain of the islands is mostly dominated by deeply forested and rugged mountains. There are also low-lying coral atolls. The highest point is Mount Popomanaseu, a volcanic mountain reaching 2,335 metres above sea level.[3,4,5]
Climate	Solomon Islands have a warm, tropical climate all year round with little seasonal variation in temperature. The mean annual temperature ranges between 25°C and 32°C.6 There are two major distinct seasons: the wet season from November to April and the dry season from May to October.7 The climate of Solomon Islands is heavily affected by the El Niño Southern Oscillation (ENSO), which causes drought, floods and frequent tropical cyclones.[6]
Climate Change	The country faces the effects of climate change including changing weather patterns, extreme events and accelerated coastal erosion due to sea level rising.8 The temperature increased by 0.12–0.18°C per decade since the 1950s. The intensity and frequency of extreme heat are projected to increase. The sea level has risen by approximately 8 millimetres per year, which is higher than global projections, threatening local communities near the coastline.[9]
Rain Pattern	The precipitation ranges between 3,000 and 5,000 millimetres annually.6 In the dry season on average approximately 600 millimetres falls compared with upwards of 1,800 millimetres in the wet season.[7]
Hydrology	The islands' rivers are short and narrow. The Lungga on Guadalcanal Island is the longest river. The Tina River, also on Guadalcanal, has abundant hydropower potential.[10]

ELECTRICITY SECTOR OVERVIEW

In 2021, the installed generation capacity of Solomon Islands was 67.5 MW. This comprised 63.9 MW from thermal power plants powered by imported refined petroleum fuels, 2.5 MW from solar photovoltaics (PV), of which 1.5 MW was off-grid, 0.8 MW from bioenergy (solid biofuels and liquid biofuels) and 0.3 MW from hydropower (Figure 1).[11]

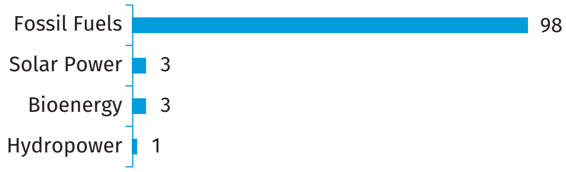
Figure 1. **Installed Electricity Capacity by Source in Solomon Islands in 2021 (MW)**



Source: IRENA[11]

Total electricity generation for 2019 stood at 105 GWh and was mainly from non-renewable energy (93 per cent), while 7 GWh (7 per cent) was generated from renewable energy sources (Figure 2).[11,12] More than 86 per cent of electricity in Solomon Islands in 2019 was generated by the diesel-fired Lungga and Honiara power plants, which produced a total of 86 GWh. Meanwhile, the mini-grids and the Henderson solar power plant produced 13 GWh (13 per cent).[13]

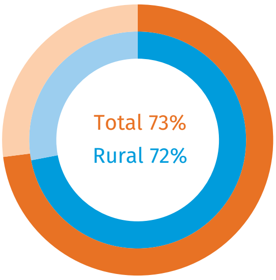
Figure 2. **Annual Electricity Generation by Source in Solomon Islands in 2019 (GWh)**



Source: IRENA[12]

Solomon Islands Energy Policy 2014 set two specific targets on electricity access — for grid-connected electricity access in urban areas to reach 80 per cent by 2020 and access to electricity in rural households and institutions to reach 35 per cent by 2020.[14] In 2020, more than 73 per cent of the population had access to electricity. However, the target for urban areas had not been achieved by 2020, although it saw a prominent increase compared with 2009 (77 per cent vs. 21 per cent). For rural areas, the electrification rate reached 72 per cent, which was twice as high as the target set in 2014 (Figure 3).[15]

Figure 3. **Electrification Rate in Solomon Islands in 2020 (%)**



Source: World Bank15

Under the State-Owned Enterprises Act 2007, Solomon Islands Electricity Authority (SIEA), trading as Solomon Power (SP), is responsible for the electricity generation, distribution and selling to connected customers in approved areas in the country. In 2018, SIEA commenced the Electricity Access and Renewable Energy Expansion Project, funded by the World Bank, to deliver renewable energy mini-grids, electricity connections in low-income areas and new grid-connected solar power.[16,17]

The Government of Solomon Islands conducted a feasibility study of hydropower potential on the Tina River near Honiara, the capital city. A site with 15–20 MW of potential capacity and annual electricity generation of over 70 GWh was identified.[16] In 2017, the 15 MW Tina River hydropower project, the largest hydropower project in the country was officially approved. The cost of the project is USD 240.48 million and it is to be completed in 2025. The new project will allow increasing electricity generation from renewable energy in Honiara, with hydropower as a result accounting for approximately 68 per cent of the city's total generation.[18]

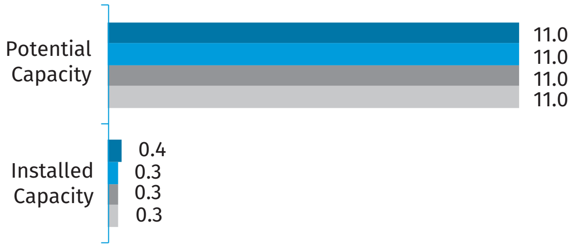
Under the Electricity Tariff (Base Tariff and Tariff Adjustments) Regulations 2016, the customers are divided into two categories — regular and non-regular — and are further classified as domestic, commercial and industrial customers. The electricity tariffs valid from 1 June 2021 for domestic regular consumers range from 5.27 SBD/kWh (0.65 USD/kWh) for consumption of less than 50 kWh to 6.18 SBD/kWh (0.76 USD/kWh) for consumption of more than 500 kWh. For the commercial and industrial regular customers, the rate is 5.27 SBD/kWh (0.65 USD/kWh) and 5.15 SBD/kWh (0.63 USD/kWh), respectively.[19]

SMALL HYDROPOWER SECTOR OVERVIEW

In Solomon Islands, there is no official definition of small hydropower (SHP). For this chapter, the standard definition of up to 10 MW will be used.

Hydropower is a renewable energy source suitable for development in Solomon Islands due to the good hydrological conditions and year-round river flows. It can both supply the major electricity grids through centralized generation and be considered for supplying rural areas via distributed mini-grids. The mountainous terrain of the country provides natural conditions for SHP development. As of 2022, the installed capacity of SHP plants was at 361 kW, while potential stood at 11 MW.[20,21,22] Thus, compared to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity has increased as a result of renovation and upgrade works on several plants, while the potential remained unchanged. (Figure 4).

Figure 4. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Solomon Islands (MW)**



Source: SIG,[20] IRENA,[21] *WSHPDR 2019*,[22] *WSHPDR 2016*,[23] *WSHPDR 2013*[24]

The Japan International Cooperation Agency (JICA) completed a feasibility study of hydropower potential in Solomon Islands in 2001. A total of 130 potential hydropower sites were identified, with a total potential of 327 MW, including the Lungga and Komarindi hydropower projects.[25] It should be noted, however, that the study did not account for technical obstacles, such as restricted areas or topographical limitations. The Government developed its own database of over 100 sites for potential SHP development, of which 62 had an estimated overall capacity of 11 MW.[26]

There are 13 hydropower plants with capacities of up to 150 kW, 8 of these were operational as of 2018 (Table 1).[20,21] The 150 kW Buala SHP plant is the largest SHP plant in Solomon Islands and was commissioned in 1996. However, because of unreliable operation, its service was suspended in 2007. The World Bank supported a project aiming to rehabilitate the plant, with a budget of USD 250,000. The refurbishment was completed in 2015.[27]

The Government committed to developing the 750 kW Fiu hydropower project in Malaita Province with funds of USD 15 million, however, this had to be cancelled because of land dispute issues.[28] The funds allocated to the project were transferred to a hybrid project in Auki (the capital of Malaita Province), including a solar power plant with an estimated capacity of 1.44 MW, a 560 kW backup diesel generator and a 4 MWh battery storage.[22]

Table 1. **List of Existing Small Hydropower Plants in Solomon Islands**

Name	*Capacity (MW)*	*Operator*	*Launch year*	*Funding*	*Comment*
Masupa	0.040	Community	2010	SIG	Operating
Nariao'a	0.025	Community	2004	CHINA	Operating
Raea'o	0.025	Community	2002	CHINA	Operating
Manawai	0.050	Community	1997	CHINA	Operating
Bulelavata	0.029	Community	1997	AUSAID	Operating
Ghatere	0.012	Community	1997	AUSAID/ APACE	Incomplete and damaged
Buala (Jejevo)	0.150	SIEA (Government)	1996	SIG	Operating
Vavanga	0.012	Community	1994	AUSAID/ APACE	Operating
Iriri	0.010	Community	1993	UNIDO/ APACE	Ceased operation 1997
Atoifi	0.036	Adventist Hospital	1986	Unknow	Under repair, no recent progress reported
Malu'u	0.030	SIEA (Government)	1986	SIG	Operating
Atoifi	0.030	Adventist Hospital	1973	Unknow	Ceased operation around 1980
Fauabu	0.010	Melanesian Mission	1952	Unknow	Not operational

Source: SIG,[20] IRENA,[21] *WSHPDR 2019*[22]

In 2021, the national Government fully funded the 30 kW Beulah micro-hydropower plant under the National Energy Development Project through the Ministry of Mines, Energy and Rural Electrification (MMERE) at a cost of approximately SBD 2.5 million (USD 306,375). The Beulah project, scheduled to be operational by 2026, will supply electricity to the Beulah Provincial Secondary School and nearby committees for the next 20 years.[29] According to Solomon Islands National Infrastructure Investment Plan, the estimated cost of another proposed Nafinua and Ladeabu mini-hydropower project is SBD 6 million (USD 735,300). However, there is no information on the project's capacity or its recent progress.[30]

RENEWABLE ENERGY POLICY

MMERE is responsible for the national policy formulation and implementation, legal and regulatory development in the energy sector. In the Renewable Energy Strategy and Investment Plan (RESIP), MMERE set the target to achieve 100 per cent share of renewable energy in electricity generation by 2050. SIEA set a more ambitious target of reaching 100 per cent of renewable energy by 2030.[31]

The National Energy Policy Framework 2007 sets out the broad policy directions for the planning and management of the energy sector for the 2013–2023 period. There are two overarching goals in the framework: to promote the optimal use of renewable energy technologies and to minimize negative impacts on the environment from the production, distribution and consumption of energy. The strategy for renewable energy includes:

- Increasing public awareness of the benefits of renewable energy;
- Promoting incentives for the use of renewable energy technologies;
- Ensuring there is in-country capacity to implement renewable energy projects;
- Ensuring that renewable energy resources are used in an economically and environmentally sustainable manner;
- Promoting and or supporting research and development of appropriate renewable energy technologies;
- Encouraging partnership in the development of renewable energy with the private sector.[32]

Solomon Islands Energy Policy 2014 set out the target of the utilization of renewable energy sources for power generation to be increased to 50 per cent by 2020. The policy statements include:

- Establishing an appropriate, reliable, affordable and sustainable renewable energy supply system;
- Assessing renewable energy potential and the cost for the promotion;
- Increasing productivity in rural areas by adopting renewable energy services;
- Developing renewable energy policy instruments (standards and regulations, net metering policies, market-based instruments, procurement strategies);
- Facilitating public or private partnerships for renewable energy development.[14]

The Project for Formulating Renewable Energy Road Map aiming to draft a roadmap for encouraging more renewable energy access for the Honiara grid was initiated in 2019. It provided technical suggestions and a development pathway for renewable energy expansion.[31]

For small-scale independent power producers (IPPs) in Solomon Islands, there is no format for a power purchase agreement (PPA), nor is there a feed-in tariff (FIT) scheme. Commercial conditions for each project are to be negotiated individually.[31]

COST OF SMALL HYDROPOWER DEVELOPMENT

The approximate costs of the planned SHP projects are as follows:

- The 150 kW Buala and 30 kW Malu'u plants — approximately SBD 6 million (USD 735,300);
- The 30 kW Beulah plant — SBD 2.5 million (USD 306,375);

- The Nafinua and Ladeabu pants — SBD 6 million (USD 735,300).[29,30]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The key barriers to SHP development in Solomon Islands include:

- Lack of standardized and streamlined approaches for land acquisition and resettlement for SHP;
- Lack of financial incentives for investment, which coupled with high upfront costs can discourage developers;
- Technical issues for hydropower facility construction such as the uncertainty of geological conditions during operation;
- Need to strengthen MMERE's capacity to develop appropriate policies and regulations.[33]

Enablers for SHP development in Solomon Islands include:

- The significant identified SHP potential;
- Policy focuses on renewable energy development;
- Availability of funding from various sources;
- Experience of SHP development and rehabilitation.

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Vanuatu

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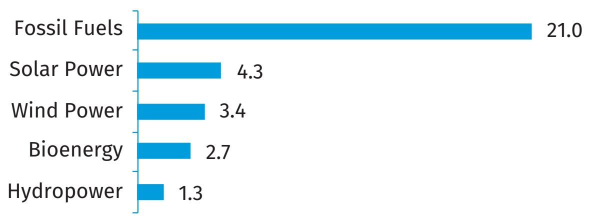
KEY FACTS

Population	299,882 (2019)[1]
Area	12,190 km^2[2]
Topography	Vanuatu comprises 82 islands, of which 65 are inhabited.[3] Many of these islands are volcanic, covered by tropical forest and are mountainous or have a rugged terrain. The highest point is Mount Tabuemasana on Santo Island at 1,897 metres above sea level.[4]
Climate	Vanuatu has a tropical and maritime climate, with an average temperature of 24oC. The average minimum is 22oC and average maximum is 26 oC.[5] The climate of Vanuatu varies from the north to the south. It is very wet, hot and humid in the north and warm and less humid in the south. The wet season is from November to April. Temperatures are higher during this time and there is heavy rain, as well as occasional cyclones.[4] There are south-eastern trade winds from May to October.6 The warmest month is February, while the coolest is July or August.[5]
Climate Change	Vanuatu faces the effects of climate change from rising temperatures to rising sea levels and resulting storm surges. By 2030, the temperature increase in Vanuatu is projected to be in the range of 0.4–1.0°C under a high emission scenario. The sea level has risen by 6 millimetres per year since 1993 and will continue to rise to reach up to 18 centimetres. Increases in average temperatures will also result in a rise in the number of hot days and warm nights and a decline in cooler weather. Increased wet season rainfall is expected due to the projected intensification of the South Pacific Convergence Zone.[7,8]
Rain Pattern	Rainfall is heaviest in January. Average annual rainfall between 1991 and 2015 was estimated at approximately 2,500 mm.5 However, there is geographical variation in precipitation, with an average of 4,200 mm in the northern parts of the country and approximately 1,500 mm in the southern islands.4 Rainfall is variable on the smaller islands, depending on their location and size. The south-eastern (windward) side of most of the country's islands tends to receive more rainfall than the north-western (leeward) side.[9]
Hydrology	The size of each of the Vanuatu islands limits the availability of water resources.[9] The volcanic islands tend to have rivers and streams that drain from the mountains, including the Jourdain, Sarakana and Wamb Rivers.4 River courses tend to be short and flows are short-lived, particularly during the dry periods. Nevertheless, there are substantial amounts of groundwater that can provide large amounts of water, even during droughts.[4]

ELECTRICITY SECTOR OVERVIEW

The total installed electricity capacity of Vanuatu in 2019 was 33 MW.[10,11] This comprised 21.0 MW from fossil fuel-fired power plants, 3.4 MW from on-shore wind power, 2.7 MW from bioenergy (liquid biofuels), 1.3 MW from hydropower and 4.3 MW from solar photovoltaics (PV), of which 1.8 MW was off-grid (Figure 1).[10,11] Total generation for 2019 stood at 82 GWh and was mainly from fossil fuels (66 per cent), while 23 GWh (34.1 per cent) was generated from renewable energy sources. [10,11] Vanuatu does not have fossil fuel resources and is wholly reliant on imports. In 2013, the Vanuatu Department of Energy set a target to achieve a 65 per cent share of renewable energy in generation by 2020. In 2016, the target was updated to 40 per cent by 2020. In 2020, however, even the lower objective was not achieved.[10,12]

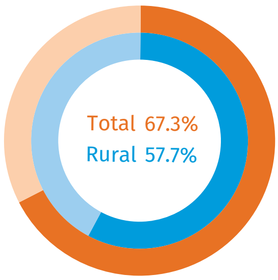
Figure 1. **Installed Electricity Capacity by Source in Vanuatu in 2019 (MW)**



Source: UN Statistics,[10] IRENA[11]

The estimated electrification rate of the country for 2020 was 67 per cent, while access in rural areas was 58 per cent (Figure 2).[13] A 100 per cent electrification target has been set for 2030.[14] Rural electrification has been challenging, partially because of the high cost of energy from diesel generation and the geographical dispersion of the 82 islands.[14] The fact that the islands are spread out and are not interconnected implies the necessity of independent systems on each island, therefore, each system incurs a fixed cost and there are limited opportunities for economies of scale.[15] The share of diesel in electricity generation greatly impacts the price paid by consumers for electricity services. The greater its share in the overall generation mix, the higher the electricity bills customers must pay.[15] Furthermore, extreme weather situations such as cyclones often have an adverse effect on the infrastructure.

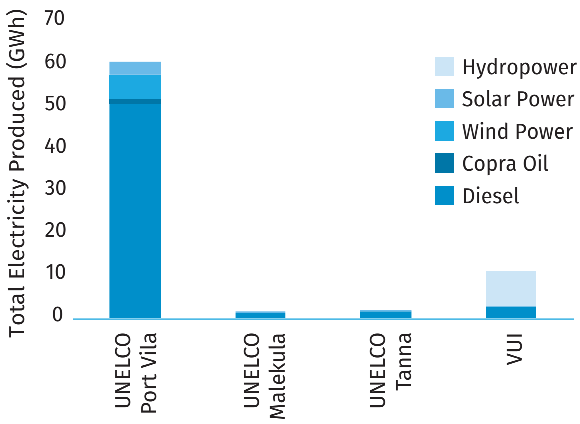
Figure 2. **Electrification Rate in Vanuatu in 2020 (%)**



Source: ESMAP[13]

There are two private companies that supply electricity in Vanuatu: UNELCO and Vanuatu Utilities and Infrastructure Limited (VUI). These companies supply electricity to the four main urban centres through private-sector concessions. The four concession areas are Port Vila (the capital) on Efate Island, Malekula, Tanna and Luganville. Diesel accounts for the largest share of electricity generation in these areas, except for Luganville, where hydropower makes up the largest proportion of the energy mix (Figure 3).[16]

Figure 3. **Energy Mix in Concession Areas in Vanuatu in 2020 (GWh)**



Source: URA[16]

Note: VUI 2020 data is inclusive of Luganville, Port Olry, Talise (Maewo), Ambae and Vanua Lava.

The electricity market was privatized after Vanuatu gained independence in 1980. The Utilities Regulatory Authority (URA) was established in 2008 to regulate tariffs on water and electricity services in the country. URA monitors the private utilities operating in concession areas and may also regulate small utilities operating outside them.[17] In October 2014, the URA put in place a new tariff system to support the integration of variable renewable energy sources into the electricity system. The aim of the tariff system is to encourage the development of small-scale on-grid solar power with a feed-in and net-metering programme. An access fee was implemented to compensate for network use. The fee only applies to domestic consumers and is based on the size of the domestic consumer's solar home system. In the case that there is excess electricity fed into the grid, it will be used to offset the fee and any fixed charges.[18]

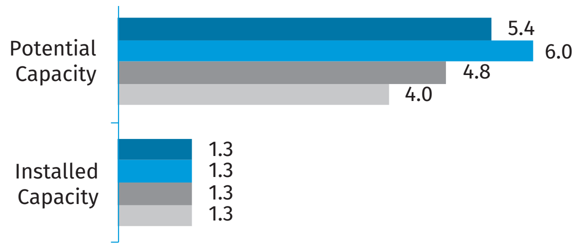
Based on a government initiative, the consumer electricity tariff system offers cross-subsidies. Small domestic customers, with consumption levels of up to 60 kWh per month, are heavily subsidized by other consumer groups in an effort to encourage electricity access and consumption by low-income earners. In June 2022, low-voltage domestic consumers using up to 60 kWh of electricity per month paid to UNELCO 0.34 VUV/kWh (0.003 USD/kWh). For consumers using up to 120 kWh per month, the price was 1.21 VUV/kWh (0.009 USD/kWh) and for those using above 120 kWh per month it was 3 VUV/kWh (0.03 USD/kWh).[19]

The first phase of the Vanuatu Rural Electrification Project (VREP) lasting from 2014 to 2020 provided a 50 per cent subsidy to private sector suppliers to distribute solar home systems. The first phase provided access to electricity to consumers where grid systems are unlikely to be economically feasible, with the target of 17,500 households, 2,000 not-for-profit community halls and 230 aid posts.[20] The second phase of the VREP lasting until June 2022 focused on increasing access to electricity in rural areas through the use of mini- and micro-grids. The project aimed to cover 37 public institutions and 8,400 rural households that are unable to access electricity and to electrify 550 households and public institutions and businesses through mini-grids.[21]

SMALL HYDROPOWER SECTOR OVERVIEW

The installed capacity of small hydropower (SHP) in Vanuatu is 1.28 MW and potential capacity is estimated at 5.4 MW.[11,22,23] Between the *World Small Hydropower Development Report (WSHPDR) 2019* and *WSHPDR 2022*, there has been no change in installed capacity, whereas the potential has decreased based on new data (Figure 4).

Figure 4. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Vanuatu (MW)**



Source: IRENA,[11] *WSHPDR 2019*,[23] *WSHPDR 2013*,[24] *WSHPDR 2016*[25]

There is substantial untapped technical hydropower potential in Vanuatu and the topography makes run-of-river type plants the main option. The Loltong on North Pentecost and Talise hydropower projects on Maewo Island are good examples of this. The Talise plant with an installed capacity of 75 kW was launched in 2017 to supply electricity to the villages of Talise, Narovorovo and Nasawa. The 3 kW Loltong plant was launched in 2016 to provide electricity for 70 households. The largest existing SHP plant is the 1.2 MW Sarakata plant on Espiritu Santo.[12]

Thirteen potential micro-hydropower sites, with a total potential capacity of 1.5 MW and located on six different islands, have been investigated by the European Union.[26] There have been further studies to suggest a technical potential on Efate Island (e.g., 1.2 MW at Teouma) but with high cost.[26] Further, the Government of Japan proposed the construction of a run-of-river hydropower plant in Santo. A feasibility study has confirmed the existence of a suitable site with a capacity of 1 MW downstream of the existing Sarakata plant.[27] In 2021, the development of the 422 kW Brenwei hydropower plant was started based on studies undertaken in 2014 and 2016 and funded by the Asian Development Bank (ADB).[28] Based on these studies, the known SHP potential of Vanuatu stands at 5.4 MW, although further studies are required.

Vanuatu is prone to cyclones and the existing and potential small run-of-river plants are highly vulnerable to destruction during periods of very high water flow, which can exceed typical flows by a thousand times during the passage of a cyclone. As a result, the potential of a site and the potential for flood damage can only be accurately determined after the resource has been measured for at least several years.[26]

RENEWABLE ENERGY POLICY

Ensuring that there is a secure and reliable supply of energy is a high priority for Vanuatu. Since the country is highly dependent on fuel imports, consumers are exposed to certain risks. These risks include oil price variability, price shocks and interruptions to fuel deliveries due to natural phenomena or international or domestic political turmoil.[26]

A key way to manage the country's exposure to fuel price volatility and supply disruptions is to diversify energy supply. Vanuatu is rich in renewable energy resources, including hydropower, wind power, solar power and geothermal power, which could reduce reliance on imported diesel. This would not only improve energy supply but would also contribute to its sustainability.[26] It will also help to reduce electricity tariffs for consumers and achieve the supply efficiency targets. Between 2013 and 2019, the share of renewable energy in total installed capacity rose from 23 per cent to 35 per cent.[10]

The Government of Vanuatu has embarked on developing appropriate legislation in the energy sector to promote new projects to modernize the country's power industry and enable a greener energy future. The National Energy Road Map 2016–2030 identifies five priority areas for the energy sector:

- Accessible energy: Increase electricity access by households in and near concession areas, households in off-grid areas, public institutions (on- and off-grid);
- Affordable energy: Improve the efficiency of diesel generation;
- Petroleum: Reduce the cost of distributing petroleum products in Vanuatu;
- Secure and reliable energy: an energy-secure Vanuatu at all times;
- Sustainable energy: Increase the share of electricity generated from renewable energy sources; improve electricity sector end-use efficiency; improve transport (land and marine) energy efficiency; improve biomass end-use (cooking and drying) efficiency; ensure all energy infrastructure projects comply with Government and donor environmental and social safeguard requirements.[12]

Moreover, the Intended Nationally Determined Contribution (INDC) of Vanuatu has listed the following renewable energy plans to mitigate emissions:

- The installed capacity of wind power is to reach 5.5 MW by 2025;
- Install 10 MW of grid-connected solar PV by 2025 and 10 MW by 2030;
- Commission the proposed first stage of the 4 MW geothermal plant by 2025 and the second stage by 2030;
- Substitute fossil fuels with coconut oil-based electricity generation.[29]

These proposed interventions would cost approximately USD 180 million if completed within the suggested time frame.[29]

COST OF SMALL HYDROPOWER DEVELOPMENT

The investment in the 75 kW Talise SHP plant amounted to VUV 32,000,000 (USD 272,240).[30] Overall, the costs of SHP development in Vanuatu are very site-specific.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

There are a number of major barriers hindering SHP developments in Vanuatu, including:

- Lack of good sites near population centres;
- Complexity of transporting electricity generated from renewable energy through the transmission system to communities and public institutions;
- High costs of feasibility studies, including due to extreme weather conditions;
- The fact that Vanuatu comprises more than 80 islands that are not interconnected adds to economic challenges;
- Limited technical expertise in SHP development;
- Lack of regulation on technical specifications, in particular for power grid connection.

Enablers for SHP development in Vanuatu include:

- Available undeveloped potential;
- Availability of climate funding from various sources, including private financing and international agencies;
- Policy support for renewable energy development and micro-grids.[31]

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