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ON SMALL HYDROPOWER

World Small Hydropower Development Report 2022

Eastern Africa

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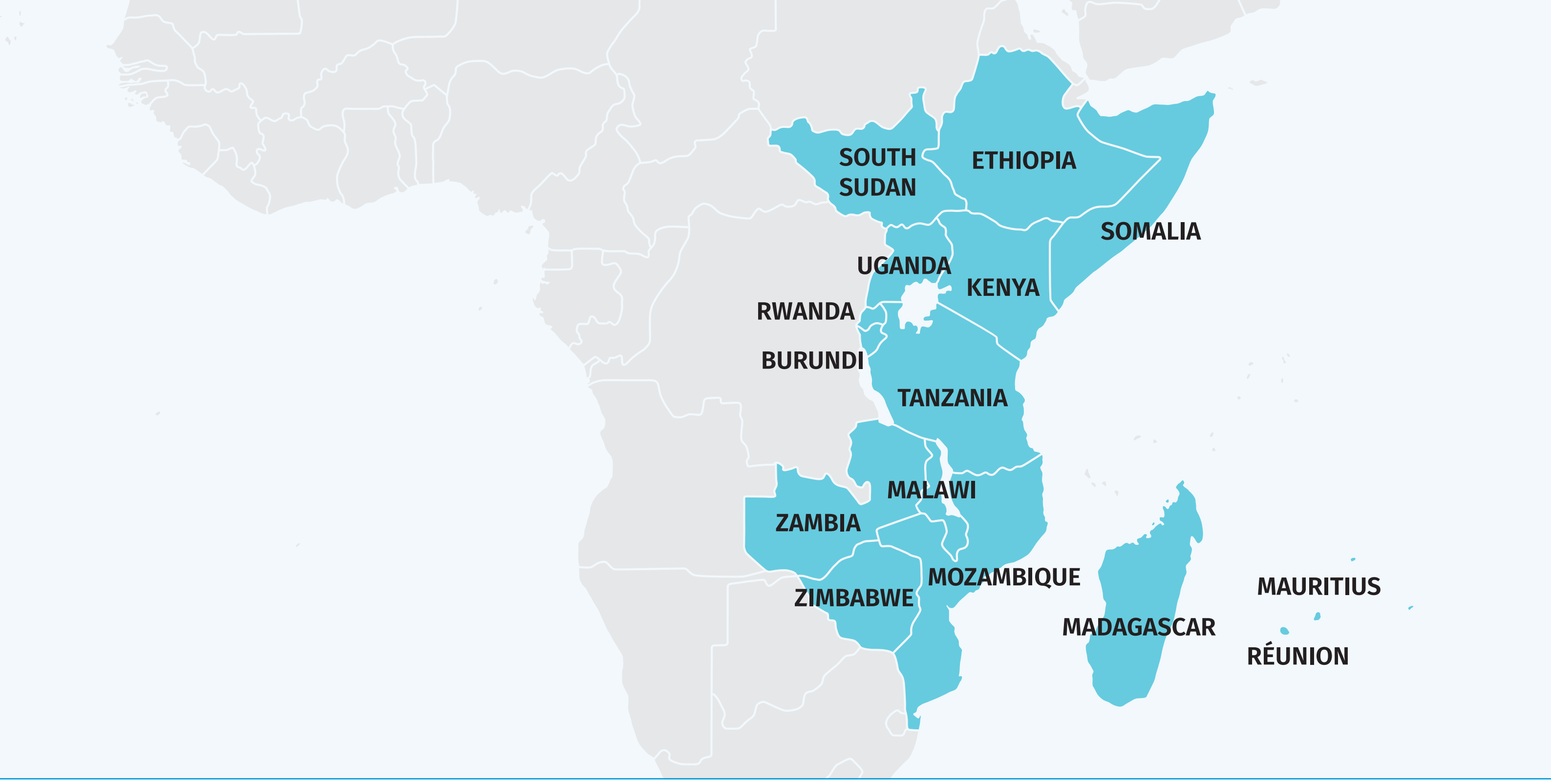


Eastern Africa

Countries: Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Réunion, Rwanda, Somalia, South Sudan, Tanzania, Uganda, Zambia, Zimbabwe

INTRODUCTION TO THE REGION

Countries comprising the Eastern Africa region are highly diverse in terms of geography, population dynamics and socio-economic conditions, with the regional electricity sector development reflecting this diversity. Access to electricity in the region ranges from 100 per cent in Mauritius to 7 per cent in South Sudan, which is also the lowest rate of electricity access in the world. Across other countries in Eastern Africa, access to electricity in the region averages below 50 per cent and displays significant disparities between urban and rural areas.

The main sources of electricity generation in Eastern Africa are thermal power and hydropower. Renewable energy sources other than hydropower are most widely represented by solar power, which exists in nearly all countries of the region but contributes a relatively small share of generated electricity. Kenya is the regional leader in geothermal power and, along with Ethiopia, employs considerable wind power capacities. Bioenergy from a variety of sources, including bagasse and bioethanol, is a widespread form of supplementary electricity generation in the region and accounts for a significant share of installed capacity in Réunion, Ethiopia, Malawi, Mozambique, Tanzania and Zimbabwe.

The role of hydropower in Eastern Africa is very significant, although installed and potential hydropower capacities vary widely by country. The regional leaders in hydropower generation are Ethiopia, Mozambique and Zambia. Hydropower is the largest single source of electricity generation in these three countries and additionally in Burundi, Malawi, Rwanda, Uganda and Zimbabwe. In Kenya, Madagascar, Mauritius, Réunion and Tanzania, hydropower is an important but supplementary source of electricity generation. There is no operational hydropower capacity in Somalia and South Sudan, although Somalia retains at least one major hydropower plant that is currently out of service.

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

Table 1. Overview of Eastern Africa

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)*
Burundi	12	12	4	88	346	50	178
Ethiopia	115	51	30	4,817	14,553	4,071	13,655
Kenya	54	75	52	2,840	11,467	834	4,233
Madagascar	27	20	12	861	1,370	163	664
Malawi	19	11	4	574	1,887	394	N/A
Mauritius	1	100	100	844	2,882	60	116
Mozambique	32	31	4	2,915	15,603	2,204	14,826
Réunion	1	N/A	N/A	903	2,978	133	423
Rwanda	13	67	N/A	210	821	95	397
Somalia	15	35	15	106	N/A	0	0
South Sudan	11	7	6	175	581	0	0
Tanzania	58	38	19	1,764	7,594	581	N/A
Uganda	44	41	32	1,347	4,414	1,073	4,032
Zambia	18	43	14	2,981	15,040	2,399	12,332
Zimbabwe	15	48	28	2,431	9,351	1,081	5,504
Total	**-**	**-**	**-**	**22,856**	**-**	**13,139**	**-**

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

Countries in Eastern Africa adhere to different definitions of small hydropower (SHP). The up to 10 MW definition is the most common and has been adopted by Ethiopia, Mozambique, Réunion and Tanzania. Malawi and Rwanda use the up to 5 MW definition, while Uganda and Zambia adhere to the up to 20 MW definition. Finally, SHP is defined as up to 1 MW in Burundi, up to 3 MW in Kenya and up to 30 MW in Zimbabwe. No official definition of SHP exists in Madagascar, Mauritius, Somalia and South Sudan.

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

Table 2. **Small Hydropower Capacities by Country in Eastern Africa (MW)**

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed capacity (≤10 MW)*	*Potential capacity (≤10 MW)*
Burundi	Up to 1 MW	2.2	30.5	17.4	61.0
Ethiopia	Up to 10 MW	12.9	1,500.0	12.9	1,500.0
Kenya	Up to 3 MW	N/A	N/A	66.3	3,000.0
Madagascar	N/A	N/A	N/A	37.0	836.0
Malawi	Up to 5 MW	4.7	150.0	12.9	150.0*
Mauritius	N/A	N/A	N/A	19.7	19.7
Mozambique	Up to 10 MW	4.8	1,000.0	4.8	1,000.0
Réunion	Up to 10 MW	10.6	16.6	10.6	16.6
Rwanda	Up to 5 MW	34.4	111.1	34.4*	111.1*

Country	Local SHP definition	Installed capacity (local def.)	Potential capacity (local def.)	Installed capacity (≤10 MW)	Potential capacity (≤10 MW)
Somalia	N/A	N/A	N/A	0.0	4.6
South Sudan	N/A	N/A	N/A	0.0	688.1
Tanzania	Up to 10 MW	30.5	480.0	30.5	480.0
Uganda	Up to 20 MW	186.0	400.0	107.9	214.1
Zambia	Up to 20 MW	N/A	N/A	18.7	62.0
Zimbabwe	Up to 30 MW	31.4	N/A	16.1	120.0
Total	**-**	**-**	**-**	**389.1**	**8,263.2**

Source: *WSHPDR 2022*[1]

Note: *Based on the local definition of SHP.

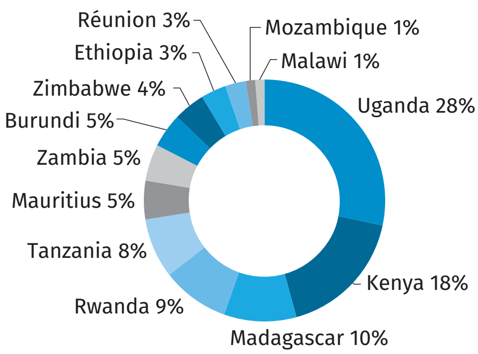
The total installed capacity of SHP up to 10 MW in Eastern Africa is at least 389.1 MW, while total potential capacity is estimated at 8,263.2 MW. Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity has increased by 41 per cent both due to ongoing SHP development in the region and access to better data on previously-existing plants. The potential capacity has increased by 21 per cent, largely as a result of a re-evaluation of SHP potentials in Madagascar and South Sudan.

SHP is a widespread source of electricity generation across much of Eastern Africa with the exception of Somalia and South Sudan and is commonly utilized for electrification of remote population centres as well as off-grid agro-industrial facilities including tea factories and multi-use facilities such as missions. SHP accounts for 23 per cent of all installed hydropower capacity in Madagascar, 33 per cent in Mauritius, 36 per cent in Rwanda and 39 per cent in Burundi, while hydropower capacities in other countries in the region are heavily dominated by large-scale plants.

Activity in the SHP sector in the region is uneven, with some countries actively pursuing SHP development and others prioritizing other renewable energy sources. In recent years, construction of new SHP plants has been most active in Uganda, Kenya, Madagascar, Rwanda and Zambia, while in other countries in the Eastern Africa region little new SHP development has taken place and changes in reported installed capacity are generally accounted for by more precise data on previously-existing SHP plants. Additionally, SHP development and planning in parts of the region is hampered by political and economic instability.

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

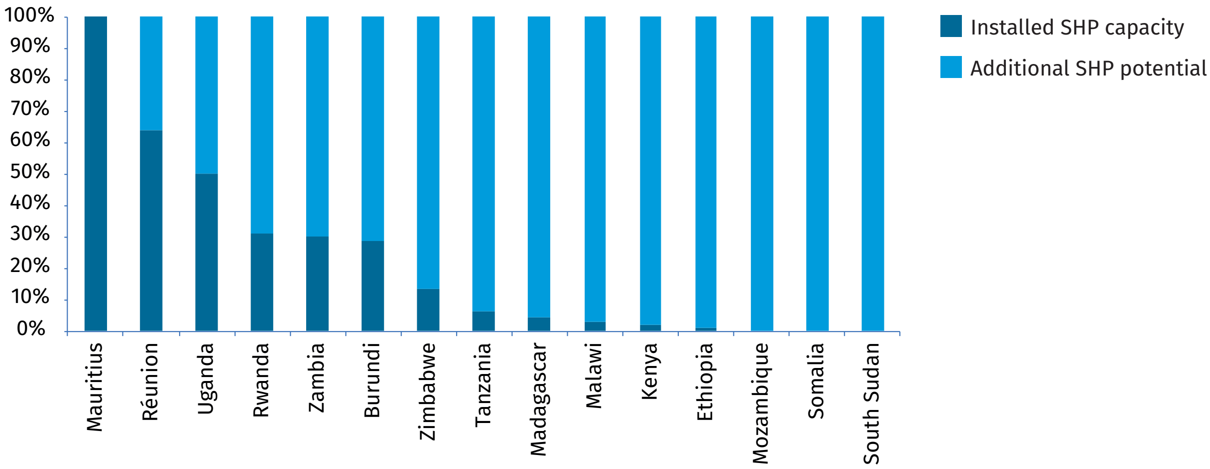
Figure 1. **Share of Regional Installed Capacity of Small Hydropower up to 10 MW by Country in Eastern Africa (%)**



Source: *WSHPDR 2022*[1]

Note: Somalia and South Sudan are not included due to lack of installed SHP capacity.

Figure 1. **Share of Regional Installed Capacity of Small Hydropower up to 10 MW by Country in Eastern Africa (%)**



Source: *WSHPDR 2022*[1]

The installed SHP capacity up to 1 MW in **Burundi** is 2.2 MW, while the estimated potential capacity is 30.5 MW, indicating that 7 per cent has been developed. For SHP up to 10 MW, installed and estimated potential capacities are 17.4 MW and 60 MW, respectively, indicating that 29 per cent has been developed. While no new SHP plants have been commissioned in recent years, two SHP projects with a cumulative capacity of 9.1 MW were in the planning stages as of 2021.

In **Ethiopia**, the installed capacity of SHP up to 10 MW is 12.9 MW, while potential capacity is estimated at 1,500 MW, indicating that less than 1 per cent has been developed. While Ethiopia is in the process of expanding its already considerable large hydropower capacity, the SHP sector in the country has seen little development in the last few years and there are no plans for the construction of any additional SHP plants in the near future.

The installed capacity for SHP up to 10 MW in **Kenya** is 66.3 MW, while potential capacity has been estimated at 3,000 MW, indicating that approximately 2 per cent has been developed. The country has actively pursued SHP development, with a large number of plants operated by the Kenya Tea Development Authority (KTDA) to support the operation of tea processing facilities. More than 260 potential SHP sites have been identified in studies carried out over the last decade, with the highest concentration of potential sites located in the Tana River basin. Many new SHP projects are either under construction or in the planning stages, with the KTDA continuing to play a key role in SHP development in the country.

The installed capacity of SHP up to 10 MW in **Madagascar** is 37 MW. The estimate of potential capacity, updated on the basis of a 2017 study, is 836 MW, suggesting that 4 per cent has been developed. SHP development in the country is actively ongoing, with several new plants commissioned between 2019 and 2021 and three SHP projects under development as of 2021.

In **Malawi**, the installed capacity for SHP up to 5 MW is 4.7 MW, while potential capacity is estimated at 150 MW, indicating that 3 per cent has been developed. Recent activity in the SHP sector has included major reconstruction of existing SHP plants, with the total installed capacity of SHP up to 5 MW actually decreasing as several ageing plants were replaced by a newer SHP plant with an installed capacity of 8.25 MW in 2020. Consequently, the installed capacity for SHP up to 10 MW in the country reached 12.9 MW. Two additional ongoing SHP projects with a total capacity of 9.5 MW have passed the feasibility study stage.

Mauritius has an installed capacity of 19.69 MW for SHP up to 10 MW. No additional undeveloped potential has been identified, suggesting that the country's SHP potential is fully utilized. The most recently-constructed SHP plant was commissioned in 2019, but most of the country's SHP fleet is old and requires refurbishment. A government study has been launched to assess the existence of additional undeveloped potential.

The installed capacity for SHP up to 10 MW in **Mozambique** is 4.8 MW, while potential is estimated at 1,000 MW, indicating that less than 1 per cent has been developed. Little SHP development has taken place in the country over the last decade, as activity in the hydropower sector has been focused on large hydropower projects. The largest concentration of SHP plants in Mozambique is located in the central parts of the country and most existing plants have an installed capacity under 1 MW. Recent in-depth studies have identified hundreds of potential SHP sites across the country with a combined potential capacity of over 672 MW.

The installed capacity for SHP up to 10 MW in **Réunion** is 10.6 MW, with an additional 6 MW of untapped potential. The total estimated potential capacity in the country is thus 16.6 MW, of which 64 per cent has been developed. The last SHP plant in the country was commissioned in 2018. A number of additional SHP projects are in the planning stage, all with capacities under 1 MW.

In **Rwanda**, the installed capacity for SHP up to 5 MW is 34.4 MW, while the potential capacity is estimated at 111.1 MW, indicating that 31 per cent has been developed. The country has seen active SHP development in recent years, with several new plants commissioned between 2017 and 2020. Likewise, 10 additional plants are expected to become operational by 2024.

Somalia has no operational SHP capacity, although the existence of one previously operational SHP plant suggests a potential capacity of at least 4.6 MW if the plant were to be refurbished or rebuilt. The SHP sector in the country is stagnant, although plans to rehabilitate the existing SHP infrastructure in the country have been announced by the Government in a 2016 report.

South Sudan likewise has no operational SHP capacity. However, the potential capacity for SHP up to 10 MW is considerable, estimated at 688.1 MW in a 2018 study. There are no known plans for SHP development in the country on the national level and the country overall lacks a comprehensive renewable energy framework. Existing plans for renewable energy development focus on solar power projects and large hydropower.

The installed capacity for SHP up to 10 MW in **Tanzania** is 30.5 MW, while potential is estimated at 480 MW, indicating that approximately 6 per cent has been developed. The country has over 1,600 SHP plants, most of which are operated by faith-based groups for the provision of power to community facilities and health centres. Several SHP plants with capacities below 1 MW were commissioned between 2017 and 2019 and at least four different studies have identified hundreds of potential SHP sites across the country.

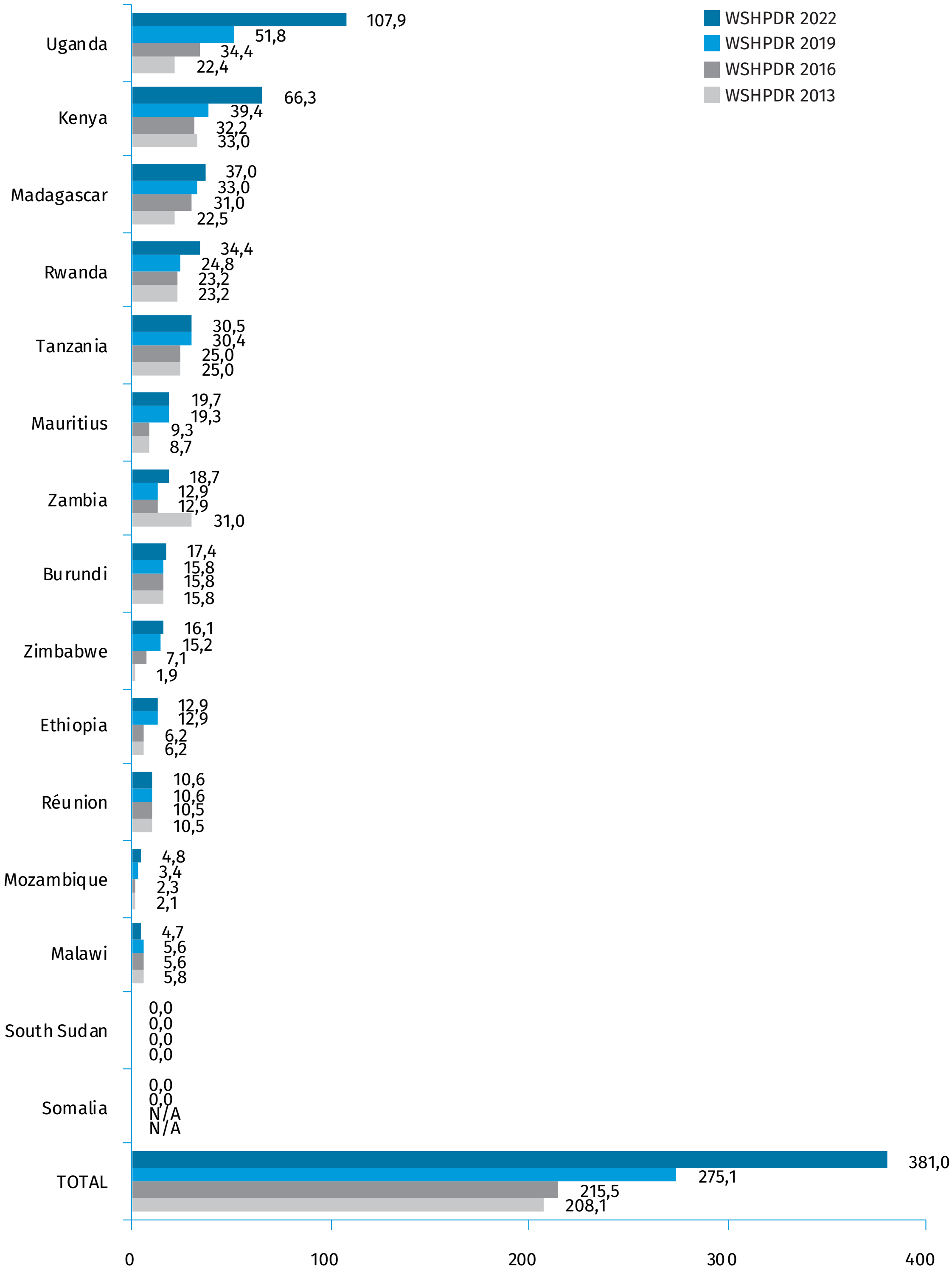
Uganda leads the Eastern Africa region in installed SHP capacity. The installed capacity of SHP up to 20 MW in the country is 186 MW, while estimated potential is 400 MW, indicating that 47 per cent has been developed. For SHP up to 10 MW, the installed capacity is 107.9 MW and estimated potential is 214.1, indicating that 50 per cent has been developed. SHP development in the country is very active, with over a dozen SHP plants up to 20 MW constructed between 2017 and 2022. Seventeen additional SHP projects were under construction as of 2022 and 20 potential SHP sites have been identified in various parts of the country.

The installed capacity of SHP up to 10 MW in **Zambia** is 18.7 MW, while the potential capacity is estimated at 62 MW, indicating that 30 per cent has been developed. The installed SHP capacity of the country has increased substantially due to the commissioning of two new SHP plants in 2020 with a combined capacity of 10.6 MW. In addition to new stream development, older SHP plants have either undergone refurbishment and capacity upgrades or have been decommissioned and replaced with new plants. Several SHP projects were in various stages of development as of 2020.

The installed capacity of SHP up to 10 MW in **Zimbabwe** is 16.1 MW, while the estimated potential capacity is 120 MW, indicating that approximately 12 per cent has been developed. For SHP up to 30 MW, the installed capacity is 31.4 MW, although no estimate of potential capacity is available. SHP plants in Zimbabwe are employed either as grid-connected facilities, which are operated by private companies, or as off-grid systems owned by communities and supported by non-governmental organizations (NGOs). One new SHP plant was commissioned in Zimbabwe in 2018 and several additional SHP projects are under construction.

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

Figure 3. **Change in Installed Capacity of Small Hydropower from *WSHPDR 2013* to *WSHPDR 2022* by Country in Eastern Africa (MW)**



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

Note: For SHP up to 10 MW with the exception of Malawi, where the local definition of SHP is used for consistent comparison with previous editions of the *WSHPDR*.

Climate Change and Small Hydropower

Almost half of the installed SHP capacity of Africa is located in Eastern Africa, with over 55 per cent of regional SHP capacity located in the Nile River basin. Climate change impacts on SHP in the region vary significantly depending on the models used. Projected variability in rainfall patterns and changes in temperature are likely to threaten water supply and storage, and pose a challenge to electricity generation in countries highly reliant on hydropower. A particular risk is a potential future decrease in wet season precipitation across the region. At the same time, expected increases in precipitation and runoff in certain parts of Eastern Africa can present an opportunity for SHP development. For example, some watersheds in Tanzania could see an increase in runoff of 160 per cent. Finally, climate change is expected to impact the reliability of estimates of hydropower potential in the region and the feasibility of previously identified sites. Consequently, older estimates of SHP potential in regional countries may no longer be accurate.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The development of SHP in **Burundi** is hampered by the lack of funds, local expertise in the SHP sector and limited hydrological data. At the same time, the country has a considerable untapped SHP capacity, with a range of potential sites already identified.

The main barrier to SHP development in **Ethiopia** is the Government's focus on large hydropower, which has resulted in a lack of funding for SHP as well as a lack of detailed and up-to-date information on potential SHP sites in the country. Ongoing political instability has been another factor holding back SHP projects. On the other hand, several recent government initiatives may be conducive to SHP development in the future, including a directive simplifying licensing for power generation on mini-grids and initiatives targeting rural electrification. The country's large untapped SHP potential suggests the country could considerably expand its overall generation capacity through SHP development.

Despite a robust and active SHP sector, SHP projects in **Kenya** face long lead times, high upfront costs and a lack of coordination between various government agencies responsible for SHP policy and oversight. More generally, climate change vulnerability and conflicts over land use present additional barriers to the implementation of SHP projects. However, SHP in Kenya also benefits from incentives including tax exemptions and feed-in tariffs (FITs), as well as from a well-established regulatory framework for public-private partnerships. Finally, the country's large undeveloped SHP potential is mapped in several recent studies.

Barriers to SHP development in **Madagascar** include a lack of funding opportunities, lack of local manufacturing capacity for turbines and risks induced by climate change. Enabling factors include the updated assessment of SHP potential in the country, which suggests the feasibility of SHP development on a greater scale than previously estimated, as well as the competitive per kWh cost of SHP in the country relative to other renewable energy sources.

SHP development in **Malawi** faces several significant obstacles including a lack of funding, lack of human capacity in the SHP sector and lack of awareness on the benefits of SHP among local communities. In addition, the SHP sector in the country is under pressure from environmental degradation, the vulnerability of old electrical infrastructure to extreme weather events, and vandalism of physical assets. At the same time, the demand for additional generation capacities is very high in Malawi due to low electricity access, and the existing untapped SHP potential in the country is well-studied. The Government provides certain tax exemptions for SHP projects and financing mechanisms for SHP are also available.

In **Mauritius**, the main obstacle for SHP development is the lack of identified undeveloped SHP potential. Government studies are underway to determine if undeveloped potential exists in the country, which could enable additional development in the SHP sector. Refurbishment of ageing SHP plants could present an additional opportunity for investment.

The development of SHP in **Mozambique** is hampered by the lack of a consolidated legal framework and the absence of an SHP-specific investment strategy, as well as the lack of locally-produced technology in the SHP sector. At the same time, the largely untapped and well-studied SHP potential in the country presents an important opportunity for meeting the electricity needs of remote and rural communities.

A major barrier to SHP development in **Réunion** is the island's isolated location, which significantly raises the cost of projects. Additional barriers unique to the island are its status as a World Heritage Site, volcanic activity and vulnerability to severe weather, all of which also contribute to raising the costs of SHP development. One promising direction for future SHP development in Réunion is the construction of SHP facilities on existing water supply infrastructure, which would minimize the impact of some of the aforementioned barriers.

Barriers to SHP development in **Rwanda** include the high cost of construction caused by difficult topography, geographic isolation and lack of local manufacturing capacity for SHP components, as well as unstable hydrological conditions. Enablers include the compatibility of SHP with micro-grids using other forms of renewable energy, suitable conditions for run-of-river plant construction and the Government's commitment to a climate-resilient model of development.

The main barrier to SHP development in **Somalia** is the ongoing political instability and fragmentation in the country, which severely complicates any development work. Additional barriers include the lack of financing from the private sector, local technical capacity in SHP and the limited regulation and oversight of the electricity sector. The main opportunity in the SHP sector in Somalia is the potential rehabilitation of the formerly operational 4.6 MW SHP plant.

The development of SHP in **South Sudan** is likewise hampered by political and economic instability, as well as by a focus on the development of fossil fuel-fired power plants, large hydropower and solar power. The main enabler for future development in the SHP sector is the country's large and fully undeveloped estimated SHP potential. SHP plants could be employed to at least partially address the problem of electricity access in the country, particularly in rural areas.

In **Tanzania**, barriers to SHP development include the lack of financing for projects as well as the problems with long-term financial sustainability of projects funded by NGOs, as the local customers are unable to bear the financial burden of power development and maintenance. SHP projects are also adversely impacted by issues with long-term planning and the lack of local technical expertise in the SHP sector. On the other hand, the country's large untapped SHP potential has been extensively studied and the country can lean on extensive experience in SHP project implementation. Additionally, Government policy is supportive of off-grid generation, and renewable energy sources including SHP plants are incentivized with standardized power purchase tariffs.

Despite a rapid pace of development, the SHP sector in **Uganda** is hampered by several obstacles, including deficiencies in the quality of the transmission and distribution network, limited local manufacturing capacity, a lengthy and bureaucratic process of land acquisition for projects and poor implementation of environmental oversight. Despite these issues, SHP development in the country is supported by a conducive regulatory environment and incentives for power generation from SHP, including several categories of FITs, in addition to other forms of government support and long-term planning, particularly with regard to using SHP to extend electricity access to rural communities.

Barriers to SHP development in **Zambia** are multi-faceted and include a lack of accurate hydrological data, lack of a comprehensive energy policy, issues with power transmission, financing and incentivization of investments through tariffs. The poor quality of the road network creates additional complications in accessing potential SHP sites. On the other hand, the country has a stable and growing market for electricity with steadily increasing demand, as well as an array of economic and fiscal incentives for SHP development including several categories of FITs, tax incentives, risk cost sharing and subsidies.

In **Zimbabwe**, barriers to SHP development include extreme weather conditions, lack of standard FITs and procurement methods, high cost of local financing coupled with lack of access to foreign financing opportunities and the lack of local manufacturing capacity for SHP equipment. The primary enablers of SHP development in the country are the substantial undeveloped SHP potential and the availability of net metering for SHP projects.

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Burundi

Willy Ciza, Ministry of Hydraulics, Energy and Mines

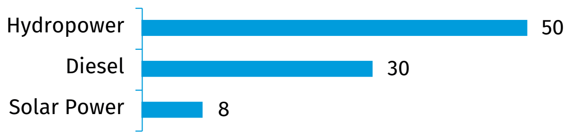
KEY FACTS

Population	12,255,429 (2021)[1]
Area	27,834 km^2[2]
Topography	The terrain of Burundi is dominated by plateaus and mountains. Plains are only found along the Ruzizi River, north of Lake Tanganyika, forming the border with the Democratic Republic of the Congo. In the west of the country, mountain ranges run from north to south, culminating at Mount Heha, which reaches 2,670 metres above sea level.[2]
Climate	The climate is equatorial, with temperatures ranging according to altitude, from 12 °C at high altitudes in the western mountainous areas to 32 °C in the plains, near Lake Tanganyika and at the Ruzizi River Plain. The capital city of Bujumbura experiences an average annual temperature of 23 °C.[2]
Climate Change	The key climate change impacts experienced by Burundi include increased heavy rainfall, leading to floods and soil erosion; precipitation reduction and long periods of drought, resulting in reduced water resources; increased heat and more frequent extreme weather events. In 1991–2020 the mean temperature was 0.5 °C higher than in the 1971–2000 period and almost 1 °C higher than in 1951–1980. Conversely, mean precipitation reduced, decreasing by an average of 7 mm per decade over the 1951–2020 period.[3]
Rain Pattern	The wet season in Burundi lasts from October to April and the dry season from May to September. Annual precipitation varies by region, ranging from 800–1,000 mm in the north-east to 1,600–2,000 mm at higher elevations in the mountains.[4]
Hydrology	The four major rivers are the Kanyaru, Malagarasi, Rusizi and Ruvubu. The largest lakes are Tanganyika, Cohoha and Rweru.[5]

ELECTRICITY SECTOR OVERVIEW

In 2022, the total installed capacity of Burundi was approximately 88 MW, which consisted of approximately 50 MW of hydropower, 30 MW from a diesel-fired power plant and 7.5 MW from one solar power plant (Figure 1).[6,7,8,9] Additionally, Burundi imports 15.5 MW from the regional Ruzizi hydropower complex located on the border between the Democratic Republic of the Congo and Rwanda.

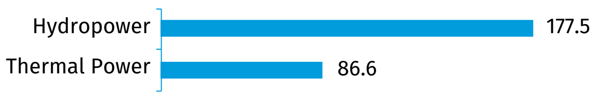
Figure 1. **Installed Electricity Capacity by Source in Burundi in 2022 (MW)**



Sources: Ciza,[6] Nsabimana,[7] Anadolu Agency,[8] REPP[9]

In 2020, electricity generation by the state-owned company Directorate for Production and Distribution of Water and Electricity (REGIDESO) amounted to 264 GWh, of which hydropower accounted for 67 per cent (Figure 2).[10] REGIDESO owns the majority of the electricity generation capacity in the country, however, besides its plants there are also plants owned by the Rural Electrification Agency (ABER) and independent power producers (IPPs). Total electricity generation in the country in 2020 including all producers amounted to 346.3 GWh, however, a breakdown by source for this total is not available.[11]

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



Source: ISTEEBU[10]

Note: Includes only generation by REGIDESO.

The World Bank reports an almost 12 per cent national electricity access rate and less than 4 per cent in rural areas.[12,13] However, no studies to determine the electricity access rate in the country have been carried out and these values should be considered as indicative. Overall, electricity supply critically lags behind demand. The Government of Burundi has implemented the policies and regulations to improve the country's energy sector, with a particular focus on renewable energy sources. The goal is to develop the economy, reduce poverty and create more opportunities for income generation from the energy sector.

In order to improve electricity access, a number of projects are currently under development, including, the 49 MW Jiji-Murembwe, 20 MW Kaburantwa and 10.4 MW Mpanda hydropower plants.[7] The plants most recently added to the country's generation fleet include the 7.5 MW solar plant in Mubuga and the 15 MW Ruzibazi hydropower plant in the south of Bujumbura.[8,9] In rural areas, the Government has set up two projects, Soleil Nyakiriza and Umuco w'Iterambere, in order to increase the rate of access to electricity, mainly for public infrastructure (health centre and secondary school) and to create a market for solar equipment in Burundi.

The electricity transmission system in Burundi is made up of 750 kilometres of 110 kV high-voltage lines and 30 kV medium-voltage lines.[14] Due to its dilapidated state, the electricity network does not support the load that passes through it, which leads to blackouts and electricity shortages. Studies are being finalized to rehabilitate the electricity network, mainly in the city of Bujumbura.

The Government of Burundi has opened the country's energy sector to private actors through the liberalization of the renewable energy sector. Investors can participate in electricity production, transportation and distribution as well as carry out marketing activities for the electricity produced. REGIDESO manages the electricity transmission and distribution infrastructure throughout the country, therefore, it acts as the buyer for projects undertaken within the public-private partnership (PPP) framework. For isolated power plants, a legal framework is in place to facilitate customer connection and electricity sales.

Electricity tariffs in Burundi were established in 2017 and are uniform on the entire territory of the country with differentiation according to the customer type (Table 1).[15]

Table 1. **Electricity Tariffs in Burundi**

Type of consumption	*Tariff (FBU/kWh (USD/kWh))*	*Fixed charge (FBU/Month (USD/kWh))*
Households (0–50 kWh)	82 (0.047)	0 (0)
Households (51–150 kWh)	290 (0.166)	0 (0)
Households (≥151 kWh)	546 (0.312)	6,822 (3.898)
Commercial (0–100 kWh)	195 (0.112)	4,122 (2.355)
Commercial (101–250 kWh)	313 (0.179)	8,266 (4.723)
Commercial (≥251 kWh)	399 (0.228)	12,398 (7.085)
Administration	313 (0.179)	11,500 (6.571)

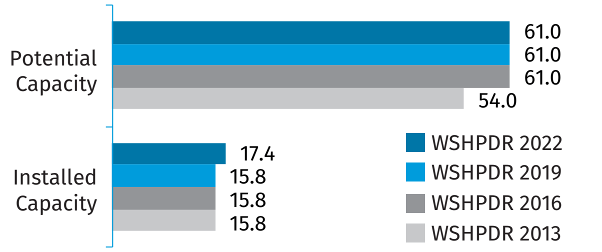
Source: Agence Bujumbura News[15]

SMALL HYDROPOWER SECTOR OVERVIEW

Small hydropower (SHP) is defined in Burundi as hydropower plants with capacity of up to 1 MW.

According to the local definition, there are 16 SHP plants in the country with a combined installed capacity of 2.2 MW (Table 2) and an annual generation of 76 GWh.[6] The potential of SHP up to 1 MW is estimated at 30.5 MW.[16] Following the up to 10 MW definition of SHP, the installed capacity of Burundi is 17.39 MW, while the potential, as determined based on planned SHP projects, is 61 MW.[6,16] The changes in installed capacity compared to the *World Small Hydropower Development Report (WSHPDR) 2019* are based on more accurate estimates, whereas the potential estimates have remained unchanged (Figure 3). No new SHP projects have been launched since the previous edition of the report; however, a number of projects are planned as part of the country's efforts to advance the renewable energy sector, including the 300 kW Karonke plant and the 8.8 MW cascade at Dama.[4]

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



Sources: Ciza,[6] *WSHPDR 2019,*[16] *WSHPDR 2013,*[17] *WSHPDR 2016*[18]

Note: Data for SHP up to 10 MW.

Table 2. **List of Existing Small Hydropower Plants up to 1 MW in Burundi**

Name	*Location*	*Capacity (MW)*	*Operator*	*Launch year*
Kayongozi	Ruyigi	0.500	ABER	2013
Mutumba	Bujumbura	0.092	Private	2009
Kiganda	Muramvya	0.043	Private	1990
Butezi	Ruyigi	0.234	ABER	1987
Nyabikere	Karuzi	0.138	ABER	1986
Murore	Cankuzo	0.023	ABER	1985
Buhiga	Karuzi	0.232	REGIDESO	1984
Mpinga	Rutana	0.020	Private	1983
Kigwena	Bururi	0.067	ABER	1982
Ryarusera	Muramvya	0.029	ABER	1982
Musongati	Rutana	0.015	Private	1981
Kiremba	Ngozi	0.068	Private	1980
Teza	Muramvya	0.418	Private	1979
Masango	Cibitoke	0.029	Private	1977
Burasira	Gitega	0.032	Private	1961
Nyamyotsi	Muramvya	0.300	Private	N/A

Source: Ciza,[6] Nsabimana[7]

The total hydropower potential in the country has been estimated to be approximately 1,700 MW, of which approximately 300 MW is economically viable.[19] Table 3 shows a list of selected potential sites identified for SHP development in the country.

Table 3. **List of Selected Potential Small Hydropower Sites in Burundi**

Name	*Location*	*Potential capacity (MW)*	*Type of side (New/refurbishment)*
RUVU197	Shombo	8.400	New
RUVU203	Bugendana	6.900	New
NYKI032	Itaba	6.844	New
SIKU011	Bururi	6.636	New
DAMA015_ATL	Burambi	6.091	New

Source: Ciza[6]

SMALL HYDROPOWER PROJECTS AVAILABLE FOR INVESTMENT

Table 4 shows a list of selected SHP projects available for investment.

Table 4. **List of Selected Small Hydropower Projects Available for Investment in Burundi**

Name	*location*	*Capacity (MW)*	*Developer*	*Development stage*
Kagu 006	Cibitoke	6.0	Ministry of Hydraulics, Energy and Mines	Preliminary study
Dama	Rumonge	8.0	Ministry of Hydraulics, Energy and Mines	Preliminary study
Muyo	Rutana	7.0	Ministry of Hydraulics, Energy and Mines	Preliminary study
Musas	Rutana	0.3	Ministry of Hydraulics, Energy and Mines	Preliminary study
Nyen	Rumonge	8.0	Ministry of wHydraulics, Energy and Mines	Preliminary study

Source: Ciza[6]

RENEWABLE ENERGY POLICY

The Government of Burundi aims to promote renewable energy as part of its efforts to protect the country's natural resources. This includes a range of planned hydropower, solar power, peat-fired and waste-to-power projects as well as exploration of the wind power and geothermal power potential in the country.[20] To support these efforts, the Government has prepared renewable energy legislation, which at the moment of writing of this chapter was under consideration. There are no feed-in tariffs in place.

As the majority of population uses wood as a source of energy for cooking, the Government of Burundi has planned a programme of planting trees across the country and calls the population to use other less polluting sources of energy, for example, ecological briquettes from biodegradable waste.

The following laws aiming to further liberalize the electricity sector have been implemented:

- Law No. 1/23 of 24 September 2008 defined tax benefits for investors;
- Law No. 1/177 of 19 October 2009 established the Investment Promotion Agency;
- Law No. 100/318 of 22 December 2011 established the ABER to develop and implement rural electrification projects and programmes;
- Law No. I/13 of 23 April 2015 aims to reorganize and liberalize the electricity sector;
- Electricity (Generation Services for Export and Electricity Importation) Regulations, 2016;
- Electricity Licensing (Generation Services for Own Use and Trade) Regulations, 2016;
- Electricity (Transmission, Distribution and Electricity Trade) Regulations, 2016.[16]

Licensing of SHP projects is overseen by the Regulatory Authority of Water and Energy Sectors (AREEN) and is a rather easy process. Each project is required to undertake an Environmental and Social Impact Assessment (ESIA).

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

The Government of Burundi is the main source of financing for SHP projects in the country, including through PPPs and loans.

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

So far, only minor effects of the climate crisis on the hydropower sector have been recorded in the country. Electricity generation drops in the summer period, which should be taken into account in future SHP developments. As adaptation measures for the hydropower sector, the Government uses generation from thermal power and plants trees around hydropower plants.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The key barriers preventing SHP development in Burundi include:

- Lack of funds;
- Lack of local skills and expertise;
- Limited hydrological data.

At the same time a range of favourable conditions for SHP development exist:

- A very low electricity access rate and need for electricity sector development so that the country can develop economically, socially and financially;
- Significant improvements in the business environment in the country have been made;
- Policy focus on hydropower development;
- A range of suitable SHP sites have been identified.

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Ethiopia

Zelalem Girma, Arba Minch University; and Davy Rutajoga, International Center on Small Hydro Power (ICSHP)

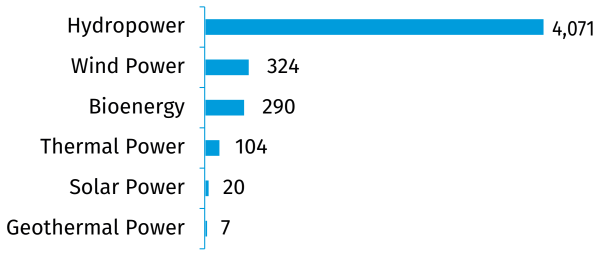
KEY FACTS

Population	114,963,583 (2020)[1]
Area	1,129,300 km^2 [2]
Topography	Ethiopia has one of the most rugged topographies in Africa that can be categorized into five zones: the Eastern Highlands, the Western Highlands, the Eastern Lowlands, the Western Lowlands and the Rift Valley. The highest point in the country is the Ras Dejen (or Ras Dashen) mountain, peaking at 4,533 metres.[3]
Climate	Ethiopia is located in the tropical latitudes and thus experiences climatic conditions typical of tropical regions in its lowlands. The country's highlands, however, enjoy a temperate climate due to their elevation offsetting the desert-like conditions of the lowlands. This variety in topography translates into mean temperatures ranging from -15 °C in the highlands to over 25 °C in the lowlands.[4]
Climate Change	Ethiopia has been experiencing increasing temperatures and variabilities in rainfall patterns due to climate change. The average temperatures have been increasing, especially in the July-September period, by an average of approximately 1 °C since 1960, with an average increase rate of 0.25 °C per decade. The average number of hot nights and hot days has increased, while cold days have also been decreasing exponentially. The higher rates of warming have been observed to affect the central regions and highland areas more, with increased evapotranspiration and reduced soil moisture. There has also been observed a decrease in precipitation and an increase in volatility. The south-central region, for example, has seen a 20 per cent decrease in rainfall since 1960. This has all led to increased droughts and unpredictable rainfall patterns.[4]
Rain Pattern	Ethiopia experiences considerable variability in rainfall. The equatorial forests in the south and south-west receive high rainfall. Conversely, while the Afroalpine zone on the Bale and Simien Mountains as well as the eastern, north-eastern and south-eastern lowlands experience desert-like conditions. Ethiopia has three rainfall seasons: the rainiest season, or Kiremt, accounting for most of the rainfall between June and September; the Belg, which is a secondary wet season from February to May in the central and northern regions; and the Bega in the southern regions, which occurs from October to December. The mean annual rainfall is approximately 2,000 mm in the south-western highlands and approximately 300 mm in the south-eastern and north-eastern lowlands.[4]
Hydrology	Ethiopia has 9 major rivers and 12 big lakes, including Lake Tana, which is the source of the Blue Nile. There are three major drainage systems in Ethiopia: the Western drainage, which includes the Blue Nile (or the Abay River), the Baro Rivers and the Tekeze and flows towards the White Nile in South Sudan and Sudan; the Rift Valley internal drainage system, including the Awash River, Omo River and the Lakes Region; and the Shebele and Genale Rivers drainage system which flows southwards towards Somalia and the Indian Ocean.[3]

ELECTRICITY SECTOR OVERVIEW

The main sources of electricity in Ethiopia are hydropower, wind power, bioenergy and solar power, respectively accounting for 93.9 per cent, 5.8 per cent, 0.2 per cent and 0.1 per cent of total production, which amounted to 14,553 GWh in 2019. All electricity production in the country was from renewable sources, with hydropower alone amounting to 13,655 GWh in 2019 (Figure 1).[5]

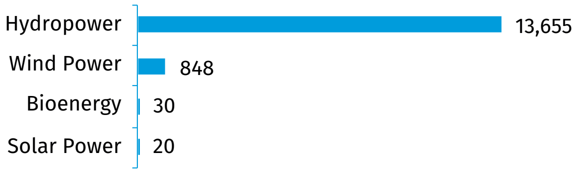
Figure 1. **Annual Electricity Generation by Source in Ethiopia in 2019 (GWh)**



Source: IRENA[5]

In 2020, the total installed electricity capacity in Ethiopia was 4,817 MW of which hydropower, wind power, bioenergy, solar power and geothermal power accounted for almost 85 per cent, less than 7 per cent, 6 per cent, 0.4 per cent and 0.3 per cent, respectively. Non-renewable thermal power capacity amounted to 104 MW (or 2.1 per cent) in 2020 (Figure 2).

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



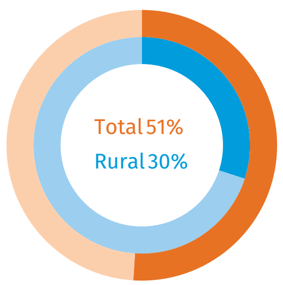
Source: IRENA[5]

Electricity in Ethiopia is regulated by the Ethiopia Electric Authority (EEA), while the Ethiopian Electric Utility (EEU) and the Ethiopian Electric Power (EEP) are responsible for generation, transmission and delivery. The latter was formed by Council of Ministers Regulation No. 302/2013.[6]

The EEA regulates tariffs for on-grid and off-grid electricity, with tariffs in Ethiopia being some of the lowest in Africa due to government incentives and a fixed cost of electricity. This tariff underwent an amendment in 2018, after which costs were ranging from 0.005 USD/kWh to 0.04 USD/kWh for residential consumers, and for industrial consumers from 0.03 USD/kWh to 0.02 USD/kWh.[7]

Electricity and the energy sector in general are a focal point of the Ten-Year Perspective Development Plan (2021–2030) of Ethiopia, also known as Vision 2030. Under Vision 2030, Ethiopia is projected to become a lower-middle income country and reach a 100 per cent electrification rate by 2025. The National Electrification Programme 2.0 (NEP 2.0) is the national strategy outlining the plan to achieve universal access to electricity through on- and off-grid solutions. Adopted in 2019, it is tied into Vision 2030 and highlights large-scale projects to double electricity production such as the Grand Ethiopian Renaissance Dam (GERD) and the 2,160 MW Koysha hydropower plant. The former, a large-scale hydropower project, is expected to be completed by 2023 but has already begun producing electricity and is expected to reach a production capacity of 6,450 MW, making it the largest hydropower plant in Africa.[8,9,10]

Figure 3. **Electrification Rate in Ethiopia in 2020 (%)**



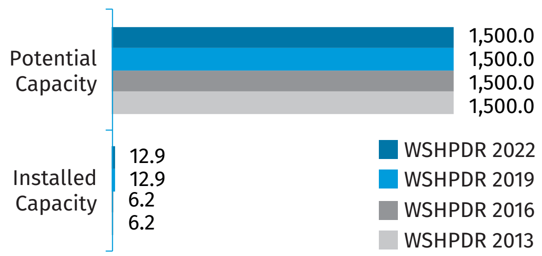
Source: World Bank[10]

The country's electrification rate was 51 per cent in 2020, with 30 per cent of the country's rural population having access to electricity (Figure 3). Electrification rates are expected to increase dramatically once the GERD is operating at full capacity.[11,12]

ALL HYDROPOWER SECTOR OVERVIEW

In Ethiopia, small hydropower (SHP) refers to plants with an installed capacity of up to 10 MW. The installed SHP capacity in 2018 was 12.89 MW and the SHP potential is estimated to be at least 1,500 MW, with most potential sites located in western and south-western Ethiopia.[13,17] The potential and installed capacity have not changed since the publication of the *World Small Hydropower Development Report (WSHPDR) 2019* as no new data have been made available (Figure 4).

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



Source: *WSHPDR 2013*,[14] *WSHPDR 2016*,[15] *WSHPDR 2019*,[16] MoST[17]

There is currently no reliable information on the number of SHP plants in operation in Ethiopia. In 2017, there were 28 operational SHP plants (Table 1).

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

Name	*River*	*Installed capacity (kW)*	*Potential upgrade up to (kW)*
Sor	Sor	5,000.0	–
Aba Samual	Aba Samuale	4,500.0	–
Dembi	Gilo	800.0	–
Jibo	Jibo	420.0	–
Yadot	Yadot	350.0	–
Ropi	Bilate	300.0	–
Gelenmite	Gelenmite	195.0	–
Chemoga	Chemoga	195.0	–
Welega	Welega	162.0	–
Hulka	Hulka	150.0	–
Yaye	Yaye	150.0	170.0
Sotosomere	Sotosomere	147.0	–
N/A	–	130.0	–
Deneba	Deneba	123.0	–

Name	*River*	*Installed capacity (kW)*	*Potential upgrade up to (kW)*
Hagara Sodicha	Lalta	43.5	55.0
Rago Senbete	–	30.0	–
Rasa Dango	–	30.0	–
Gobecho II	Gangea	28.0	34.0
Enkule	–	27.0	–
Shebe leku	–	18.0	–
Welega	–	15.0	–
Murago	–	15.0	–
Leku	Boru	13.0	20.0
Kersa	–	11.8	–
Ererte	Ererte	10.0	33.0
Keramo	–	10.0	–
Gera dusta	–	7.5	–
Gobecho I	Gangea	7.0	–
Total		**12,887.8**	

Source: MoST[17]

Note: Data as of 2017.

RENEWABLE ENERGY POLICY

As part of the NEP, a climate-resilient green economy approach is essential to achieving Vision 2030, and renewable energy is stated as one of the four pillars of this green economy. To achieve the Vision 2030 target of universal electricity coverage fixed by the Government of Ethiopia, a focus is made on the expansion of renewable energy in both the on- and off-grid mode.[9]

One of the policies addressed in the NEP is the National Biogas Programme (NBP) launched in 2009 with the aim of providing biogas digesters to Ethiopian households. In the first phase of the project, over 14,000 rural households were serviced and 360,000 low-income households are targeted for the current phase II. Further efforts to improve clean energy access in low-income households in the country were manifested in the National Improved Cookstove Programme (NICP), a programme launched in 2010 with the aim of providing cleaner cooking technologies to divest from traditional biomass-based fuels (firewood, charcoal). Within the first five years of implementation of the programme, over 9 million improved cookstoves had been distributed in Ethiopia. Under the Rural Electrification Fund launched in 2003, more than 45,000 solar home systems have been provided to previously unelectrified communities in Ethiopia and over 200 technicians were trained in the operation and maintenance of solar home systems.[9]

In response to the growing demand for renewable energy via off-grid systems, the Government of Ethiopia partnered with the International Development Association (IDA) to launch the Market Development Credit Line (MDCL) as part of the Electricity Network Reinforcement and Expansion Project (ENREP). Through this credit line, imports of technologies and equipment for renewable energy projects are facilitated by the supply of retail loans to Ethiopian private sector enterprises and small and medium-sized enterprises for up to two years, at 12 per cent interest and with guaranteed access to forex. The credit line also enables wholesale loans to Ethiopian micro-financial institutions in the local currency for up to six years at 6 per cent interest. The Government of Ethiopia is also considering alternative financial institutions to allow consumers in remote areas to be able to pay for their solar tariffs as part of the NEP.[9]

The Government has also implemented feed-in tariffs (FITs) for solar and wind projects, depending on the scale and location of the project, of between 0.05 USD/kWh and 0.06 USD/kWh.[14]

As a way to promote SHP development, the Government of Ethiopia introduced the Ethiopian Rural Energy Development and Promotion Centre (EREDPC). The EREDPC is overseen by the Ministry of Water, Irrigation and Energy and is mandated to promote and provide financing for SHP projects in rural Ethiopia through a rural electrification fund. Feed-in tariffs (FITs) are also being considered for hydropower to encourage private sector participation.[13]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

SHP plants are regulated by the same legislation as larger hydropower projects. The main legislation and regulation documents in Ethiopia concerning hydropower projects are:

- Energy Proclamation No. 810/2013 (as amended by Proclamation No. 1058/2018);
- Energy Regulation No. 447/2019 (Energy Regulation), which supplements the Energy Proclamation. It regulates the consent and permit procedures for generation, transmission and distribution licenses, and provides guiding principles on tariffs;
- Investment Proclamation No. 1180/2020. This is the key piece of legislation that regulates investments in any sector, including energy;
- The Federal Water Resources Management Policy (1999).

BARRIERS AND ENABLERS TO SMALL HYDROPOWER DEVELOPMENT

The development of new SHP projects is hampered mainly by:

- The lack of available relevant information on the state and future of SHP in the country, which can discourage prospective investors;
- Although studies of hydropower potential are regularly conducted in the country, they often target larger-scale hydropower;

- Increasingly volatile political situation and conflicts affect SHP development as entire regions of the country are often out of access or too dangerous to be visited for potential site analysis. Many water resources are also found in these out-of-reach zones of conflict;
- The focus on large-scale hydropower projects to respond to the growing demand for electricity, such as the GERD project, is likely to eclipse the potential of SHP in solving those issues, particularly in remote and rural areas.
- Lack of expertise in manufacturing, installation and maintenance of equipment or parts for SHP plants;
- Expansion of irrigation projects in small hydrostreams may prevent hydropower development downstream.

Enablers for SHP development in Ethiopia include:

- Government support for renewable energy in general: this is an encouraging sign as future policies are likely to keep reflecting this engagement;
- Institutional support for hydropower development through encouraging policies that target small-scale renewable energy development, particularly in rural Ethiopia;
- Considerable water resources and SHP potential in Ethiopia;
- Increasing foreign investment and private sector involvement in small-scale off-grid reflects an increasing interest in renewable energy solutions to the electrification issues of the country;
- Establishment of the EREDPC with a mandate to promote renewable energy technologies for rural electrification. Under the EREDPC, soft loans with low interest rates are available to private power producers;
- The mini-grid directive launched in 2020 simplifies the process of obtaining licences for electricity generation, distribution and sale as well as tariff setting.

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Kenya

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KEY FACTS

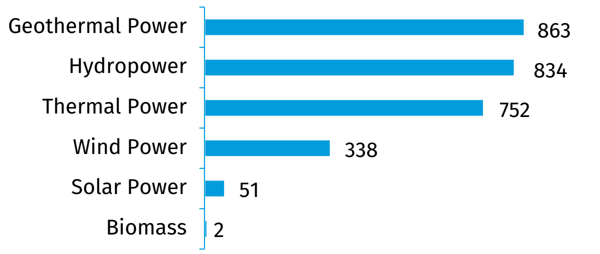
Population	53,771,300 (2020)[1]
Area	580,370 km^2 [2]
Topography	Kenya is located across the equator and is characterized by a diverse topography varying across its 47 counties.[3] Its Indian Ocean coastline contains swamps of the East African mangroves. Inland are broad plains and numerous hills. Central and western Kenya is characterized by the Rift Valley, home to the country's highest mountain and the second highest mountain in Africa, Mount Kenya, with an altitude of 5,199 metres above sea level. The landscape of Kenya includes deserts, such as the Chalbi, as well as glaciated mountain ranges.[2]
Climate	The climate of Kenya ranges from tropical in the southern, western and central regions to arid and semi-arid in the north and north-east.[4] Meanwhile, the country's central highlands have an equatorial climate.[5] Temperatures average 27 °C in the coastal areas, 19 °C in the capital, Nairobi, and 13 °C in the mountains.[6]
Climate Change	Climate change in Kenya has been well-documented, with both minimum and maximum daily temperatures on the rise since the early 1960s. Between 1960 and 2006, the minimum temperature has increased by 0.7-2.0 °C and the maximum by 0.2-1.3 °C.[7] Regionally, western parts of the country have seen the most significant temperature rise, with surface temperatures around Nairobi having risen by more than 2.5 °C since the 1960s. On the contrary, coastal areas have experienced more moderate warming trends. Projections of climate change for countries in the Eastern Africa region, including Kenya, forecast an increase in mean annual temperatures of 2.2 °C by 2065 and 4.0 °C by 2100 under a high-emissions scenario.[8]
Rain Pattern	The two rainy periods in Kenya are set apart by dry periods and referred to as the "long rains", from March to May, and the "short rains", from October to December. These have extensive implications for the country's agricultural system, with different crops being grown during each rainy period. The average annual rainfall is 630 mm, with a variation from less than 200 mm in northern Kenya to over 1,800 mm on the slopes of Mount Kenya.[2,9]
Hydrology	The drainage system of Kenya consists of five major basins: Lake Victoria, Rift Valley, Athi and the coastal area, Tana and Ewaso-Nyiro/North-Eastern. The two largest perennial rivers are the Tana (724 km) and the Athi-Galana-Sabaki (390 km). Both empty into the Indian Ocean.[10]

ELECTRICITY SECTOR OVERVIEW

The electricity sector of Kenya is characterized by a diversified energy mix and a high degree of reliance on renewable energy sources (RES). Petroleum products still form a major component of the national energy consumption, including for electricity generation, and demand for them continues to increase by approximately 10 per cent annually. However, Kenya is also endowed with an abundant RES potential, varying in type across geographic areas. The solar power potential is high across the country, while potential for biomass and hydropower is plentiful in the wet, forested central and southern regions. The wind power potential is highest in the north-west and parts of the Great Rift Valley, which also contains much of the country's geothermal energy resources.[11,12,13,14]

The installed generation capacity of Kenya has been increasing in recent years, and rose from approximately 2,819 MW in 2019 to 2,840 MW in 2020; however, the effective and contracted capacity in 2020 reached only 2,708 MW, in part due to the impact of the COVID-19 pandemic on the country's electricity sector.[14,15,16] Geothermal power was the single largest contributor of installed capacity in 2020 at 863 MW (30 per cent). Meanwhile, hydropower contributed 834 MW (29 per cent), thermal power 752 MW (26 per cent), wind power 338 MW (12 per cent), solar power 51 MW (2 per cent), and biomass 2 MW (less than 1 per cent) (Figure 1).[14] The geothermal power capacity expanded substantially in 2019 with the addition of the 165-MW Olkaria V plant, cementing the position of Kenya as one of the world leaders in geothermal power.[16,17] Given the additional importance of hydropower in the country's energy mix, the geothermal power capacity of Kenya is crucial in ensuring the security of electricity supply in periods of drought, with traditional thermal power deployed in a supplementary capacity. By the end of 2021, the installed capacity of traditional thermal power is expected to decrease to 622 MW, reflecting the country's ongoing transition to RES.[14]

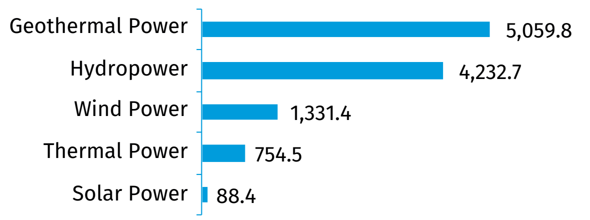
Figure 1. **Installed Electricity Capacity by Source in Kenya in 2020 (MW)**



Source: Government of Kenya[14]

In 2020, annual electricity generation in Kenya equalled 11,466.9 GWh, increasing slightly from 11,408.6 GWh in 2019. Of this total, 93 per cent of electricity was generated from renewable sources; geothermal power provided 5,059.8 GWh (44 per cent), hydropower 4,232.7 GWh (37 per cent), wind power provided 1,331.4 GWh (12 per cent), and solar power 88.4 GWh (1 per cent). Generation of electricity by thermal power, the only non-renewable source, accounted for 754.5 GWh (7 per cent) (Figure 2).[16]

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



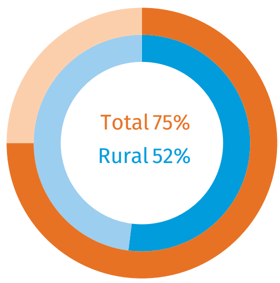
Source: KNBS[16]

In 2019, wind power generation experienced a more than four-fold increase relative to the previous year and reached 1,562.7 GWh, due to the full operationalization of the 310 MW Lake Turkana wind power plant, while solar power generation increased by nearly seven times relative to 2018 due to the commissioning of the Garissa power plant. However, in 2020 generation from both energy sources decreased slightly. In 2019, imports of electricity reached 212.0 GWh, but decreased to 136.7 GWh in 2020.[16,18]

In 2020, the total electricity supply decreased to 11,603.6 GWh from 11,620.7 GWh in 2019, with domestic demand falling to 8,796.4 GWh from 8,854.0 GWh over the same period. Transmission and distribution losses amounted to 2,790.7 GWh in 2020, accounting for 24 per cent of the total electricity supply.[16] Prior to 2020, Kenya had been experiencing an upward trend in electricity demand. The rise in demand has been associated with the increased number of consumers connected to the grid and the Government's efforts to attain universal access to electricity by 2022, as laid out in the Kenya National Electrification Strategy 2018–2022.[17] However, the economic slowdown induced by the COVID-19 pandemic led to a decrease in electricity demand of up to 8 per cent, with a system peak demand of 1,926 MW in February 2020 dropping to 1,465 MW in April 2020.[19] Further expansion of generating capacity to meet the rising demand is targeted at geothermal power, as part of a push to eliminate generation from fossil fuels.[20]

In 2018, access to electricity in Kenya stood at 75 per cent, with 52 per cent in rural areas (Figure 3).[21,22] Nationwide, almost 54 per cent were connected to the national grid and another 22 per cent were using off-grid solutions as their main source of electricity.[21] By 2020, overall access to electricity increased to 77 per cent, establishing Kenya as a regional leader in electricity access. The number of consumers connected to the national grid has grown rapidly in recent years, from 3,611,904 customers in 2015 to 7,576,145 in 2020, with an average annual increase of approximately 19 per cent. During the 2019/2020 reporting year alone, over 400,000 new customers were connected to the national grid. Rural connections reached 1,502,943 customers in 2020, accounting for approximately 20 per cent of all connections.[14,15] These results were achieved through a number of interventions by the Government of Kenya in collaboration with development partners, including the Last Mile Connectivity Programme (LMCP), electrification of all public primary schools, the Global Partnership on Output-Based Aid (GPOBA), the Rural Electrification Programme (REP), the Kenya Off-Grid Solar Access Project (KOSAP), the Slum Electrification Project (SEP), the Lifeline Tariff and the Energy and Cash Plus Initiative.[17]

Figure 3. **Electrification Rate in Kenya in 2018 (%)**



Source: The World Bank[21,22]

Despite the accelerating growth of the electrification rate, nearly 25 percent of the population still lack access to electricity.[15] Obstacles to full electrification include high connection charges, high costs of supplying electricity to rural areas, lack of incentives for private investment, inappropriate technical standards, general lack of capacity, administrative barriers and demands for excessive compensation for the issuing of development licences.

The key institutions in the energy sector of Kenya include the following:

- Ministry of Energy and Petroleum (MOEP), the lead Government institution in charge of making and ar-

ticulating energy policies as well as granting and revoking generation and distribution licences upon the recommendation of the Energy and Petroleum Regulatory Authority (EPRA);
- Energy Tribunal, an independent legal entity that arbitrates disputes between parties in the energy sector;
- Energy and Petroleum Regulatory Authority (EPRA), previously the Energy Regulatory Commission (ERC), the independent regulator established under the Energy Act, 2019. EPRA's mandate includes licensing, technical and economic regulation, enforcement and compliance and handling of complaints and dispute regulation;
- Kenya Power and Lighting Company (KPLC, also Kenya Power), a public company that transmits, distributes and retails electricity to customers in the country;
- Kenya Electricity Generating Company (KenGen), a state-owned company that owns approximately 72 per cent of the country's installed capacity and is responsible for developing new public sector generation facilities to meet increased demand;
- Rural Electrification and Renewable Energy Corporation (REREC), mandated by the Energy Act, 2019 to be the lead agency for the development of renewable energy resources other than geothermal power and large hydropower, in addition to its previous mandate of rural electrification;
- Geothermal Development Company (GDC), a wholly state-owned Special Purpose Vehicle that undertakes surface exploration of geothermal fields, explorations, appraisals, drilling, steam production and entering into steam sales agreements with investors in geothermal electricity generation;
- Electricity Transmission Company (KETRACO), a wholly state-owned company responsible for the development of the national transmission grid network and for the facilitation of regional power trade through the transmission network;
- Independent Power Producers (IPPs), involved in generation either on a large scale or in renewable energy projects under the feed-in-tariff policy;
- Nuclear Power and Energy Agency (NPEA), formerly Kenya Nuclear Electricity Board (KNEB), a state-owned corporation established under the Energy Act, 2019 and charged with the responsibility of promoting and implementing the country's Nuclear Power Programme as well as carrying out research and development for the nuclear energy sector. To date, no nuclear plants have been built in Kenya;
- Kenya Renewable Energy Association (KEREA), an independent non-profit association dedicated to facilitating the growth and development of renewable energy enterprises in the country;
- Private distribution companies are proposed under the Energy Act, 2019 with the intention of enhancing competition in the distribution sector and thereby improving efficiency. It is envisaged that future power distribution will involve the purchase of bulk power from power generating companies. With KETRACO facilitating the transmission, generating companies will be able to sell power directly to consumers;
- County governments, which, under the Energy Act, 2019, are required to prepare county energy plans for the Cabinet Secretary. Some counties provide supplementary funding for rural electrification;
- Independent entities that act as arbiters in disputes between parties in the energy sector;
- Mini-grids, supplying electricity to a localized group of customers not covered by the national power grid as approved by EPRA.

Over the last years, the Government of Kenya has accelerated its efforts in upgrading the existing transmission and distribution networks and building new ones for effective power evacuation. The national grid network is composed of 400 kV, 220 kV and 132 kV transmission systems, while the distribution network includes 66 kV, 33 kV and 415/240 V systems.[15] The total length of the transmission and distribution network increased to 243,207 kilometres for all voltage levels in 2019/2020, compared to 59,322 kilometres in 2014/2015, with the length of the transmission network alone at 7,174 kilometres.[14] The expansion of the network has been spearheaded by KETRACO. As of the moment of writing of this chapter, KETRACO was in the process of constructing approximately 4,500 kilometres of new lines as well as connecting the power systems of Kenya and Ethiopia through the construction of a 1,045-kilometre 500 kV high voltage direct current (HVDC) transmission line and 2,000 MW HVDC converter substations at both ends of the line.[23,24] The Kenya-Ethiopia electricity interconnection will represent the longest transmission line in Eastern and Middle Africa, as well as the first direct current line in Kenya having 500 kV high-voltage direct current.[25] The entire national interconnected electricity distribution network is operated by KPLC.

EPRA sets, reviews and adjusts electricity tariffs and tariff structures in line with key policy objectives.[21] The set tariffs must be approved by the regulator before enforcement. Retail electricity tariffs vary according to the customer category (Table 1).

Table 1. **Electricity Tariffs in Kenya for 2018/2019**

Consumer category	*Consumption limit (kWh/ month)*	*Electricity charge (KSH/kWh (USD/kWh))*	*Demand charge (KSH/ kVA (USD/ kVA))*
Domestic-Lifeline (240 V)	< 100	10.0 (0.09)	-
Domestic-Ordinary (240 V)	> 100	15.8 (0.14)	-
Small Commercial 1 (240 V)	Up to 100	10.0 (0.09)	-
Small Commercial 2 (240 V)	101–15,000	15.6 (0.14)	-
Commercial/Industrial (415 V)	> 15,000	12.0 (0.11)	800 (7.28)
Commercial/Industrial (11 kV)	No limit	10.9 (0.10)	520 (4.73)
Commercial/Industrial (33 kV)	No limit	10.5 (0.10)	270 (2.46)
Commercial/Industrial (66 kV)	No limit	10.3 (0.09)	220 (2.00)
Commercial/Industrial (132 kV)	No limit	10.1 (0.09)	220 (2.00)
Street lighting	No limit	7.5 (0.07)	-

Source: EPRA,[15] KPLC[26]

SMALL HYDROPOWER SECTOR OVERVIEW

The definition of small hydropower (SHP) in Kenya generally includes hydropower plants with an installed capacity of up to 3 MW (Table 2), but some government sources define SHP as plants of up to 10 MW.[27,28,29] For the purposes of this chapter, the up to 10 MW definition will be used.

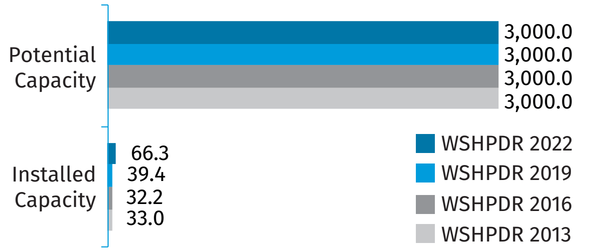
Table 2. **Definitions of Small Hydropower in Kenya**

Category	*Capacity range (kW)*
Pico	< 5
Micro	5–100
Mini	100–1,000
Small	1,000–3,000

Source: MOEP,[27] Ngure[28]

As of 2019, total installed capacity of SHP up to 10 MW in Kenya stood at 66.26 MW, including 26.99 MW operated by KenGen and 39.27 MW by private companies and rural communities.[14,18,30,31,32] Undeveloped potential capacity for SHP up to 10 MW is estimated at 3,000 MW.[29,33] Compared to the *World Small Hydropower Development Report (WSHPDR) 2019,* installed capacity increased by approximately 68 per cent due to up-to-date information on recently commissioned plants becoming available. Potential capacity has remained the same as no new country-wide studies of SHP potential have been conducted since 2004 (Figure 4).[34]

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



Source: Government of Kenya,[14] KPLC,[18] MOEP,[29] The World Bank,[30] Vogeler et al.,[31] EPRA,[32] *WSHPDR 2019,*[34] *WSHPDR 2013,*[35] *WSHPDR 2016*[36]

SHP development in Kenya accelerated following the introduction of the feed-in-tariff (FIT) policy in 2008, with the majority of new SHP plants constructed by the Kenya Tea Development Authority (KTDA). The plants are expected to significantly reduce energy costs of operation for KTDA tea factories as well as generate surplus electricity, which will be sold to the national grid.[31] A list of the 20 most recently commissioned SHP plants is displayed in Table 3.

Table 3. **List of Selected Operational Small Hydropower Plants in Kenya**

Name	*Location (River)*	*Capacity (MW)*	*Operator*	*Launch Year*
Iraru	Iraru	1.50	KTDA	2017
Nyakwana	Kisii	2.00	KTDA	2017
Teremi Falls	Kyuwa	5.00	GenPro Power Systems Ltd.	2017
Gura	Gura	5.80	KTDA	2016
Chania	Chania	1.00	KTDA	2016
North Mathioya/ Metumi	Mathioya	5.60	Metumi Power Co Ltd	2016
Lower Nyamindi	Nyamindi	1.80	KTDA	2016
South Mara	South Mara	2.00	KTDA	2016
Nyabunde	Gucha	0.50	KTDA	2016
Gikira	Gikira	0.51	Kengen	2014
Tindinyo Falls	Yala	1.50	Tindinyo Falls Resort	2014
Imenti	Imenti	0.90	KTDA	2009
Kleen Energy	Embu	6.00	N/A	2008
Community MHPs	N/A	0.02	Community	2002
Thima	Mukenge-ria	0.01	Community	2001
Kathamba	Kathamba	0.00	Community	2001
Tungu-Kabiru	Tungu	0.01	Community	2000
James Finlay 5	Kericho	1.10	Tea Company (James Finlay)	1999
Diguna	N/A	0.40	Missionary	1997
James Finlay 4	Kericho	0.3	Tea Company (James Finlay)	1984

Source: Government of Kenya,[14] KPLC,[18] MOEP,[29] The World Bank,[30] Vogeler et al.,[31] EPRA,[32] *WSHPDR 2019*[34]

Various studies conducted in Kenya over the past 10 years have identified many prospective sites for SHP development.[14,37,38] More than 260 individual potential hydropower sites have been identified, with the largest number found in the Tana River drainage basin, an area with a high population density and energy demand.[39] Both existing and prospective SHP plants in Kenya are often designed as stand-alone electricity supply facilities for agro-industrial establishments, in particular tea factories. A survey of 72 tea factories in Kenya indicated that 80 per cent are located 3–15 kilometres away from a potential hydropower site, although no detailed assessments of potential have been carried out. The KTDA can be expected to continue playing a major role in the development of SHP in the country, having committed itself to an array of SHP projects to be commissioned throughout the 2020s.[14] Table 4 displays several SHP projects currently under construction.

Table 4. **List of Selected Ongoing and Planned Small Hydropower Projects**

Name	*Location*	*Capacity (MW)*	*Developer*	*Planned Launch Year*
Kianthumbi	Meru	0.51	Hydro Project Service Peters Ltd.	2021
Gatiki Small Hydro Plant		9.60	Power Technologies	2022
Nithi Hydro	Tharaka Nithi	5.60	Frontier	2025
Kipsonoi 1	Bomet	0.60	KTDA (Settet Power Co.)	2025
Buchangu		4.50	Global Sustainable Ltd.- Buchangu	2026

Source: Government of Kenya,[14] The World Bank[30]

RENEWABLE ENERGY POLICY

The Energy Act, 2019 introduced various reforms to the energy sector of Kenya, aligning the sector with the Constitution of 2010 regarding the functions of the national and county governments.[40] Notably, through the introduction of the RES FIT system, the Act developed on the FIT policy introduced by MOEP in 2008 and reviewed in 2010, 2012 and 2021. The 2021 FIT Policy is a revision of the 2012 FIT Policy, with substantial changes introduced to the process of RES project development in Kenya to better align the Policy with the Energy Act, 2019 and other recent developments in the Kenyan energy sector. The FIT policy has been supplemented by the Renewable Energy Auction Policy (REAP) of 2021; FITs now apply to RES power plants not exceeding 20 MW and relying on biomass, biogas or small hydropower, while energy auctions have replaced FITs for solar and wind power and for all RES plants above 20 MW.[42] The current FITs for RES are listed in Table 5.

Table 5. **Feed-in Tariffs for Renewable Energy Projects in Kenya as of 2021**

Plant type	*Installed capacity (MW)*	*Standard FIT (USD/kWh)*	*Scalable portion of the tariff*
Hydropower	0.5	0.090	8%
	10	0.082	
Biomass	0.5 - 10	0.095	15%
Biogas	0.2 - 10	0.095	15%

Source: Ministry of Energy[43]

Note: For values between 0.5 MW and 10 MW, interpolation shall be applied to determine the tariff for hydropower.

The Energy Act, 2019 was adopted to consolidate the laws relating to energy and the promotion of RES, replacing the previously adopted Energy Act of 2006, Kenya Nuclear Electricity Board Order of 2013 and the Geothermal Resources Act of 1982. The new Act gave greater recognition to non-traditional energy sources, including RES and nuclear energy.[44] Additional legislation important for the RES sector includes:

- Sessional Paper No.4 of 2004, which cemented the process of liberalizing the energy sector started in the 1990s;
- the Electricity Licensing Regulations of 2012, which detail the permit and licensing requirements that are applied to any individual or entities undertaking or planning to engage in electricity generation, transmission, distribution or retail supply business;
- the VAT Act (2013) and the Amended VAT Act (2014), which exempt investors in RES from value-added tax and import duties on temporary and permanent materials and equipment required for RES projects;
- the Public-Private Partnerships Act of 2013, which provides for the participation of the private sector in the financing, construction, development, operation and maintenance of public infrastructure and development projects; and
- the Public Procurement and Asset Disposal Regulations of 2020, which seek to harmonize and operationalize public procurement procedures.[29,45]
- Renewable Energy Auction Policy (REAP) 2021, the primary objective of which is to procure renewable energy capacity in line with the LCPDP and the Integrated National Energy Plan (INEP) at competitive prices through the establishment of energy auctions.[42]

In additional to regulatory legislation, promotion of RES development in Kenya is realized through the following strategies and plans:

- The long-term development strategy of Kenya, Vision 2030, targets energy access as a key enabler for achieving its development targets, including projected increases in population, which are in turn expected to lead to a rise in electricity demand. According to the Least Cost Power Development Plan (2011–2031), the demand for electricity in Kenya is projected to grow to 15,065 MW by 2030;

- Sustainable Energy for All (SE4ALL) Action Agenda, which outlines how the country will achieve universal access to modern energy services, increase the rate of energy efficiency and increase the share of RES in the energy mix to 80 percent by 2030;
- The Kenya Electricity Sector Investment Prospectus 2018–2022, which outlines investment and financing opportunities in geothermal power development, power generation, electricity transmission and distribution, off-grid electrification and energy efficiency;
- The Investment Plan for Scaling-Up Renewable Energy (SREP), currently under implementation, supports the development of hybrid mini-grid systems based on RES for electrification in rural areas where grid extension is unlikely to be viable in the short and medium term.
- The Least Cost Power Development Plan (LCPDP) 2021 – 2030, which highlights the Government's intention to prioritize the development of geothermal, wind and solar energy plants as well as solar-fed mini-grids for rural electrification.[14]

The available incentives for RES development in Kenya include:

- Exemption from stamp duty for registration of companies;
- Exemption from stamp duty for instruments executed in transactions relating to loans from foreign sources for the purposes of investing in the energy sector;
- Investment deductions at the rate of 100 per cent for power generating plants and equipment, including the building housing the power generating plant and plants operating within Export Processing Zones; and at 150 per cent for plants located outside Nairobi, Mombasa and Kisumu;
- Insurance cover by the Multilateral Insurance Guarantee Agency (MIGA);
- Development of Public Private Partnerships by the Government in line with the Public Private Partnership Act No. 15 of 2013;
- Letters of support issued by the Government to both project companies and their financiers to enable project implementation;
- Kenya has no restrictions on converting or transferring investment funds;
- Foreign Investment Protection Act, Chapter 518, which guarantees capital repatriation and remittance of dividends and interest to foreign investors.

Licences and permits required for operating a power plant in Kenya include a generation licence and a distribution licence, both issued by MOEP; water rights (in the case of hydropower), obtained from the Ministry of Water Resources; and an Environmental Impact Assessment issued by the National Environmental Management Authority of the Ministry of the Environment. In case of sale of power to the grid, additional requirements include a power purchase agreement and adherence to generation and distribution standards.[46] Finally, approval of development permissions and building plans by the relevant county government and registration of the project site as a workplace with the Director of Occupational Safety and Health under the Occupational Safety and Health Act, 2007.

COST OF SMALL HYDROPOWER DEVELOPMENT

The cost of SHP construction in Kenya varies considerably based on location and the difficulty of preparing a site for construction, as well as other factors including the local economy and tax regime.[38] It is generally considered that the location and site preparation determine approximately 75 per cent of project costs, against only 25 per cent for the equipment.[47] The investment cost of an SHP plant in Kenya ranges anywhere from 1,000 to 20,000 USD/kW.[38] Maintenance costs of SHP plants in Kenya are relatively small in comparison to other technologies such as diesel generators. The initial investment cost as well as negative impacts on the environment can be greatly reduced by utilizing already existing impoundments and weirs.[38]

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

Financing models utilized by developers in Kenya involve a combination of several approaches including community finance, public funding, equity investment, grants and loans from local financing institutions. For instance, in 2015, KTDA signed a KSH 5.5 billion (USD 50 million) loan agreement with the International Finance Corporation (IFC), in partnership with the Global Agriculture and Food Security Program (GAFSP), the French Development Finance Institution (Proparco) and the Netherlands Development Finance Company (FMO) to fund the construction of seven SHP projects across tea growing regions.[48]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT.

The hydropower sector of Kenya as a whole is vulnerable to climate change, creating broad implications for the entire economy due to the relative weight of hydropower in the country's energy mix.[49] Reduced rainfall in recent years has already made hydropower production increasingly unreliable, forcing the Government of Kenya to introduce new policies and strategies that place a greater emphasis on promoting other RES.[50] Furthermore, climate change is putting additional pressure on traditional fuels including firewood and charcoal, access to which is becoming increasingly restricted as forest cover has receded.[51] SHP projects can expect to face resistance if they are perceived as further limiting access to these resources.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Some of the main obstacles to the development of RES, and SHP specifically, in Kenya include the following:

- Relatively long lead times for RES projects (from five to seven years);
- High upfront investment and capital costs, including the cost of ancillary infrastructure due to long distances to existing load centres;
- Political risks and conflicts relating to land use;
- Inadequate expertise and technical capacity in the RES sector as well as limited local capacity to produce RES materials and equipment;
- Lack of coordination between government agencies in policy implementation and promotion of RES projects, excessive licensing requirements as well as weak enforcement of standards and regulations;
- Vulnerability to climate change;
- Lack of awareness of the economic benefits of RES.

Additional barriers, specifically pertaining to the implementation of the FIT policy, include the following:

- Insufficient data and analytical tools to accurately formulate the tariff rates for different technologies;
- Lack of awareness of FITs among potential investors;
- No clear guidelines on power purchase agreement negotiations;
- Preference for certain RES technologies over others.

Enablers for SHP development include:

- High potential capacity of SHP, little of which has been realized so far;
- Incentives, including FIT and exemptions from certain taxes and duties on RES; and
- Favourable climate for private investors, which includes a robust public-private partnership framework.

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Madagascar

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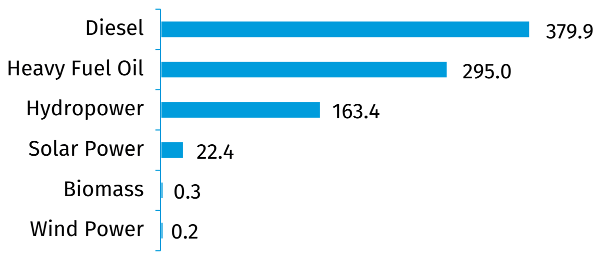
KEY FACTS

Population	26,923,353 (2021)[1]
Area	587,295 km^2 [2]
Topography	Referring to its physical map, Madagascar has an asymmetry with respect to its main axis. The western part extends gently towards the Mozambique Channel, while the eastern part has a very steep slope leading towards the Indian Ocean. Topographically, the island can be divided into three main parts: the central highlands with an altitude ranging from 800 to 1,500 metres and a peak of 2,876 metres (Maromokotra), followed by the eastern slopes and finally the sedimentary zone of the north-west, west and south.[3]
Climate	Madagascar lies in the tropics and has two seasons and five main climatic regions comprising the East Coast, Uplands, West Coast, Southern and Sambirano regions. The cool, dry season begins in mid-April and ends in mid-October. The hot, rainy season begins in mid-October and ends in mid-April of the following year. The temperature is very varied in these areas but the absolute minimum of 1 °C is observed in the highlands (Antsirabe) in July, while the absolute maximum temperature was recorded in the extreme south at a value of 43.6 °C.[4,]
Climate Change	The trend of temperature increase has been significant in Madagascar since 1950. By 2055, the annual average temperature is projected to increase by 1.1 2.6 °C. Each region will have a variation in rainfall, but it is expected to be more intense in the western part. The number of more intense cyclonic disturbances has increased and the most affected areas have migrated towards the north-east of the island. As far as cyclones are concerned, the average annual number is not expected to change but the number of intense cyclones is expected to increase by 2100.[5,6]
Rain Pattern	Rainfall varies across the five climatic regions. Annual average rainfall exceeds 2,000 mm in the East Coast and in the Sambirano region. The Uplands, West Coast and Southern regions have an annual rainfall of 1,200, 950 and 600 mm, respectively. The annual minimum is 500 mm as observed in the South, which has a semi-arid climate. The maximum rainfall can be found in the East Coast, which has a hot and humid climate, at a value of 3,700 mm with 260 rainy days per year.[4]
Hydrology	There are more than 10 major rivers in Madagascar. Their tributaries constitute river networks scattered across different corners of the big island. The drainage pattern is a consequence of the asymmetric nature of the country's relief. As a result, the rivers in the west are longer, while those in the east are shorter and have a more accentuated course with numerous waterfalls, sometimes of considerable height. The periodic passage of tropical depressions, especially in the eastern and north-eastern parts of the country, makes the hydrological regimes extremely complex.[3]

ELECTRICITY SECTOR OVERVIEW

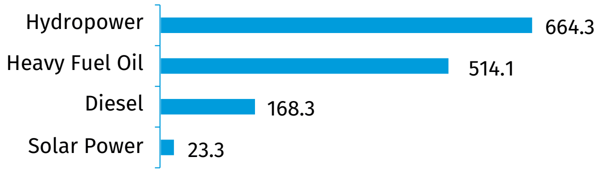
Madagascar uses several energy sources to generate electricity: hydropower, hybrid solar photovoltaic-diesel, heavy fuel oil and diesel. In 2020, 50.2 per cent of the produced electricity came from renewable sources, while 49.8 per cent came from fossil fuel sources. The total electricity generation in 2020 amounted to 1,370 GWh (Figure 1). Biomass and wind power plants are also used but in negligible proportions compared to the other sources. The total installed capacity of the country was 861.2 MW in 2020, with renewable sources accounting for approximately 22 per cent (Figure 2).[7]

Figure 1. **Annual Electricity Generation by Source in Madagascar in 2020 (GWh)**



Source: Ministry of Energy and Hydrocarbons[7]

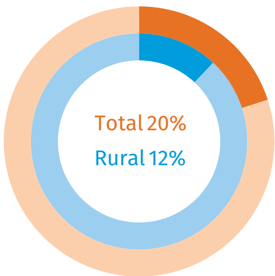
Figure 2. **Installed Electricity Capacity by Source in Madagascar in 2020 (MW)**



Source: Ministry of Energy and Hydrocarbons[7]

Madagascar does not import or export electricity due to a lack of geographical proximity to other countries. With regard to electricity access, the data collected by the Rural Electrification Development Agency (ADER) in January 2020 shows a national rate of almost 20 per cent, dividing the number of people with access to electricity infrastructure by the total population. Electrification rate is 12 per cent in rural areas and 67 per cent in urban areas.9

Figure 3. **Electrification Rates in Madagascar in 2020 (%)**



Source: ADER[9]

The electricity sector has been liberalized since 1999 following law No. 98-032 on the reform of the electricity sector. This liberalization is improved and confirmed by Law 2017-020 of 10 April 2018 on the Electricity Code of Madagascar.[8] Thus, the private sector is encouraged to finance all or part of the infrastructure through a contract signed with the Government for a fixed period of time.

The explanatory memorandum of the Electricity Code of Madagascar also specifies the attributions of the public sector.[8] The public sector is composed of the Ministry of Energy and Hydrocarbons, the Regulator and ADER. Since the adoption of the Electricity Code, ADER has been responsible for defining national electricity policy and coordinating the planning of all projects in the sector. Its remit is also the development of electrification in rural and peri-urban areas and the implementation of national policy in these areas.

Currently, Madagascar has three interconnected grids: RIA (Antananarivo), RIT (Toamasina) and RIF (Fianarantsoa), with the other major cities and rural villages supplied by off-grid power plants.[9] Two projects are being implemented for the interconnection of RIT with RIA first and RIA with RIF later, through the PRIRTEM I and PRIRTEM II projects supported by the African Development Bank and the European Union.[10]

Tariff regulation is the subject of an entire title of the Electricity Code of Madagascar.[8] It concerns sales of power and energy and their surpluses between the different actors in both interconnected and off-grid networks. The Regulator is empowered to approve the regulated tariffs. For national networks managed by national companies, four tariff zones are established according to the energy source that feeds them. In decentralized rural electrification, the tariff varies according to the business plan presented by the operator. In 2020, the average household electricity tariff was 0.120 USD/kWh and the average tariff for businesses was 0.118 USD/kWh.[11]

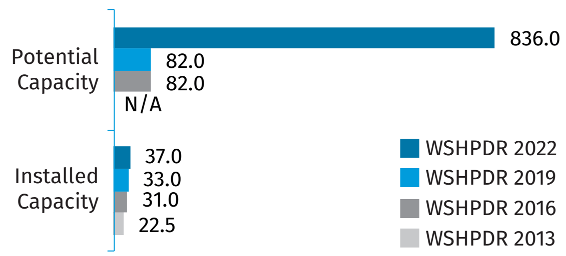
Several governmental decrees (notably Decree 2005-062 of 25 January 2005, Decree 2001-803 of 19 September 2001 and Decree 2003-194 of 4 March 2003) specify the role of the Regulator, which is responsible for the control of the electricity sector, including the determination and publication of regulated prices and fees, as well as the monitoring of their correct application.[12] The supervision of the respect of the quality-of-service standards, the control and respect of the competition principle, the mediation service, the follow-up and control of the execution of the concession and authorization contracts, the supervision of the elaboration of the Grid Code are also part of its attribution.[8]

SMALL HYDROPOWER SECTOR OVERVIEW

Madagascar does not have an official classification of hydropower plants. Thus, this chapter uses the definition of small hydropower (SHP) as plants with capacity up to 10 MW.

The installed capacity of SHP in Madagascar is 37 MW, of which 26.3 MW is available capacity. There are currently 36 installed SHP plants, of which 25 are operational. The other 11 with a total capacity of 0.5 MW require refurbishment.[16] Twenty-six of the plants, with a total capacity of 6.62 MW, are off-grid. Compared to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity increased by 12 per cent as a result of the commissioning of three new power plants (Figure 4, Table 1). The reason for the increase of the potential figures is access to more advanced and accurate data. According to the results of a study undertaken by ESMAP, which was completed in 2017, the unexploited theoretical potential of SHP up to 10 MW in Madagascar is 799 MW, making the total potential capacity 836 MW.[3] This study was performed by SHER consultancy using their internal software SiteFinder and based on an assumption of a 50 per cent annual average flow rate.

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



Source: ESMAP,[3] *WSHPDR 2013*,[13] *WSHPDR 2016*,[14] *WSHPDR 2019*,[15] ADER[16]

Table 1. **List of Selected Operational Small Hydropower Plants in Madagascar**

Name	*Location*	*Capacity (MW)*	*Operator*	*Launch year*
Behenjy	RIA	2.00	Hydro Mado	2021
Androkabe	Androkabe	1.50	BETC Nanala	2019
Ambatomanoina	Ambatomanoina	0.10	BETC Nanala	2019
Ankazomiriotra	Ankazomiriotra	0.12	Green Power	(2009) 2018*
Amberivery	Amberivery	0.04	Association FIMJA	2017
Amboasary Nord	Amboasary Nord	0.06	AIDER	2016
Sahambano	Sahambano	0.70	ERMA	2015
Ankilizato	Ankilizato	0.10	HIER	2015
Soavina	Soavina	0.06	HIER	2015
Fandriana	Fandriana	0.56	HIER	2014
Andriba	Andriba	0.09	SERMAD	2014
Sahasinaka	Sahasinaka	0.08	ECOGEMAT	2014
Tolongoina	Tolongoina	0.06	SM3E	2013
Tsiazompaniry	RIA	5.00	HFF	2010
Maroantsetra	Maroantsetra	2.58	TOZZI GREEN	2010
Ambaravaranala	Ambaravaranala	0.04	AIDER	2010
Andriantsemboka	Andriantsemboka	0.01	AIDER	2009
Andriantsiazo	Andriantsiazo	0.01	AIDER	2009
Antetezambato	Antetezambato	0.05	ADITSARA	2003
Namorona	RIF	5.60	JIRAMA	1980

Source: ADER[16]

Note: * The plant was constructed in 2009, but is undergoing refurbishment since 2018 following destruction after a cyclone in 2017.

In addition to the existing SHP capacity, three more projects were under development as of early 2021 (Table 2).

Table 2. **List of Ongoing Small Hydropower Projects in Madagascar**

Name	*Location*	*Capacity (MW)*	*Developer*	*Planned launch year*	*Stage of development*
Bealanana	Bealanana	0.40	HIER	2021	95%
Sahatona	Sahatona	1.60	HIER	2021	95%
Maheriara	Maheriara	0.70	BETC Nanala	2022	80%

Source: ADER[16]

Several aspects hamper SHP development in Madagascar. Thus, turbine manufacturing is not yet well-developed in the country and most turbines are still imported, which increases the cost of project implementation. The maximum power of locally manufactured turbines is 100 kW, but their efficiency is not entirely satisfactory. Additionally, rainfall reference stations do not cover the entire territory and geographical interpolations are often required, which introduces error. The hydrological monitoring of the rivers and streams, on which SHP plants are developed, is insufficient. In fact, it is often the case that daily monitoring is organized at the time of the elaboration of the feasibility studies and subsequently stops when the services of the consulting firms hired to carry them out are completed.

Exchange with countries already advanced in turbine manufacturing and related technology transfer is strongly recommended to further develop the sector in Madagascar. In connection with the implementation of the SHP development programme, hydrological monitoring with the installation of rain gauges should be carried out at the sites planned for development and should be continuous even if the plant is already in operation.

SMALL HYDROPOWER PROJECTS AVAILABLE FOR INVESTMENT

As of early 2021, the following SHP projects were at an advanced stage of study and ready for development. They have been identified in the Indicative Regional Development Plans. The selection of operators for their development is subject to a call for tender.

Table 3. **List of Small Hydropower Plants Available for Development in Madagascar in 2021**

Name	*Location*	*Potential capacity (MW)*	*Head (m)*	*Type of site (new/refurbishment)*
Belaoko Lokoho	Belaoko Lokoho	8.0	48.0	New
Andriamanjavona	Andriamanjavona	1.3	73.0	New
Angadanoro	Angadanoro	3.3	38.7	New
Mandalobe	Mandalobe	0.6	26.6	New
Ampasimbe	Ampasimbe	0.7	61.0	New

Source: ADER[16]

RENEWABLE ENERGY POLICY

Madagascar has ratified the Paris Agreement on climate change through Law 2016-019 and is currently developing a national strategy for each sector.[17] For the energy section, a consultation with all stakeholders was organized in February 2021. The Letter of Energy Policy 2015–2030 remains the official document containing quantified objectives in terms of renewable energy use.[18] The objective is to have an 85 per cent share of renewable energy sources in the energy mix by 2030, of which 75 per cent is to come from hydropower, 5 per cent from solar power and the remaining 5 per cent from wind power. To achieve this energy mix target, in 2015 the Government launched a call for tenders for the development of two hydropower plants: the Volobe project with a capacity of 120 MW and the Sahofika project of 205 MW.[19,20] As of early 2021, the future concessionaire had already been selected and the negotiations on the purchase contract and the concession contract were underway. In addition, the Government, which was elected in 2019, has set a target of doubling renewable energy capacity from 400 MW to 800 MW by 2023 and achieving a 50 per cent electricity access rate, including 40.8 per cent access in rural areas, where 80 per cent of the population lives. In rural areas this is to be achieved in part by the development of SHP with a total power of 35 MW until 2023, with the following phasing: 3 MW in 2021, 6 MW in 2022 and 26 MW in 2023.

According to Law 2017-020 of 10 April 2018 on the Electricity Code of Madagascar, tariffs should reflect costs. In the case of distribution to end customers, tariff setting must take into account the customers' ability to pay and the operator's financial equilibrium. This law also contains incentives for the use of renewable energy by providing for tax breaks. But the clauses on these measures are referred to in the finance law. In practice, these measures consist of customs duty exemptions and VAT exemptions. In the case of injection into the grid, priority is given to energy from renewable sources.

With regard to the price per kWh, the tariff applied on the national grid varies according to the energy source, with four tariff zones being distinguished. This difference can also be seen in the tariffs applied in isolated networks, where no standardization is carried out, but the fact remains that localities supplied by hydropower find their tariffs more affordable compared to localities served by other sources.

The development of a hydropower plant takes a long time and is not always in line with the promises made by candidates at election time. The elaboration and implementation of a multi-annual development programme for hydropower plants can contribute to policy decisions on SHP. Currently, a national electricity access strategy is being developed, and such a programme should be derived from this document as soon as it is finalized.

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

For the moment, the Government has not yet issued a specific policy for the development of SHP in the country. Concerning the existing regulations, a clear evolution is apparent since the adoption of Law 2017-020 compared to the former Law 98-032.[21] This is particularly the case for new thresholds of capacities submitted to each regulatory regime. For example, under the old law, an SHP plant of more than 150 kW would be classified under the concession regime, whereas under the new law this limit has been raised to above 5 MW. Currently, hydropower plants with a capacity of less than 500 kW are subject to the declaration regime and those between 500 kW and 5 MW fall under the authorization regime.

The awarding of a contract may be the result of a call for tenders launched by the Government or of an unsolicited application. Whatever the applicable regime, any developer must sign a contract with the Government represented by the Minister of Energy and Hydrocarbons or ADER as the case may be. According to the Electricity Code, an environmental study is mandatory before developing a project, with the requirements depending on the categorization of the project, as determined by the National Environmental Office.

COST OF SMALL HYDROPOWER DEVELOPMENT

The average cost of SHP development in Madagascar can be estimated at 3,278 USD/kW. This estimate is deduced from three power plants with capacities of 1.3–8 MW.[13] It should be noted that estimating cost per GWh generation remains difficult to produce. For SHP plants of 60–100 kW, out of the six projects already completed, the average cost is 3,632 USD/kW. It should be noted that these estimates only account for the generation, but not transmission and distribution costs.

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

Currently, there is no fund dedicated specifically to the development of SHP in Madagascar. The National Fund for Sustainable Energy (FNED), created by Law 2017-021 of 19 December 2017 is dedicated to financing projects focused on the use of renewable energy, of which SHP is a part, and energy efficiency. However, the fund is not yet functional.[22] The absence of a development bank in Madagascar also makes it difficult for project developers to obtain loans.

To date, most of the SHP projects carried out have been partly financed by the European Union, KfW, the German Agency for International Cooperation (GIZ), the United Nations Industrial Development Organization (UNIDO) or by foundations receiving grants from the environment or climate change funds. Projects are initiated either by the Government or by non-governmental organizations (NGOs). For the time being, the fund managed by UNIDO through the project Improving Access to Energy for Productive Use from Small Hydropower Plants in Rural Areas in Madagascar is the only one dedicated to activities related to SHP development in Madagascar. For SHP projects in rural areas, the Government generally participates either through the National Electricity Fund or through partners in investment subsidies. The payback period is 7–10 years for projects in rural areas subsidized at 70 per cent of the initial investment.[13]

The existence of some climate change related funds or funds from the Global Environment Facility are discussed informally and at meetings, but no clear communication has reached other sectors working on mitigation, such as energy. The same is true for carbon credits, where the process is still aberrant for project developers. Awareness raising in the relevant sectors is required.

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

The hydrological regimes of rivers in Madagascar are being disrupted by climate change and the forecasts made 10-20 years ago do not correspond to reality any longer. As recently as 2020, several large hydropower plants were operating at only 10 per cent of their capacity during low-water periods. No statistics are available at the moment on the effect of climate change on energy consumption in Madagascar.

The climate crisis, leading to the disruption of hydrological regimes, can distort estimates. Water availability due to exponential forest degradation, at a rate of one million hectares in 13 years (between 2004 and 2017), hampers the development of SHP in the country.[23] Environmental protection must be effective, including reforestation campaigns carried out with careful monitoring. The protection of the watersheds of each SHP project is among the priorities, with accompanying measures for stakeholders dependent on its exploitation before project implementation.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

In Madagascar, SHP development faces several key barriers, namely natural, financial, technical, communication and political ones. Importantly, the lack of a dedicated fund acts as a barrier to get projects off the ground. The effective operationalization of the FNED, with the concretization of the commitments of technical and financial partners, will contribute to the development of SHP projects. In addition, the establishment of a development bank would make it easier for project developers to obtain loans at reasonable rates. Systematic consultations with stakeholders in the energy sector during the budget and activity programme development phase related to the use of these funds will greatly contribute to the development of SHP.

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

- Turbines are mainly imported and not manufactured locally;
- Future risks associated with climate change as well as difficulty to attain hydrological estimates due to climate variability;
- Lack of a dedicated government fund;
- Insufficiency of rainfall monitoring systems in place;
- Lack of direct lines of communication for financing opportunities;
- Insufficient stakeholder consultation in the energy sector;
- Short election cycles incoherent with project development timescales.

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

- SHP has an attractive cost per kWh compared to other renewable energy sources;
- The possibility of a new multi-annual development programme for hydropower derived from the national electricity access strategy;
- The availability of resources off-grid for SHP development.

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Malawi

Gift Chiwayula, Department of Energy Affairs

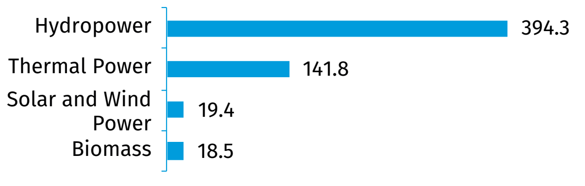
KEY FACTS

Population	19,129,952 (2020)[1]
Area	118,480 km^2 [2]
Topography	Malawi lies within the Great Rift Valley system. Lake Malawi, a body of water 580 kilometres long and lying at 460 metres above sea level, is the country's most prominent physical feature. Approximately 75 per cent of the land surface is a plateau lying at between 750 and 1,350 metres above sea level. Highland elevations rise to over 2,440 metres in the Nyika Plateau in the north and to 3,000 metres at Mount Sapitwa, the country's highest point. The lowest point is on the southern border, where the Shire River meets the Zambezi at 37 metres above sea level.[3]
Climate	The climate of Malawi is sub-tropical, with a rainy season lasting from November to April, a cool season between May and mid-August and a hot season from mid-August to November. Variations in altitude in Malawi lead to wide differences in climate, with the rainy season lasting longer in the northern and eastern mountains. Mean annual temperature is 24 °C, with average daily maximum temperatures in November reaching 29 °C, while dropping to 23 °C in July.[2]
Climate Change	In 2006, rise in average annual temperatures in Malawi was estimated at 0.9 °C over a 30-year period.[4] Several climate change models predict a countrywide increase of 1.4–3.2 °C in maximum temperature and a 1.6–2.9 °C increase in average annual temperatures by the mid-21st century, relative to the 1990s, with no significant seasonal difference in temperature rise. Over the same period, models predict a countrywide increase in annual precipitation of up to 25 per cent. On a regional level, precipitation is expected to increase in the north and decrease in the south.[5]
Rain Pattern	Precipitation is heaviest along the northern coast of Lake Malawi, where the average annual rainfall is more than 1,630 mm. Approximately 70 per cent of the country averages between 750 mm and 1,000 mm of precipitation annually.[3]
Hydrology	The main water source in the country is Lake Malawi, stretching along the eastern borders with Tanzania and Mozambique and accounting for approximately 20 per cent of the country's total area. The most significant river is the Shire (402 km), which is Lake Malawi's only outlet, flowing south into Mozambique where it meets the Zambezi.[3]

ELECTRICITY SECTOR OVERVIEW

As of June 2020, total installed capacity in Malawi amounted to 574.0 MW, of which hydropower contributed 394.3 MW (nearly 69 per cent of the total), conventional thermal power 141.8 MW (approximately 25 per cent), including 78.0 MW of emergency generators and 51.6 MW of peaking generators running on diesel, solar and wind power combined 19.4 MW (3 per cent) and thermal power from biomass 18.5 MW (3 per cent) (Figure 1). The major generating capacities are owned and operated by the Energy Generating Company (Malawi) Limited (EGENCO), with emergency generators, peaking generators and a number of other facilities including plants utilizing renewable energy sources (RES) operated by smaller private entities.[6,7,8,9,10]

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



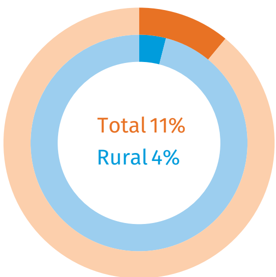
Source: Taulo et al.,[6] Chiwayula,[7] EGENCO,[8] Ministry of Finance, Economic Planning and Development,[9] USAID[10]

In 2019, annual electricity generation reached 1,887 GWh, a slight increase from the 1,808.6 GWh and 1,792 GWh generated in 2017 and 2018, respectively. However, in 2020 generation decreased across the country, with monthly generation in March 2020 only reaching 139.3 GWh, experiencing a steady decline from the 160.3 GWh generated in July 2019. As the overwhelming majority of electricity generation in

Malawi is provided by hydropower, low water levels in Lake Malawi and reduced flow in the Shire River in the second half of 2019 were responsible for this significant decline in output. Peak electricity demand and consumption have also fluctuated in recent years, with peak demand amounting to 299.6 MW in 2019 (down from 335.3 MW in 2015) and domestic consumption equalling 568.2 GWh in 2019 (down from 766.3 GWh in 2016). The main consumers of electricity in Malawi in 2019 were industry (44 per cent of total) and domestic users (36 per cent), with general use consumption (19 per cent) and exports (1 per cent) making up the remainder. At the same time, the number of individual consumers connected to the grid has more than doubled over the last decade, from 205,045 in 2011 to 439,187 in 2019. The Integrated Resource Plan developed by the Government of Malawi projects that peak demand will reach 1,158 MW by 2025 and 1,873 MW by 2030.[9]

In 2019, access to electricity decreased to just over 11 per cent nationally (4 percent in rural areas), from 18 percent (11 per cent rural) in 2018 (Figure 2).[11] Even for those with electricity access, supply is erratic and subject to frequent shortages and outages due to load shedding. The Government of Malawi has been looking to tap small-scale off-grid RES plants including solar power, wind power and small hydropower (SHP) to meet electricity demand in isolated areas where grid extension is difficult, aiming to increase nationwide access to electricity to 30 per cent by 2030.[9,12]

Figure 2. **Electrification Rate in Malawi in 2019 (%)**



Source: World Bank[11]

Electricity generation in Malawi is primarily carried out by EGENCO, created after the unbundling of the Electricity Supply Cooperation of Malawi (ESCOM). ESCOM, which previously was the sole provider of on-grid electricity in Malawi, has been unbundled into three companies, with EGENCO responsible for generation and operating all the major hydropower plants in the country. Power Market Limited (PML) is responsible for buying the generated electricity and ESCOM itself is responsible for transmission and distribution. Additionally, some generation is carried out by independent power producers (IPPs) that include Mulanje Hydro Limited as well as Aggrekko, which operates the emergency diesel-fuelled generators.[7]

Electricity tariffs differ depending on the type of customer and the phase supply being used and are lower than the tariffs in the South African Development Community (SADC) region and other neighbouring countries. The tariffs are regulated by the Malawi Energy Regulatory Authority (MERA), which is also the main regulator of all other fuels.[13] Tariffs for domestic, commercial and industrial users as of 30 March 2020 are displayed in Table 1.

Table 1. **Electricity Tariffs in Malawi in 2021**

Type of customer	*Description*	*Tariff (USD/kWh)*
Domestic	Single phase supply	0.0978
	Three phase supply	0.1420
Commercial	Single phase supply	0.1471
	Three phase supply	0.1627
Industrial	On-peak	0.1790
	Off-peak	0.0621

Source: ESCOM[14]

The Government of Malawi is making efforts to increase the capacity of generated electricity through upgrades to existing power plants and the construction of new ones, planning to increase annual generation to 3,300 GWh by 2030. Feasibility studies are currently underway for various energy sources, including hydropower, coal, biomass, geothermal power and wind and solar power. As of 2020, the Government had signed 11 power purchase agreements (PPAs) with developers to install an additional 328 MW of capacity by 2027. Plans are also underway to connect to the Zambian and Tanzanian power grids, providing investors with access to regional power markets including the Southern Africa Power Pool (SAPP). Programmes such as the Malawi Rural Electrification Programme (MAREP) and Malawi Electricity Access Project (MEAP) are ongoing with the aim of expanding electricity access in both rural and urban areas.[8,9]

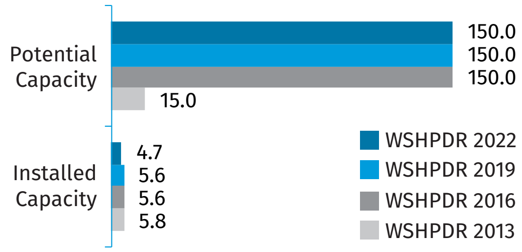
In general, the electricity sector in Malawi faces many challenges, including lack of IPPs and lack of financial resources and clear policy guidelines to promote private investors in the electricity sector. Additionally, shifting weather patterns have been creating instability in hydropower generation, requiring the procurement of emergency diesel generators in order to meet demand. In 2013, the Millennium Challenge Corporation provided the Government of Malawi with funds totalling USD 350.7 million in order to help overcome some of these challenges.[15]

SMALL HYDROPOWER SECTOR OVERVIEW

In Malawi, SHP is defined as hydropower plants with an installed capacity of less than 5 MW. As of 2021, total installed capacity for SHP plants under 5 MW in Malawi was approximately 4.7 MW, while SHP capacity up to 10 MW was 12.9 MW.[7,16,17,18] Based on studies of previous years, proven SHP potential amounts to at least 7.7 MW and theoretical potential has been estimated at 150 MW.[19,20] This indicates that approximately 4 per cent of the country's known theoretical SHP potential has been developed so far. Compared to data from the *World Small Hydropower Development Report*

(WSHPDR) 2019, the installed capacity for SHP up to 5 MW has decreased marginally as more precise data on operational plants became available and also due to the replacement of older SHP plants with a new SHP plant of over 5 MW installed capacity.[21]

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



Source: Ministry of Energy and Mining,[3] Taulo et al.,[6] Chiwayula,[7] Gilkes,[16] Ministry of Energy,[17] Jonker Klunne,[18] Kaunda et al.,[19] *WSHPDR 2019*,[20] *WSHPDR 2013*,[21] *WSHPDR 2016*[22]

Note: Data for SHP up to 5 MW.

As of 2021, the Wovwe SHP plant in Karonga is the only grid-connected SHP under 5 MW operating in Malawi, with an installed capacity of 4.35 MW.[23] The 8.25 MW Ruo-Ndiza SHP plant in Mulanje, another grid-connected power plant that falls under the up to 10 MW definition of SHP, was operational as of 2020 and is the largest SHP project in Malawi. The plant, located at the Lujeri Tea Estates, replaced two old SHP plants of 0.84 MW and 0.46 MW at the same location.[16,18] Additionally, several mini- and micro-hydropower plants are operational on isolated mini-grids, including two plants of 60 kW and one 100 kW plant that are part of the Mulanje Electricity Generating Agency (MEGA) mini-grid in Bondo, the 70 kW Chipopoma SHP plant and the 10 kW Kavuzi SHP plant.[17,24,25] Operational SHP plants are listed in Table 2.

Ongoing SHP development includes the construction of another 4.5 MW power plant at the Wovwe site to bring the total installed capacity of the plant to 9.5 MW.[23] Additionally, upgrades have been planned to the MEGA group of SHP plants by a non-governmental organization called Practical Action to bring the entire network to 2 MW of capacity. Components of the Practical Action programme originally included the development of several new SHP plants of up to 500 kW capacity, aiming to reach an annual SHP generation target of 15.6 GWh, with funding provided by the Global Environment Facility (GEF) and the Government of Scotland. Completed upgrades have brought the MEGA mini-grid to its current capacity of 220 kW. Also, a grant was awarded by EEP Africa to Practical Action to develop an SHP plant at Usingini with an initial planned capacity of 300 kW and a total potential capacity of 5 MW. However, Practical Action has recently reduced its presence in Malawi and additional MEGA upgrades as well as the Usingini project have been delayed, with the latter in advanced stages of planning.[7,17,24] Ongoing SHP projects are listed in Table 3.

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

Name	*Location*	*Capacity (MW)*	*Head*	*Plant type*	*Operator*	*Launch year*
Ruo-Ndiza	Mulanje, Lujeri Tea Estate	8.250	230	Run-of-river	Mulanje Hydro Ltd	2020
MEGA 3	Bondo, Mulanje	0.100	N/A	Run-of-river	MEGA LTD	2019
Kavuzi	Nkhatabay	0.010	N/A	Run-of-river	Kavuzi Electricity Generation and Supply Association	2018
MEGA 2	Bondo, Mulanje	0.060	N/A	Run-of-river	MEGA LTD	2016
Chipopoma	Mantchewe, Livingstonia	0.070	N/A	Run-of-river	Community-owned	2015
MEGA 1	Bondo, Mulanje	0.060	50	Run-of-river	MEGA LTD	2011
Wovwe SHP	Karonga	4.350	N/A	Run-of-river	EGENCO	1996

Source: Chiwayula,[7] Gilkes,[16] Ministry of Energy,[17] Jonker Klunne,[18] EGENCO,[23] MEGA,[24] GEF SGP[25]

Note: SHP plants of up to 10 MW.

Table 3. **List of Ongoing Small Hydropower Projects in Malawi**

Name	*Location*	*Capacity (MW)*	*Head (m)*	*Type of plant*	*Developer*	*Planned launch year*	*Development stage*
Wovwe II	Karonga	4.5	N/A	Run-of-river	N/A	2023–2023	Feasibility study completed
Usingini	Nkhatabay	5.0	150	Run-of-river	N/A	N/A	Feasibility study and design plans completed

Source: Chiwayula,[7] Ministry of Energy,[17] EGENCO[23]

Several other previously functional SHP plants are currently out of operation, including one in Matandani maintained by the Malawi Industrial Research and Development Centre, as well as the Kongwe and Malosa SHP plants. These sites, with a total installed capacity of 358 kW when operational, could be potentially refurbished. Additionally, the Malawi Rural Electrification Programme (MAREP) Master Plan Study carried out by the Japan International Cooperation Agency (JICA) identified 33 potential SHP sites, including 11 promising sites with a total estimated potential capacity of 345 kW.[7,18,26] Several potential sites for SHP plant construction or refurbishment are listed in Table 4.

Table 4. **List of Selected Potential Small Hydropower Sites in Malawi**

Name	*Location*	*Potential capacity (kW)*	*Type of site (new or refurbishment)*
Matandani	Neno district	28	Refurbishment
Katowo	Hewe River	45	New
Ruarwe	Lizunkhuni River	50	New
Nthalire	Choyoti River	60	New
Sandama	Nswazi River	75	New

Source: Chiwayula,[7] Jonker Klunne,[18] JICA[26]

RENEWABLE ENERGY POLICY

The new National Energy Policy (NEP) of Malawi, issued in 2018, and the Malawi Renewable Energy Strategy, developed in 2017, both provide for the development of RES in the country. The 2018 National Energy Policy aims to increase hydropower capacity, extend the national grid as well as expand the implementation of mini-grids in remote areas based on hydropower generation. Increases in hydropower capacity and output are to be achieved through the construction of new plants by IPPs as well as upgrades to existing plants. While hydropower is expected to provide the bulk of the country's generation, the Policy also outlines diversification into other energy sources including solar power, wind power and coal.[27]

The Malawi Renewable Energy Strategy includes the following elements:

- Incentives for RES technologies including tax waivers, which have been put in place starting with the 2020/2021 fiscal year to reduce the cost of RES development;
- Promotion of research and development in RES and increasing the number of undergraduate and graduate courses in RES offered by technical universities in Malawi, as well as training programmes in RES offered by other stakeholders;
- Awareness campaigns by various media organizations to promote RES;
- Establishment of the Malawi Renewable Energy Partnership Group (MREPG) in 2018 to oversee the implementation of RES projects in Malawi and provide coordination for RES stakeholders;
- The implementation of feed-in tariffs (FITs) and a PPA framework for RES, still in development stages.[28]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

SHP development in Malawi is covered by regulations applied to hydropower in general, outlined in the National Energy Policy. Legislation on hydropower in Malawi differentiates between grid-connected and stand-alone (off-grid) projects. In the case of grid-connected projects, the developer is given the generation licence only, after meeting the necessary technical, safety and environmental requirements, which include an environmental impact assessment. Power from grid-connected hydropower IPPs is sold to Power Market Limited and distributed exclusively by ESCOM. In the case of off-grid projects, hydropower plants (including SHP plants) can operate as a mini-grid where the developer is given generation, transmission and distribution licences after meeting the necessary requirements. Some of the requirements are that the system should be of the same standard as the main grid for easy integration and sell electricity at a tariff approved by the Malawi Energy Regulatory Authority.[27,28]

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

Financial support for SHP development in Malawi is provided by a variety of international and local entities. International organizations providing funding for SHP have included the World Bank, the United Nations Development Programme (UNDP), the European Union Energy Facility, the Organization of the Petroleum Exporting Countries (OPEC) Fund for International Development and the Global Environmental Facility Small Grants Program (GEF SGP).[7,17,24,25] Bilateral support for RES and hydropower development has been provided by the United States Government through the United States Agency for International Development (USAID) and the Millennium Challenge Corporation (MCC), while the Japan International Cooperation Agency (JICA) and the Scottish Government have supported projects specifically focused on SHP.[10,15,26] Local funding for SHP has also been provided by the Ministry of Energy as well as by private investors and international non-governmental organizations with a presence in the county.[17]

COST OF SMALL HYDROPOWER DEVELOPMENT

Costs of SHP development in Malawi have varied considerably based on project size and location. The recently commissioned Ruo-Ndiza 8.25 MW SHP plant carried a total project cost of USD 16 million, or 1,939 USD/kW.[30] The Usigini SHP project with a preliminary capacity of 300 kW and eventual planned capacity of 5 MW was initiated with funds totalling USD 328,125 (1,093 USD/kW), but has been affected by severe delays.[17] On the other end of the spectrum, JICA's Master Plan Study for MAREP estimated construction costs of between USD 299,890 and USD 1,213,930 for 11 prospective sites of 5–75 kW, averaging between 12,629.2 USD/kW and 94,690 USD/kW.[26] From these figures it becomes clear that micro-hydropower projects in Malawi are significantly more expensive than projects in the 1–10 MW range.

EFFECT OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Malawi is heavily dependent on hydropower for electricity production and has already been experiencing severe generation shortfalls due to low water levels in Lake Malawi and the Shire River, particularly in 2020.[9] Extreme fluctuations in rainfall have also caused flooding, causing damage to hydropower infrastructure. Projections of future weather pattern changes by the mid-21st century predict an increase in rainfall in the northern part of the country (up to 40 per cent during the wet season) and a decrease in the south (up to 75 per cent during the dry season). Significantly, several climate models predicted an increase in runoff of nearly 182 per cent during the wet season in the northern part of the country and a moderate 11 per cent decline in the south.[5] These data suggest that SHP in Malawi is threatened not only by water scarcity but also by the increased likelihood of flood damage, particularly in the north.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Some of the key barriers to SHP development in Malawi include:

- The lack of investors to develop SHP due to limited financing capacity;
- Environmental degradation, with deforestation from logging and farming activities upstream and near the river banks leading to rivers drying up;
- Lack of human capital to build and operate SHP plants in Malawi;
- Lack of information and awareness among communities on the benefits of SHP;
- Old electricity infrastructure vulnerable to extreme weather events;
- Vandalism of infrastructure such as transformers.

Enablers for SHP development include:

- Acute demand for additional generation capacity due to very low electrification rate in the country;
- Availability of financing mechanisms;
- Tax exemption on all RES equipment;
- Availability of detailed data on potential SHP sites and large untapped SHP potential;
- Existing political will to develop the energy sector.

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Mauritius

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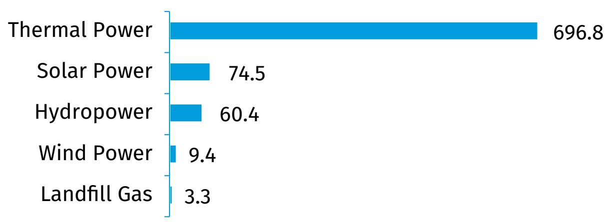
KEY FACTS

Population	1,265,475 (2019)[1]
Area	1,868 km^2 [1]
Topography	The island, located in the south-west of the Indian Ocean, was formed by volcanic activity. It has sandy beaches and fringing coral reefs, which surround most of the 322 kilometres of its coastline. The topography is categorized by undulating plains in different parts of the island and the highest point is 828 metres, which is located at Petite Riviere Noire.[2,3]
Climate	Enjoying a mild and tropical weather, the climate in Mauritius is divided into two seasons, namely summer and winter. Summer is warm and humid and it runs from November to April and winter is cool and dry lasting from June to September. October and May are the transition months. The mean temperature during summer is 22.7 °C; the climate is moderately hot and moist. During the winter the average temperature is 18.7 °C, with a relatively chilly and drier climate.[4,5]
Climate Change	Observed climate change impacts have indicated a warming trend on the island, with the average temperature at all stations rising at the rate of 0.15 °C per decade and has already risen by 0.74 1.2 °C when compared to the 1961-90 long term mean. Meanwhile a diminishing trend in annual rainfall has also been shown. In spite of the decreasing number of rainy days, the recurrence of extreme climate events, overwhelming downpours and storms with strengths equivalent to tropical cyclones or higher has expanded over the last two decades. Future projections of climatic changes anticipate a decrease of approximately 10 20 per cent in rainfall and a temperature increase of 2 °C.[2,4,6]
Rain Pattern	The annual precipitation for the year 2020 was approximately 1,993 mm, indicating a decrease by 6 per cent from 2019. The annual average rainfall from 1971 to 2000 amounted to 2,010 mm. Despite no fixed rainfall period, rainfall generally occurs during summer months, with an annual average summer rainfall of 1,322 mm (1971–2000). In the winter season, the annual average rainfall is 666 mm.[4,7]
Hydrology	The hydraulic system of Mauritius is composed of 20 main rivers with the Grand River South-East, located in the central-eastern region, having the longest length of approximately 28 kilometres. Other primary waterways include the Black River, Post River, Grand River North-west and Rempart River. Mauritius also has a few waterfalls and 10 main man-made reservoirs. The reservoirs amount to a total capacity of approximately 67.4 m^3.[2,8]

ELECTRICITY SECTOR OVERVIEW

In 2019, the total power plant installed capacity in the island amounted to 844.3 MW (Figure 1), while the total effective capacity was 771.9 MW. Electricity generation in 2020 reached 2,882 GWh (Figure 2), with the peak power demand reaching 494 MW.[9] The bulk of electricity production in Mauritius comes mainly from fossil fuels, namely coal and oil, followed by renewable energy sources including bagasse, hydropower, solar power, wind power and landfill gas. In 2020, coal and oil represented 76 per cent in the electricity production mix and the rest (24 per cent) was met by renewable energy at 688 GWh.[8] Hydropower represented approximately 4 per cent of all generation, at 115.8 GWh.[7]

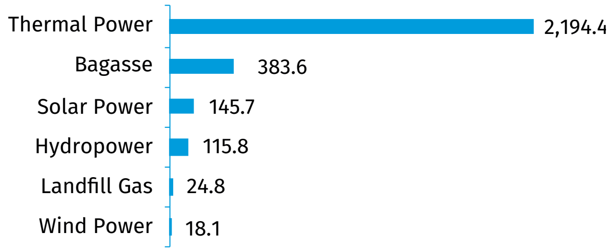
Figure 1. **Installed Electricity Capacity by Source in Mauritius in 2019 (MW)**



Source: MREPU,[9] CEB[15]

Note: According to MREPU, bagasse is included in the thermal installed capacity figures.

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



Source: CSO[7]

In the 1950s, the state-owned Central Electricity Board (CEB) was the only entity responsible for generating, transmitting and distributing electricity across the island until the sugar industry-affiliated power plants initiated the sale of electricity produced from bagasse to the CEB. This initiative was further encouraged by the Bagasse Energy Development Programme (BEDP) in 1991 and the Multi-Annual Adaptation Scheme 2006–2015.[10] Today, electricity in Mauritius is produced by the CEB and Independent Power Producers (IPPs). The share of the CEB's production in 2019 was 45 per cent, while the remaining 55 per cent was purchased from IPPs, which are mainly from the sugarcane industry.[8]

Mauritius has achieved an electrification rate of 100 per cent. The national rural electrification programme was established in 1983, allowing the connection of 153 villages and housing estates to the grid network. With an enlarged economy, Mauritius now enjoys extensive power provision infrastructure and the advantages of a steady power supply.[11]

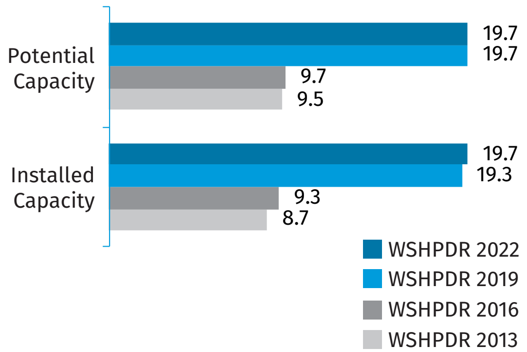
For most power projects, the Government of Mauritius looks for competitive international bids and favours collaboration between regional private bodies and international organizations. In 2017, the CEB Act (1963) was amended to permit CEB (Green Energy) Co Ltd, an entirely owned subsidiary of the CEB, to participate in power generation from renewable energy sources.

In 2019, the CEB's tariff programme had 24 different types of tariffs, ranging from 3.16 MUR/kWh (0.074 USD/kWh) for low-end residential consumers to a flat rate tariff of 10.01 MUR/kWh (0.023 USD/kWh) for commercial energy users.[12] It should be noted that special consideration has been made on social grounds for household electricity consumption. For instance, the Social Tariff 110A is applicable to households receiving the government social allowance, registered as socially vulnerable or registered under Tariffs 110 and 120 (excluding small-scale distributed generation owners) and meeting the required monthly consumption conditions.[13] However, it should be noted that electricity tariffs are not wholly cost-effective in Mauritius as industrial tariffs are subject to cross-subsidization. With no independent power utility regulator, the CEB is solely responsible for setting the tariffs. For this reason, proper planning is required for restructuring the tariff system, emphasizing the need for cost-effective production during capacity expansion.[14]

SMALL HYDROPOWER SECTOR OVERVIEW

There is no formal definition of small hydropower (SHP) in the country. This chapter uses the 10 MW definition. In 2020, the installed capacity of SHP in Mauritius amounted to 19.69 MW, indicating an increase of 0.35 MW compared to the *World Small Hydropower Development Report (WSHPDR) 2019* (Figure 3). The known potential capacity has not changed, indicating that the full known SHP potential has been exploited in the country. At present, there are 11 SHP plants including the recent Bagatelle Dam, which was commissioned in 2019 (Table 1). All SHP plants in the country, except for Riche en Eau and Bois Cherie, are owned by the CEB.

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



Source: CEB,[15] MEPRU,[16] WaterPower Magazine,[17] Bowers et al.,[18] *WSHPDR 2013*,[19] *WSHPDR 2016*,[20] *WSHPDR 2019*[21]

Apart from the Bagatelle Dam, Midlands Dam and La Nicoliere, the operational lifetime of the remaining SHP plants exceeds 50 years. The most ancient is the Reduit (now A.I.A.) SHP plant, which was established in 1906 but refurbished in 1984. Major hydropower refurbishments projects included the refurbishment and upgrading of the generating unit in the Magenta plant, which was expected to be completed by November 2019 (Table 2).[15] Although not an SHP project as such, but rather a project to increase the capacity of the 28 MW Champagne hydropower plant, the Sand Souci dam is to be fitted with a labyrinth type fuse gate, effectively increasing the generation of the nearby plant by 3 GWh.[22]

Table 1. **List of Operational Small Hydropower Plants in Mauritius**

Name	Capacity (MW)	Head (m)	Plant type	Operator	Launch year
Bagatelle Dam	0.35	–	Run-of-river with dam storage	CEB	2019
Midlands Dam	0.35	–	Run-of-river with dam storage	CEB	2013
La Nicoliere	0.35	–	–	CEB	2010

Name	Capacity (MW)	Head (m)	Plant type	Operator	Launch year
La Ferme	1.20	127	Run-of-river	CEB	1988
Le Val	4.00	183	Run-of-river with dam storage	CEB	1961
A.I.A (previously Reduit)	1.20	50	Run-of-river	CEB	1984
Ferney	10.00	123	Run-of-river	CEB	1971
Cascade Cecille	1.00	76	Run-of-river	CEB	1963
Magenta	0.94	45	Run-of-river with dam storage	CEB	1960
Riche En Eau	0.20	–	–	Private	–
Bois Cherie	0.10	–	Run-of-river with dam storage	Private	–

Source: CEB,[15] MEPRU,[16] WaterPower Magazine,[17] Bowers et al.[18]

Table 2. **List of Planned Small Hydropower Projects in Mauritius**

Name	*Location*	*Capacity (MW)*	*Head (m)*	*Plant type*	*Developer*	*Planned launch year*	*Stage of development*
Magenta	–	0.94	45	Run-of-river with dam storage	Andritz Hydro SA	2022	Refurbishment

Source: MEPRU[16]

A full feasibility study determining potential SHP sites for setting up mini- and micro-hydropower plants is yet to be completed. There is a debate around whether the country's hydropower potential has been entirely exploited, as one modelling exercise claimed that full potential has been reached, whereas proponents of SHP in the country contested this study, arguing that "the predictions did not fully consider mini- and micro-hydropower plants, which have gained momentum and been helpful in reducing pressure on the main grid".[10,23] The Integrated Energy Plan (2013–2022) indicated the Government's interest in developing mini- and micro-hydropower plants in viable locations. However, with the exception of the Bagatelle Dam, no other initiative was taken in this direction.

RENEWABLE ENERGY POLICY

In 2008, the Government brought forward the Mauritius Sustainable Island (MID) policy, strategy and action plan with the vision of delivering sustainable growth and making Mauritius an example of sustainable development. The objective of the MID project was to achieve 35 per cent of renewable energy generation by 2025, by exploring additional economic incentives to advance the development of renewable energy resources. In parallel to the MID plan, financial support was obtained from the Government for several renewable energy projects. These include the setting of a 9.4 MW wind farm at Plaine des Roches, which was commissioned in 2015, and the installation of solar photovoltaic farms amongst others.[24]

Following the Integrated Energy Plan (IEP) 2003–2012, it was noted that little advancement occurred in the introduction of renewable energy technologies in the country. Hence, the Government came up with the Long-term Energy Strategy 2009–2025 with the objectives to reduce dependency on fossils fuels, promote long-term sustainable development and augment the share of renewable energy in the electricity mix to 35 per cent by 2025. The renewable energy development pathway advocated laid emphasis on an increasing share of bagasse-based energy, while setting targets for fossil fuels and green energy.[16]

Another IEP (2013–2022) was adopted by the CEB with the goal of ensuring a secure electricity future in Mauritius. According to the new IEP, the CEB has already begun feasibility studies to identify potential sites for further hydropower development.[25] The master plan's pillar has been to maximize the use of the current power grid, keep energy costs down, promote demand-side management and create opportunities for the private sector. According to the IEP, a 20 MW wind power plant would be installed every three years after 2017 and a 10 MW solar power plant every three years after 2013. However, the plan to install any 20 MW wind farm is yet to be accomplished.[26]

The CEB Small-Scale Distributed Generation (SSDG) Net-Billing Scheme was announced in the 2018/19 budget speech. Under the scheme, residential customers (who consume up to 100 kWh per month and are in tariff categories 110, 120, and 140) will generate their own electricity as part of a project aimed at promoting renewable energy. The SSDG project is to be implemented in three stages over the course of three years.[27] The scheme employs a net-billing system and 2,500 residential customers will be able to receive up to 100 kWh of electricity free of charge per month for the next 20 years, depending on their consumption. Taking current tariffs into account, the selected customers consuming less than 100 kWh per month will have their electricity completely free.[22]

In the energy sector, the Government has been working on legal and structural reforms. The Mauritius Renewable Energy Agency (MARENA) was established by the Government in 2016 to encourage the use of renewable power in the island.[28] In 2019, the Government came up with the Renewable Energy Roadmap 2030 for the Electricity Sector, where bagasse is the predominant renewable resource followed by solar power, waste-to-energy, hydropower and wind power.[9] Under the 2030 roadmap, the share of hydropower in total electricity generation should decrease from 4.4 to 2.5 per cent by 2030.

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

Securing a licence of Environmental Impact Assessment (EIA) is essential for mini- and micro-hydropower projects. The Government's strategy has been to enable Small Independent Power Producers (SIPPs), whether residential, industrial or commercial, to join the electricity supply market by installing small generating units of mainly solar photovoltaics and wind power. A grid code has been implemented to allow SIPPs generating below 50 kW of electricity for their personal use to feed any excess into the national grid system. To facilitate such a scheme, government initiatives, such as removal of a standby charge on renewable energy, were introduced.[16]

COST OF SMALL HYDROPOWER DDEVELOPMENT

Data for cost estimates of SHP development in the island are not available. However, a cost of approximately MUR 7.1 billion (USD 170 million) has been estimated for the construction of a new dam of 14.3 m^3 capacity.[29] For hydropower plants in Mauritius, the levelized cost of energy is approximately 0.020 USD/kWh, including other associated costs, such as maintenance, refurbishment and upgrading of power plants.[9]

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

Funding for projects in the hydropower sector depends on the readiness of the project and the ability of the developer to implement the project. The water resources unit, under the Ministry of Finance and Economic Development, provides financing facilities in the form of grants. Estimates for the year 2017/2018 indicate an allocation of MUR 487 million (USD 11.4 million) for the construction of dams on the island.[29]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

The longer drought period and decreasing rainfall trend pose a challenge to the availability of water resources in the country and thus for SHP development.[9] However, hydropower development is not only subjected to climate effects. As a small developing island country, governmental priority is being given to water use for household consumption purposes, rather than hydropower generation.[9,30]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Compared to other power generating units, hydropower plants are flexible to fluctuating electricity network demand. Hydropower plants have the capacity to quickly increase or decrease output and can provide electricity at peak demand conditions.[18] Recommendations suggest a possible revamping of the hydropower sector in Mauritius through the deployment of mini- and micro-hydropower plants or pumped storage plants to cater to the intermittency of renewable energy sources.[9] The potentiality of further hydropower development in the island is known to be limited. Exploring mini-and micro-hydropower is still possible and the Government is keen to explore this potential across the island. The CEB has already begun feasibility studies to identify potential sites for further hydropower development. However, while revamping any hydropower facilities is possible, striking the optimum balance between hydropower uses and environmental impact on the restricted island ecosystem is essential.

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

- Only some locations possess the natural characteristics for exploitation (most cost-effective sites have been explored);
- Potable supply, agriculture and electricity generation compete for the water stored in reservoirs;
- Dependency of the technology on rainfall, while climate change is influencing rainfall patterns;
- The potential to expand the existing dam capacity is limited;
- High cost associated with hydropower plant construction;
- Lack of resources to conduct feasibility studies;
- Environmental impact of SHP.

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

- Government feasibility studies are underway to determine whether new potential will be available.

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Mozambique

Laura Stamm, International Center on Small Hydropower (ICSHP)

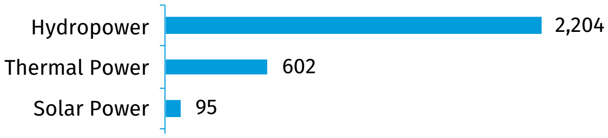
KEY FACTS

Population	32,163,045 (2021)[1]
Area	799,380 km^2 [2]
Topography	Mozambique is a topographically diverse country. The northern and western regions are predominately mountainous, while low lands cover the southern regions. There are five distinct highland regions. The Lichinga Plateau occupies the north-westernmost area along the border with Tanzania, followed by the Angonia Highlands on the north-western border with Malawi. The Maravila Highlands are found in the western pocket of land on the border with Zambia and just underneath is the Chimboio Plateau along the western border with Zimbabwe. The highest point in the country, Mount Binga at 2,436 metres, is found in the Chimboio region. The Mozambique Plateau occupies most of the northern interior, leaving a very narrow coastal plain in the north-east. In the south and south-east, where the Mozambique Plains are found, are the lowest elevations in the country, while small hills are found in the south-westernmost region.[2]
Climate	The country's climate is mostly tropical, though the south is slightly cooler than the north. The hottest temperatures, often reaching above 30 °C, are found along the north-eastern coastline especially during the summer months between December and February. The coldest temperatures, reaching 10 °C, are found in the highest altitudes along the western borders. Humidity varies greatly between regions. The northern and north-eastern regions are especially humid all year while the south is drier with a small semiarid area in the south-east.[2]
Climate Change	There has been a trend of rising temperatures in Mozambique in the past decades, which is expected to continue. The country is vulnerable to extreme weather events, particularly droughts, flooding and cyclones. These types of events have been on the increase since the 1970s. In the upcoming decades, droughts and floods are expected to become more intense and cyclones more prevalent.[3]
Rain Pattern	Rainfall varies greatly between regions and areas of the country. The northern and north-eastern regions are the wettest, with an average annual rainfall of between 1,000 mm and 1,780 mm with some pockets of over 2,000 mm. The west and southern interior receive the least rainfall, with annual averages between 600 mm and 800 mm. The semiarid region in the south-west receives an average of 300 mm in rainfall per year. The wet season throughout the country is between November and February, while the dry season is between April and October.[2]
Hydrology	Mozambique is a water-rich country. The major rivers flow eastwards from the western highlands to drain into the Mozambique Channel and Indian Ocean. The largest river in the country is the Zamebezi flowing 819 kilometres through the central region. The major rivers in the north include the Rovuma that creates the country border with Tanzania, the Messalo, Lurio and Ligonha. The major rivers in the south include the Buzi, Save, Changane and Limpopo. Rivers tend to have a seasonal flow, flooding during the end of the wet season and are slow during the end of the dry season. The largest lakes are along the border with Malawi including Lake Nyasa and Lake Chilwa.[2]

ELECTRICITY SECTOR OVERVIEW

In 2020, the total installed capacity in Mozambique was 2,915 MW. Of this, hydropower accounted for 2,204 MW (just under 76 per cent), thermal power for 602 MW (21 per cent), solar power for 95 MW (3 per cent) and biomass for 14 MW (0.5 per cent) (Figure 1).[4] The country's energy mix has been dominated by hydropower since the opening of the Cahora Bassa plant in 1974. In the past few years, the country has been diversifying into other renewable energies, with strong focus on solar power. The country's first large-scale solar power plant, with an installed capacity of 40 MW, opened in 2019 and is located in Mocuba. Shortly after, in 2020, an additional 41 MW solar power plant was commissioned in Metero by French-owned power producer, Neoen.[5]

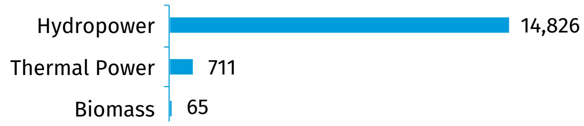
Figure 1. **Installed Electricity Capacity in Mozambique by Source in 2020 (MW)**



Source: IRENA[4]

The total electricity generated in 2019 in Mozambique was 15,603 GWh. Of this, hydropower generated 14,826 GWh (95 per cent), thermal power 711 GWh (over 4 per cent) and the last percentage was split between 65 GWh of biomass and 2 GWh of solar power (Figure 2).[4] As more recent data are not available, this does not reflect the electricity generated by the new Mocuba solar power plant which has an estimated generation capacity of 79 GWh/year.[5]

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



Source: IRENA[4]

The Electricity Law of 1997 first allowed independent power producers (IPPs) to participate in the supply of electricity in Mozambique. Prior to this, state-owned Electridade de Moçambique (EDM) was the main electricity supplier, with the exception of Hidroeléctrica de Cahora Bassa S.A. (HCB), and still holds a significant market share of electricity generation. HCB, which operates the one large hydropower plant with an installed capacity of 2,075 MW was once mostly owned by REN of Portugal, but since 2007 the majority ownership has been transferred to the Government of Mozambique, which currently owns over 92 per cent of the shares. In recent years IPPs have played an important role in the electricity sector. The largest IPPs include Central Termoelectrica de Ressano Garcia (CTRG) with an installed capacity of 175 MW, Gigawatt Ressano Garcia with 110 MW, Nacala floating powership with 102 MW, Kuvaninga with 40 MW and Aggreko with temporary contracts of 122 MW and 107 MW. As EDM is responsible for the distribution and transmission of electricity in the county, these IPPs operate within power purchase agreements (PPAs) with EDM.[6]

The Ministry of Natural Resources and Energy (MIREME) is responsible for supervising operation and development in the electricity sector. The Energy Regulatory Authority (ARENE) is the organization responsible for regulating the sector. EDM makes the final approval of tariffs for end customers. Different tariffs are determined for five different types of consumers: low voltage, major consumers of low voltage, medium voltage, agriculture medium voltage and high voltage.[6] Social tariffs with a special rate are provided for some low-voltage customers for 0.97 Mt/kWh (0.015 USD/kWh). The regular tariffs prices for all other customers are listed in Table 1.[7]

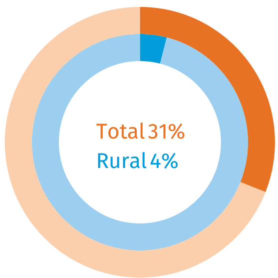
Table 1. **Electricity Tariffs in Mozambique**

Type of consumer	*Tariff (MZN/kWh (USD/kWh))*
Low voltage households:	
< 200 kWh	6.00 (0.094)
200–500 kWh	8.49 (0.130)
> 500 kWh	8.91 (0.140)
Major low voltage	5.74 (0.090)
Medium voltage	4.78 (0.075)
Medium voltage (agricultural)	2.72 (0.043)
High voltage	4.70 (0.074)

Source: EDM[7]

The electrification rate of Mozambique in 2020 was just under 31 per cent, which includes an urban rate of 75 per cent and a rural rate of just above 4 per cent (Figure 3).[8] The current policy objectives of the Government and EDM are focused on rural electrification and increasing the number of new users on a continuous basis. While many extensions have been carried out since 2007, there is still much to be accomplished in order to meet targets. The most recent national plans include targets of reaching a 50 per cent electrification rate by 2023 and universal access by 2030. To push this agenda, the Government of Mozambique partnered with the World Bank to draw up the National Electrification Plan in 2018. As a result of the plan, the World Bank approved a USD 82 million direct grant along with a USD 66 million grant through a Multi Donor Trust Fund (MDTF) to expand and densify the national grid and implement off-grid solutions in some remote places.[9]

Figure 3. **Electrification Rate in Mozambique in 2020 (%)**



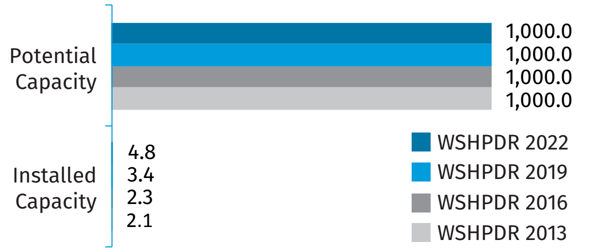
Source: World Bank[8]

Improving infrastructure quality is another main focus in the energy sector. Due to structural inefficiencies and far distances between generation and consumption, distribution and transmission losses are substantial. In 2017, losses amounted to approximately 26 per cent. In response, projects to strengthen the transmission network have been undertaken and will continue to be important. Furthermore, the current capacity will not be sufficient to bring electricity to the whole population. To address this, several sites have been identified for future projects. Many of the large-scaled projects are with hydropower, namely Mphanda Nkuwa (1,500 MW), HCB North bank (1,245 MW), Lupata (600 MW), Boroma (200 MW) and Lurio (120 MW). Solar power projects are also substantial, including 43 on-grid projects that amount to 599 MW and 343 smaller off-grid projects to bring electricity to remote communities.[6]

SMALL HYDROPOWER SECTOR OVERVIEW

In Mozambique, small hydropower (SHP) is classified as plants with an installed capacity up to 10 MW.[10] In 2017, the total installed capacity of SHP up to 10 MW was at least 4.77 MW, while the total potential capacity of SHP is estimated to be 1,000 MW.[6,11] Compared to the *World Small Hydropower Development Report (WSHPDR) 2019,* installed capacity has increased by 1.4 MW due to new information and the potential capacity has remained the same (Figure 4).

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



Sources: ALER,[6] *WSHPDR 2019,*[11] *WSHPDR 2016,*[12] *WSHPDR 2013*[13]

The country's greatest hydropower potential lies in the Zambezi River basin at sites such as Cahora Bassa North and Mphanda Nkuwa. The overall hydropower potential in the country is estimated to be approximately 19,000 MW.[14] Much of the potential is large hydropower, but at least 5 per cent of it is SHP. Most of the SHP already installed is below 1 MW, with the exception of Pequenos Libombos (1.5 MW) and Cuamba (1.1 MW) (Table 2).[6]

Table 2. **List of Selected Existing Small Hydropower Plants in Mozambique**

Name	*Installed capacity (MW)*	*Operator*
Pequenos Libombos	1.50	IPP
Cuamba	1.10	EDM
Lichinga	0.76	EDM
Rotanda	0.63	FUNAE
Majaua	0.60	FUNAE
Muôha	0.10	FUNAE
Sembezeia	0.06	FUNAE
Chiuraírue	0.02	FUNAE

Source: ALER[6]

SHP plants in Mozambique are particularly concentrated in the centre of the country, more specifically in the Provinces of Manica, Tete and Zambézia. The main players involved in the SHP sector are EDM and the country's Energy Fund, FUNAE. There are additional SHP plants with capacities below 30 kW that were funded and provided technical assistance by the German Corporation for International Cooperation (GIZ) and are operated by local private entities. Some non-governmental organizations including Practical Action and the Association Kwaedza Simukai Manica (AKSM) have also been involved in the funding and execution of other SHP projects.

FUNAE is a publicly owned organization that focuses on small, low-cost power solutions particularly for rural or remote areas. In addition to establishing five SHP plants, the organization also carries out feasibility studies for potential SHP projects with the aim to be invested in by private entities. A feasibility study for a Mavonde SHP project of 0.90 MW was carried out, approved and will begin construction once funds become available. Studies for SHP plants in Berua and Luaice have also been conducted, but no further progress has been announced.[6] SE4ALL, in collaboration with the African Development Bank, has expressed interest in aiding the investment in the creation of green mini-grids to be located in remote areas of Mozambique, which includes power from SHP. An in-depth assessment was made in 2017 that identified hundreds of potential SHP sites in eight provinces with a combined capacity of over 672 MW. These mini-grids along with others from solar power and biomass could bring electricity to 22 per cent of the total population, especially to the hardest to reach communities. To implement these projects, partnerships with international companies, banks and organizations would be necessary.[6]

RENEWABLE ENERGY POLICY

Mozambique is a country rich in natural resources with vast potential for renewable energy including 23,000 MW of solar power, 19,000 MW in hydropower, 4,500 MW of wind power and 2,000 MW of biomass. Harnessing these potentials would not only provide enough energy for the domestic population, but would produce a surplus that could be exported to surrounding countries.[14] Recent national plans routinely mention the development of renewable energy as a priority. The Five Year Plan 2015–2019 discussed the use of renewable energy to obtain other social development goals, such as increasing the electrification rate to 33 per cent by 2019 by increasing hydropower and solar power in rural areas and using solar power to electrify schools and health centres.[6] The actual national electrification rate in 2019 was slightly more than 29 per cent, indicating that this goal was missed by 4 percentage points.[8] The Energy Strategy published in 2015 in conjunction with the World Bank put forth the goal for the national electrification rate to reach 50 per cent by 2023 and 100 per cent by 2030. As of 2020, the country was still 19 percentage points away from reaching the goal in the three following years.

Some of the legal framework for foreign investment and renewable energy is currently undergoing review. The applicable laws presently in place are the Investment Law (Law 3/1993 and Decree 43/2009), Electricity Law (Law 21/1997, Decree 8/2000 and Decree 42/2005), Energy Policy (Resolution 5/1998 and Resolution 10/2009) and Private Public Partnership Law (Law 15/2011 and Decree 12/2012).[11] In 2021, the Government passed regulation framework for off-grid energy production to encourage private sector involvement in installing mini-grids in remote areas in hopes to accelerate electrification of these areas.[15] As of March 2022, the Government proposed, but not yet fully approved, an update of the Electricity Law that would also encourage private investments in the sector and make a more competitive environment.[16] As financial support to make the necessary enabling conditions for private sector investments, Sustainable Energy Fund for Africa (SEFA) approved a USD 740,000 grant in 2015 for technical assistance to do so.[16]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

The National Water Policy (PNA, 1995) stipulates that hydropower installations are required to have a water use concession. In addition, the 1995 policy used two mechanisms for implementation, the Rural Water Transition Plan and the Implementation Manual for Rural Water Projects (MIPAR). In 2007, the PNA was revised and became the Water Policy (PA). The revision was aimed at meeting the United Nations Millennium Development Goals and included private investment in local water management and utilization. The Water Policy mentions the use of water resources for standalone and dam-connected hydropower purposes and states that small- and medium-scale hydropower facilities should be encouraged for off-grid electricity generation in remote areas, extension of the national electricity grid production and transmission capacity, as well as economic development in general.[11]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The challenges hindering the development of SHP in Mozambique include:

- Lack of a consolidated legal framework;
- Absence of a strategy defining governmental investment plans for hydropower plants;
- Limited information about the number and location of the existing plants as well as potential sites;
- Lack of local technologies;
- Underdeveloped market.

The factors encouraging SHP development in Mozambique include:

- Over 995 MW of SHP potential is untapped which offers considerable technical opportunities;
- Access to electricity in the country is still far from universal, especially in rural or remote areas. SHP development in remote areas can bring electricity to communities that have been without;
- Government plans favourable to SHP development.

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Réunion

Gaelle Gilboire, Energie Réunion

KEY FACTS

Population	868,846 (2022)[1]
Area	2,512 km^2 [2]
Topography	Réunion island is the result of volcanic activity, with mountain peaks in the interior and two distinct volcanoes: the Piton des Neiges (Snow Peak), which is now extinct, and the Piton de la Fournaise (Furnace Peak), which is younger and more active. The Piton des Neiges is also the highest point on the island at 3,072 metres above sea level.[2]
Climate	In general, the weather in Réunion is tropical and humid. The warm and humid season lasts from November to April, while the drier season occurs from May to October.[3] The summer, which lasts from December to March, has a mean temperature of 26 °C on the coast. Winter, from April to November, has an average temperature of 20 °C on the coast. At higher altitudes, temperatures drop significantly.[2]
Climate Change	Between 1968 and 2021, the average temperature in Réunion rose by 0.18 ° C per decade, or nearly 1 °C in total. By 2100, the average temperature rise is projected to reach 1–3 °C, which will impact the intensity and duration of heat waves and droughts. Between 1961 and 2021, the average rainfall decreased by 1.6 per cent per decade. By 2100, there should be one in five extra rainy days in the wet season and one less rainy day every five days in the dry season. The eastern part of the island will retain much more rainfall than the western part.[4]
Rain Pattern	Summer (January–March) is the wettest season with approximately 200 mm of rainfall per month falling along the coast and up to 1,000 mm in the inland areas. February is usually the wettest month. Annual rainfall exceeds 3,000 mm on the eastern coast and is below 1,000 on the western coast.[5]
Hydrology	A large number of rivers flow through Réunion, including the Rivière des Marsouins that runs abundantly all year round. Other notable rivers are the Sainte Suzanne, Grand-Bois, Salazie and Mafate Rivers.[2]

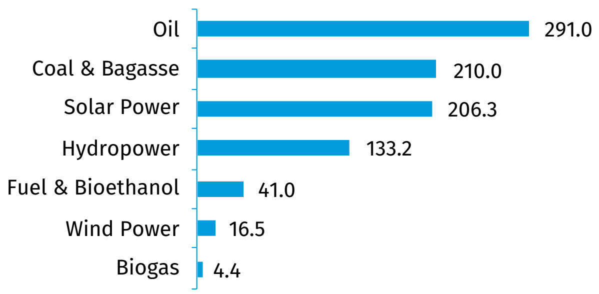
ELECTRICITY SECTOR OVERVIEW

Réunion Island is an overseas department and an administrative region of France. The French company Électricité de France (EDF) is the electricity provider on the island.

In 2020, total electricity generation on the island amounted to 2,978 GWh. Electricity was generated from thermal and renewable energy sources, with coal dominating the generation mix at almost 37 per cent of the total. Renewable energy sources accounted for a total of 31 per cent (Figure 1).[6]

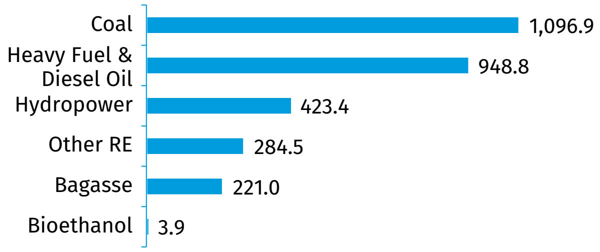
Total installed capacity as of December 2020 was 902.5 MW, of which oil-fired plants accounted for 32 per cent, coal- and bagasse-fired plants for more than 23 per cent, solar power plants for almost 23 per cent, hydropower for 15 per cent, fuel- and bioethanol-fired plants for over 4 per cent, wind power for 2 per cent and biogas for 0.5 per cent (Figure 2).[6] Until 2011, hydropower was the most utilized renewable energy source, as it was one of the first renewable energy sources developed on the island. However, since 2012, Réunion has invested in the development of other renewable energy technologies and now solar power exceeds hydropower in installed capacity.[6] In addition to the listed installed capacities, there is also 6 MW of storage capacity from two batteries.[6]

Figure 1. **Annual Electricity Generation by Source in Réunion in 2020 (GWh)**



Source: Energies Réunion[6]

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



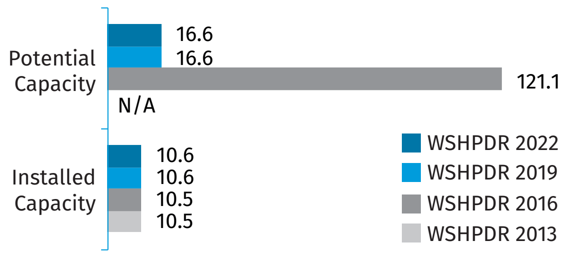
Source: Energies Réunion[6]

Although the cost of producing electricity is higher in Réunion Island due to its insularity, consumers benefit from tariff equalization, meaning that the prices are identical to those in Metropolitan France. Basic electricity tariffs vary according to the voltage and frequency of the electronic devices used as well as the time of the day when they are used. As of 2022, residential tariffs (inclusive of taxes) varied from 0.1371 EUR/kWh (0.14 USD/kWh) to 0.1706 EUR/kWh (0.18 USD/kWh).[7]

SMALL HYDROPOWER SECTOR OVERVIEW

Réunion, in accordance with French legislation, defines small hydropower (SHP) as hydropower plants up to 10 MW. The total SHP installed capacity in Réunion is 10.6 MW (Table 1).[6] The total untapped hydropower potential in the island is estimated at 121.1 MW, of which 59.1 MW is difficult to be developed, 50.5 MW can be developed under strict conditions and 11.5 has no limitations for development.[8] As far as SHP is concerned, the island has 6 MW of untapped potential, making it 17 MW in total.[7] Compared to *the World Small Hydropower Development Report (WSHPDR) 2017*, both installed and potential capacity remained unchanged (Figure 3).

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



Source: Energies Réunion,[6] Direction de l'eau,[8] *WSHPDR 2013*,[9] *WSHPDR 2016*,[10] *WSHPDR 2019*[11]

Hydropower on the island is produced at Rivière de l'Est (79.2 MW), Takamaka I (17.4 MW) and II (26.0 MW), Bras de la Plaine (4.6 MW), Langevin (3.6 MW), Bras des Lianes (2.2 MW), Ligne Paradis (0.2 MW) and RT4 (0.02 MW) plants, for a combined capacity of 133.2 MW.[6] Although a large share of the SHP potential has been tapped, there are still a number of potential sites where micro-hydropower projects can be developed (Tables 2 and 3).[14]

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

Name	*Location*	*Capacity (MW)*	*Operator*	*Launch year*
Ligne Paradis	Saint-Pierre	0.2	SAPHIR	2018
RT4	Saint-Paul, Ermitage	0.02	ALTERELEC	2013
Bras de la Plaine	Saint-Pierre	4.6	N/A	N/A
Langevin	Saint-Joseph	3.6	N/A	N/A
Bras des Lianes	Bras, Panon	2.2	N/A	N/A

Source: Energies Réunion[6]

Table 2. **List of Planned Small Hydropower Projects in Réunion**

Name	*Location*	*Capacity (MW)*
Sainte Etienne Riverr	Saint-Pierre	0.80
Restitution Rivière des Galets	Saint-Paul	0.50
Ligne Paradis	Saint-Pierre	0.42
Bras Cilaos – Maniron	Saint-Louis	0.39
Bras Cilaos – Bellevue	Saint-Louis	0.24
Bras cilaos – Larrey	Saint-Louis	0.15
ILO – RT8	Saint-Leu	0.10
Capteur de pression – A501C02	Saint-Pierre	0.07
PT13000 Interconnection ILO – BC	Les Avirons	0.07
Community reservoir "ville2"	Petite-Ile	0.06
ILO – RT3	Saint-Paul	0.04
ILO – RT6	Saint-Leu	0.04

Source: Regional Council of Réunion[12]

Table 3. **List of Potential Small Hydropower Projects in Réunion**

Name	*Location*	*Potential capacity (MW)*	*Type of site (new/refurbishment)*
Matarun	Cilaos	0.011	New; pipeline network
N/A	West coast	0.018	New; pipeline network

Source: Regional Council of Réunion[12]

RENEWABLE ENERGY POLICY

Act No. 2015-992, Article 1, of 17 August 2015 lays down the guidelines for energy policies and renewable energy for French overseas departments.[13] The law states that overseas departments should be energy-autonomous by 2030, with an intermediate goal of 50 per cent of renewable energy in the energy mix by 2020. In addition, incentive mechanisms are also in place to encourage the development of renewable energy, including tax exemptions, direct subsidies and feed-in tariffs (FITs) controlled by EDF.

In 2017, in the Multiannual Energy Programme (PPE) the Regional Council of Réunion Island and the Government of France defined the energy policy until 2023 for the island. The PPE set the development objectives for each renewable energy source for the period from 2018 to 2023 in order to achieve energy autonomy by 2030. The programme takes into account population and electricity consumption growth, with objectives focusing on demand-side management as well. In this document, the objective for hydropower is to add 39.5 MW of capacity between 2016 and 2023. However, the project of a new 39 MW turbine on which this objective was based will not be realised.[14]

In April 2022, an updated version of the PPE was adopted with new objectives set for 2023 and 2028. These include reducing electricity consumption by 263 GWh/year by 2023 and 438 GWh/year by 2028 as well as stopping using coal and heavy fuel oil for electricity generation. The two existing carbon-fired power plants will be converted to the use of biomass. The new objectives defined for hydropower are to add 6.6 MW of capacity by 2023 and another 1 MW by 2028, indicating a reduced focus on hydropower in the new edition of the PPE in favour of other renewable energy sources.[12]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The main barriers to SHP development include:

- Costly technology due to the insularity of the island and the related costs of transportation and taxes, which limits contractors' willingness to undertake financial risks and invest in Réunion;
- Climatic variations and destruction coupled with volcanic activity are other risk variables of the island that investors and contractors need to face;
- Réunion is classified by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as a World Heritage Site, which has two main consequences: first, environmental impact assessments are stringent; and second, the price of land per square metre has experienced a significant increase, affecting initial investment expenditures;
- Ineffective coordination between local and overseas authorities prolongs the implementation process for project owners;
- Lack of local technical support;
- Lack of information and contradictory sources, slowing down the process of development.

On the other hand, the key enablers include:

- Availability of undeveloped SHP potential;
- Policy support of renewable energy;
- Availability of irrigation and water treatment infrastructure on which SHP plants could be installed.

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Rwanda

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

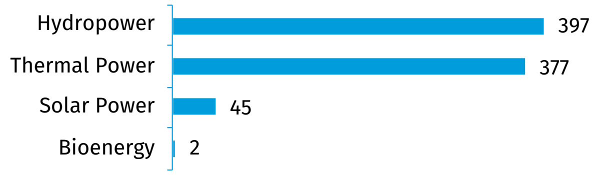
KEY FACTS

Population	12,955,736 (2021)[1]
Area	26,338 km^2 [2]
Topography	Rwanda is a landlocked country that lies 120 kilometres south of the equator in the Tropic of Capricorn. Rugged with steep hills and deep valleys, the altitude ranges from approximately 1,000 metres above sea level in the east to the 4,507 metre peak of Mount Karisimbi in the Virunga Volcano Range in the west of the country.[2,3]
Climate	Rwanda has a temperate tropical highland climate characteristic of high-altitude regions in the equatorial belt. Average annual temperatures range between 23 °C and 24 °C in lowlands and reach up to 17 °C in high altitude areas. Generally, temperatures vary little throughout the year.[4]
Climate Change	As a country that relies heavily on rain-fed agriculture, Rwanda is highly vulnerable to rising temperatures as well as the irregular rainfall patterns that have been projected to increase in the future. Increases in temperature of between 1.4 °C and 2.6 °C have been observed in the south-western and eastern regions of the country between 1971 and 2016. Precipitation also exhibited noticeable variations, with mean rainfall decreasing significantly in January, February, May and June and increasing significantly from September to December. Climate projections for the high-emissions scenario estimate an annual mean temperature increase of 1.1 °C between 2020 and 2039, 1.9 °C between 2040 and 2059, 2.9 °C between 2060 and 2079 and 3.9 °C between 2080 and 2099. Annual precipitation is also likely to increase, with a higher intensity of heavy rainfall. These variations in temperature and precipitation are projected to also impact water resources, which could in turn impact the energy sector.[5]
Rain Pattern	Rwanda experiences relatively abundant rainfall through its two rainy seasons: the long rainy season (March to May) and the short rainy season (September to November). The eastern plains enjoy an annual rainfall of between 700 mm and 1,100 mm, the central plateau of between 1,100 mm and 1,300 mm and the highlands of between 1,300 mm and 1,600 mm. The areas around the town of Bugarama and Lake Kivu benefit from an annual rainfall of between 1,200 mm and 1,500 mm. The mean annual precipitation in the country is 1,177.7 mm.[5]
Hydrology	Located in the Great Lakes region of Africa, Rwanda has 101 lakes split into two basins: the Nile basin to the east and the Congo basin to the west. The country's hydrological network covers approximately 8 per cent of the national territory, with 10 per cent of the water draining into the Congo basin. The largest lake in Rwanda is Lake Kivu, a methane-rich lake shared with the Democratic Republic of the Congo.[5]

ELECTRICITY SECTOR OVERVIEW

The electricity supply in Rwanda is made up of domestic generation and electricity imported from neighbouring countries and regional shared power plants.[6] The main sources of electricity in Rwanda are hydropower, thermal power (diesel and methane) and solar power accounting for approximately 48 per cent, 46 per cent and 6 per cent, respectively, of total production, which amounted to 821 GWh in 2019 (Figure 1). Renewable energy contributed a combined 54 per cent of the electricity generated.[7]

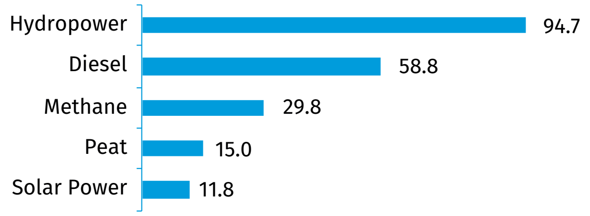
Figure 1. **Annual Electricity Generation by Source in Rwanda in 2019 (GWh)**



Source: IRENA[7]

The total installed capacity in 2020 was 210.1 MW, of which approximately 45 per cent came from hydropower, 49 per cent from thermal power (diesel, methane, peat) and 6 per cent from solar power (Figure 2). Thermal power is only used during peak hours due to the high operating costs associated, with hydropower taking over during off-peak hours as a cheaper option. Additionally, Rwanda imports electricity from the National Electricity Company of Congo (SNEL) and the Uganda Electricity Transmission Company (UETCL).[8]

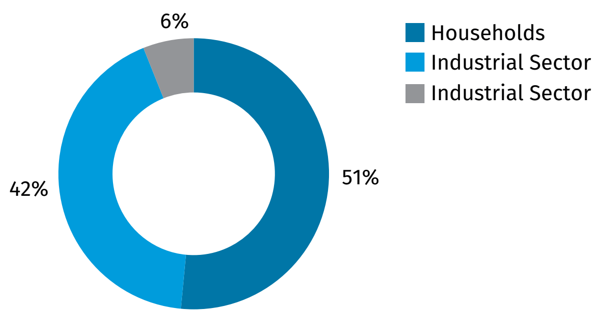
Figure 2. **Installed Electricity Capacity by Source in Rwanda in 2020 (MW)**



Source: REG[8]

In Rwanda, the dominant consumers of electricity are households, followed by industries and the public sector, with consumption rates of approximately 51 per cent, 42 per cent and 6 per cent, respectively (Figure 3). The per capita consumption rate is expected to increase to 3,080 kWh in 2050 from 50 kWh in 2019, with at least 60 per cent of the electricity to be generated from renewable energy sources under the Vision 2050 strategic plan for the transformation and modernization of the country.[5]

Figure 3. **Electricity Consumption by Sector in Rwanda (%)**



Source: World Bank[5]

Electricity in Rwanda is distributed by the Rwanda Energy Group (REG), a Government-owned corporation which oversees all energy development and investment plans in the country under the auspices of the Ministry of Infrastructure (MININFRA). Private entities can purchase, build and operate power plants in Rwanda, but the distribution is handled by the REG. As of 2021, the cumulative connectivity rate was 67 per cent of Rwandan households, including approximately 49 per cent connected through the national grid and 19 per cent accessing through off-grid systems (primarily solar power). An electricity access target of 100 per cent of households by 2024 with 69 per cent connected through the grid and 31 per cent off-grid has been set by the Government.[9]

Electricity tariffs are established by the REG and are based on flat rates and smart meters that measure levels of electricity consumption. The electricity tariffs for the main groups of consumers are listed in Table 1.

Table 1. **Average Electricity Tariffs in Rwanda**

Type of consumer	*Type of rate*	*Average electricity tariff (USD/kWh)*
Residential	Smart meter	0.089–0.245
Commercial	Smart meter	0.157–0.201
Industrial	Flat rate	0.106–0.151
Industrial 2	Smart meter	0.094–0.134
Public sector	Smart meter	0.126

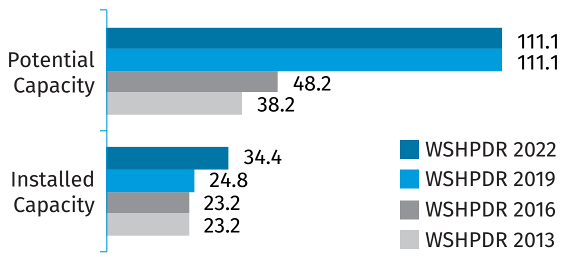
Source: REG[10]

Based on a study conducted by Israel Electric on the current and forecasted electricity demand in Rwanda for the years 2016–2040, an average of a 10 per cent annual demand growth rate has been estimated.[8] As part of the Vision 2050 plan, the development of electricity connectivity focuses on hydropower as the area with the most potential to meet the demand due to the abundance of water resources in the country and region.[5]

SMALL HYDROPOWER SECTOR OVERVIEW

Small hydropower (SHP) plants in Rwanda are defined as plants with an installed capacity of up to 5 MW. There were 29 SHP plants operating in Rwanda in 2020 out of 333 identified potential sites, with a total installed capacity of 34.4 MW and an available capacity of 18.66 MW.[8] The total theoretical SHP potential capacity in Rwanda is estimated to be 111.1 MW (based on planned projects and identified sites).[11] Compared to the *World Small Hydropower Development Report (WSHPDR) 2019*, the SHP installed capacity increased as a result of the commissioning of new plants, whereas the potential estimate remained unchanged (Figure 4).

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



Source: REG,[8] *WSHPDR 2019*,[11] *WSHPDR 2016*,[12] *WSHPDR 2013*[13]

Note: Data for SHP up to 5 MW.

Table 2 lists 20 of the SHP plants operational in Rwanda.

Table 2. List of Selected Operational Small Hydropower Plants in Rwanda

Plant name	*Installed capacity*	*Available capacity*	*Operator*	*Launch year*
Mukungu	0.016	0.0096	IPP	2020
Kigasa	0.272	0.1000	IPP	2020
Nyirantaruko	1.840	1.2000	IPP	2020
Rubagabaga	0.450	0.2400	Rubagabaga Hydropower Ltd.	2019
Rukarara V Mushishito	2.300	1.2000	IPP	2019
Rwaza Muko	2.600	1.5600	Rwaza Hydropower Ltd.	2018
Gaseke	0.500	0.5238	Novel Energy	2017
Giciye II	4.000	1.6000	Rwanda Mountain Tea (RMT)	2016
Giciye I	4.000	1.6000	RMT	2013
Nyirabuhombohombo	0.500	0.1750	RGE Energy UK Ltd	2013
Rukarara II	2.200	1.1550	Prime Energy	2013
Mukungwa II	3.600	2.6280	Prime Energy	2013
Musarara	0.400	0.2205	Amahoro Energy	2013
Gashashi	0.280	0.1120	Prime Energy	2013
Nshili I	0.400	0.2400	Government of Rwanda	2012
Nyabahanga I	0.200	0.1100	Government of Rwanda	2012
Janja	0.200	0.1600	RGE Energy UK Ltd	2012
Mazimeru	0.500	0.2450	Carera-Ederer	2012
Cyimbili	0.300	0.1500	Adre Hydro&Energycotel	2011
Nkora	0.680	0.3400	Adre Hydro&Energycotel	2011
Nyamyotsi I	0.100	0.0600	Adre Hydro&Energycotel	2011

Source: REG[8]

In addition to the existing SHP plants, a further 10 SHP plants are planned in Rwanda, with some expected to start commercial operation between 2022 and 2024 (Table 3). The total nominal capacity of the planned SHP plants with an individual capacity of less than 5 MW is 32.8 MW and the nominal capacity of all planned plants up to 10 MW is 52.4 MW.[8]

Table 3. List of Selected Planned Small Hydropower Projects in Rwanda

Plant name	Nominal capacity (MW)	Planned launch year
Ngororero	2.7	2022
Nyundo	4.5	2022
Rwondo	2.3	2022
Base I	2.9	2024
Base II	2.9	2024

Source: REG[8]

MININFRA commissioned a study to identify potential hydropower sites, which was carried out in 2006-2007 by SHER ingénieur-conseil, a Belgian-based company funded by the Belgian Development Corporation. Through this study, a hydropower atlas highlighting the different potential areas for hydropower development was developed. Each identified site was classified based on its potential capacity, from pico-hydropower sites (up to 5 kW) to larger sites with more than 1 MW of capacity. Almost 50 per cent of the potential sites were found to be in the range of 5–100 kW. The theoretical hydropower potential capacity identified in the study totalled 82.6 MW, including 61.2 MW at already equipped or soon-to-be equipped sites.[8]

RENEWABLE ENERGY POLICY

The renewable energy sector is led by the Rwanda Energy Policy (REP), established as a guiding framework for the sector in 2015, following Law No. 21/2011 of 23 June 2011 governing electricity in Rwanda. Under the REP, the Rwanda Utilities Regulatory Authority (RURA) is mandated to regulate the supply of sufficient, reliable, affordable and sustainable energy to all customers. This supply follows the targets set for renewable energy by the Energy Sector Strategic Plan for 2018/19–2023/24, which guides the implementation of the REP.[14]

As part of the Vision 2050 plan, Rwanda is putting climate resilience and a low-carbon economy at the heart of its development. To this end, the share of renewable energy in the country's generation mix is targeted to reach at least 60 per cent by 2035.[5] SHP is an integral part of the country's effort towards achieving this goal, with sustainable small-scale generation installations in rural areas being a key component of the Green Growth and Climate Resilience Strategy of Rwanda. This strategy is highlighted in the country's Nationally Determined Contribution (NDC), with the increased use of hydropower (both large and small) representing the largest share of the identified greenhouse gas (GHG) mitigation potential.[15]

As part of the country's effort to promote SHP, a feed-in tariff (FIT) scheme was introduced between 2012 and 2015 by the Energy, Water and Sanitation Authority (EWSA) in close collaboration with the RURA. The scheme covered hydropower plants ranging in capacity from 50 kW up to 10 MW and located within 10 kilometres from the transmission network (Table 4). Although the policy expired after a duration of three years and has now been replaced by renewable energy tenders, this does not affect the projects that signed power purchase agreements (PPAs) under the scheme during that period.[16]

Table 4. **Small Hydropower Feed-in Tariffs in Rwanda**

Plant installed capacity (MW)	*Feed-in tariff (USD/kWh)*
0.05	0.166
0.10	0.161
0.15	0.152
0.20	0.143
0.25	0.135
0.50	0.129
0.75	0.123
1.00	0.118
2.00	0.095
3.00	0.087
4.00	0.079
5.00	0.072
6.00	0.071
7.00	0.070
8.00	0.069
9.00	0.068
10.00	0.067

Source: RURA[16]

Rwanda is a signatory to the United Nations Sustainable Energy for All Initiative (SE4ALL) and the Regional Strategy on Scaling up Access to Modern Energy Services adopted by the Council of Ministers of the East African Community. As such, the country adopted policies to create an environment that enables off-grid energy service provision including the development of small-scale renewable energy solutions.[16]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

SHP plants are regulated by some of the same legislation as larger hydropower projects. The main legislation and regulation documents in Rwanda concerning hydropower are:

- The National Energy Plan (2015);
- Regulations No.001/ENERGY/RURA/2012 Of 09/02/2012 On Rwanda Renewable Energy Feed-In Tariff (2012);
- Guidelines No.02/GL/EL-EWS/RURA/2019 On Minimum Technical Requirements for Mini-Grids in Rwanda (2019).

Any energy generation project in Rwanda, including SHP plants, is required to receive a generation licence from the Rwanda Utility Regulatory Authority (RURA), with the fee depending on the planned capacity of the project (Table 5).

Table 5. **Electricity Generation Licence Fees in Rwanda**

Capacity	*Fee (USD)*
Less than 0.5 MW	5,000
0.5–1 MW	10,000
1–5 MW	15, 000

Source: RDB[17]

In addition to the generation licence fee, a licence application fee of USD 500 is to be paid.[17] As part of the application, the following documents have to be filed:

- Application letter addressed to the RURA Director General;
- Original receipt of the application fee payment;
- Domestic company registration certificate from the Rural Development Board (RDB);
- Business plan;
- Copy of the feasibility study of the project;
- Environmental Impact Assessment Certificate;
- Memorandum of understanding/Concession agreement between the Republic of Rwanda and the applicant;
- Power purchase agreement (not applicable to provisional licence);
- District authorization approving planned activities;
- Copies of applicant's financial statements audited by an independent auditor for the previous three years for the existing companies and the initial balance sheet for newly formed companies;
- Other relevant information detailed in the Electricity Licensing Regulations depending on the type of licence applied for.[17]

All licensing of power plants in Rwanda is acquired through the RDB, which oversees development projects in the country. The RDB is open to investors who wish to invest in SHP projects and has a directory of potential SHP sites and projects to accommodate investors. Most SHP projects are Government-funded through the RDB and the REG, with the remaining projects owned by companies and IPPs.

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

With Rwanda depending on hydropower for most of its electricity generation, the effects of climate change are likely to significantly affect the energy sector in the country. Indeed, variations in rainfall patterns have already been observed and changes in mean temperature are predicted to occur, threatening water storage and supply.[5] In addition, hydropower is also vulnerable to the increased risk of damage to infrastructure, including roads, dams, turbines and supply lines, caused by floods. On the other hand, increased rainfall could also present an opportunity for SHP development as it would increase generation capacity at potential sites, which would bring the country closer to its goal of 60 per cent share of renewable sources in the generation mix by 2035.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Though SHP development presents an opportunity for Rwanda to reach its target energy goals, there are factors that hinder that development, such as:

- High costs associated with construction due to the relatively complex design of SHP plants, which require significant custom engineering. With few manufacturers to purchase from, the prices of building equipment are relatively high;
- Rwanda does not manufacture the necessary equipment for SHP plants and has to import them from outside of Africa, with import costs being relatively high due to the lack of a sea port in the country;
- The siltation as a result of the erosions caused by the hilly topography of the country and human activity (e.g., agriculture);
- The water levels drop by approximately 30 per cent during dry seasons, which affects generation by SHP plants;
- The mountainous topography of the country makes transmission and distribution relatively expensive.[18,19]

Enablers for further SHP development in Rwanda are:

- The availability of undeveloped potential SHP sites, which, due to their distributed nature, might be complimentary to micro-grids to provide 24/7 generation in combination with solar photovoltaic (PV) installations;
- Domestic production of electricity eliminates the need for foreign currency used for imports;
- Most potential SHP sites identified are suitable for development using run-of-river methods, which do not require large dams to impound water and, hence, are less environmentally challenging and more cost-effective;
- The Government's strategy to transition to a climate-resilient and low-carbon model of development specifically highlights the need for small-scale renewable energy production.

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Somalia (Federal Republic of)

Victor Odundo Owuor, One Earth Future Foundation

KEY FACTS

Population	15,442,905 (est. 2019)[1]
Area	627,340 km^2 [2]
Topography	Located in the Horn of Africa, Somalia boasts the longest coastline of any country in the continent. In the north, higher plateaus and mountains reach between 900 and 2,100 metres above sea level, gradually declining into a central plateau. In the south, the region transitions into lower coastal plains and fertile agricultural areas between the Jubba and Shabelle Rivers, before extending into low pastureland on the border with Kenya.[3]
Climate	Somalia has a semi-arid to arid climate, which is determined by its location in the Intertropical Convergence Zone.[4] Temperatures range between 20 °C to 40 °C in the south with cooler temperatures along the coast and reach as high as 45 °C in the northern coastal plains.[5]
Climate Change	Since 1991, the median annual temperature in Somalia has increased by 1–1.5 °C. Climate change projections predict that median annual temperatures will further increase by another 3.4–4.3 °C by the year 2100. Extreme weather phenomena are becoming more common and harder to predict. While a slight increase in rainfall of approximately 3 per cent is predicted by 2050, an increase in droughts and dust storms has also been observed. Additionally, the changing global and regional weather patterns have led to massive locust invasions in the Horn of Africa, costing Somalia approximately 20 per cent of national crop yields in 2020.[6,7]
Rain Pattern	The major wet season (*Gu*) lasts from April to June, followed by the *Haggai* season, which brings relatively cool temperatures with drier conditions on the inland plateau and light showers along the coast.[8] The *Deyr* rains occur from October through November, which lead into the longer dry *Jilaal* season spanning from December through March. Precipitation levels range from 700–800 mm/year in the Jubba and Shabelle regions to less than 100 mm/year along the northern coast.[4]
Hydrology	The majority of the country's water resources are dominated by surface water obtained from the Jubba and Shabelle Rivers, with 90 per cent of flows originating in the Ethiopian Highlands. Total internal water resources, including both surface and ground water, average 6 km^3/yr.[3]

ELECTRICITY SECTOR OVERVIEW

As of 2020, the installed electricity capacity of Somalia was estimated at 106 MW, down from an estimated historical capacity of 175–180 MW prior to the outbreak of the civil war in the early 1990s. The majority of the country's electricity is supplied by fossil fuel-based thermal generators (100.0–103.4 MW), with some renewable energy generated through solar and wind power (2.6–6.0 MW) (Figure 1).[3,9,10] Within the energy sector as a whole, as much as 80 to 90 per cent of energy originates from biomass sources, with the greatest share represented by charcoal. Fossil fuel usage accounts for 10 per cent of the energy mix, of which diesel-powered generators represent approximately 2 per cent.[9,10]

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

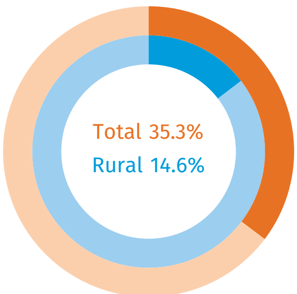
Source: AfDB,[3] USAID[9]

The decades' long civil war has undermined and destroyed much of the energy sector of Somalia. The combination of the protracted conflict and subsequent statelessness has significantly reduced the country's electrical generation capacity, namely through the destruction of electrical grids and by allowing infrastructure to fall into disrepair. Perhaps just as damaging was the effect that the war had on reducing international investment, the availability of a skilled workforce and Government regulatory oversight. In recent years, an added element of concern is the security risk that Al Shabaab and other armed militia groups pose to any large-scale infrastructure projects due to the potential for inflicting significant damage to the country's economic system.[11]

Precise and reliable data relating to installed capacity and electricity generation is difficult to obtain due to the fragmented nature of the energy sector and the sparse availability of data. The World Bank reported that 29.9 per cent of the population has access to electricity in 2016, which translated into an estimated 270,000–679,073 individual connections to households and businesses, while the most recent World Bank estimate indicates a 35.3 per cent electricity access rate in 2018 (Figure 2).[11,12] Other recent estimates put electricity access at as low as 16 per cent of the total population.[9] In terms of overall electricity consumption, estimates indicate that Somalis rank in the bottom 1 per cent of the world average at 28.7 kWh per capita and that some 2.4 million households do not have electrical power.[11]

These numbers do not reflect the vast disparity that exists between rural and urban populations' access to electricity. Electrification in rural areas is limited or non-existent due to the lack of infrastructure and connections to a larger electrical grid structure.[11] However, it should be noted that rural electricity access has shown gradual improvement with the added accessibility and convenience of solar photovoltaics (PV) technology, which has allowed some households and businesses to access electricity on a smaller, individual scale. Urban electrification varies by city and region, depending on the level of infrastructure and the generating capacity of privately owned electrical companies.[3] For example, estimates of electricity access in Mogadishu and Somaliland have reached as high as 60 to 70 per cent, whereas smaller cities, such as Merka, only have 23 per cent access.[13] The latest World bank estimates suggest a 60.5 per cent electricity access in urban areas, but only 14.6 per cent access in rural areas.[12]

Figure 2. **Electrification Rate in Somalia in 2018 (%)**



Source: World Bank[12]

As a result of the weakened state of the Somalian public energy sector, the private sector has taken a primary role in sourcing and providing electricity. Rather than through large, centralized systems of power generation, the majority of electricity in Somalia is generated by small independent providers operating through local or regional companies.[14] Without the Government oversight, these independent power companies have improvised their own local systems of electricity distribution, but lack a coherent interconnected grid between generators that could promote more efficient and cost-effective economies of scale.[11] In addition to these independent networks, there is also a smaller subset of semi-public utility companies that provide electricity to large urban areas, but they operate on dated grid systems and are only present in selected cities, including Hargeisa, Qardo, Berbera and Bosaso.[3]

While the flexible and adaptive nature of the private sector energy companies has its advantages, including access to private funding sources in the Somali diaspora and fast mobilization, they also have distinct weaknesses. The radial system of individual electrical networks is characterized by medium- to low-tension power supplies, which are further diminished by transmission losses of up to 50 per cent of starting power levels. Compared to other African countries or even other fragile and conflict-affected countries, this is four and two times higher than the average rate of losses, respectively.[3] This means that, on average, voltage rates are typically 220–400 V, but are often as low as 150–220 V. As a result, most households with access only use electricity for lighting purposes or other low current appliances.

The national and regional Governments are responsible for overseeing and implementing the energy sector policy. In 2010, the Ministry of Mining, Energy and Water Resources of Somaliland passed an Energy Policy that initiated a regulatory framework for the region. In conjunction with the Energy Policy, Somaliland has made multiple attempts to pass an Electrical Energy Act, which would establish a formal legal framework overseeing tariff rates, administration and skilled training initiatives; however, the Act has not been adopted as of 2021.[15] Overall, no legislation has been passed at the federal level that specifically addresses the electricity industry. However, in 2016 the Government partnered with the African Development Bank Group to complete an Energy Sector Needs Assessment, which laid out multiple strategies aimed towards expanding the electrical capacity of Somalia. One such strategy calls for increasing the supply of electricity to regional capitals through hybrid mini-grids, implying close to 200 MW of additional generating capacity over a 10-year period.[3] To date, the Government does not have the necessary staff or budget to initiate such projects and requires international donor support to accomplish its large-scale energy infrastructure goals.

This lack of regulation and oversight extends into the affordability of electricity as well. With average rates between 0.80 and 1.20 USD/kWh (Table 1), the electricity tariffs in Somalia rank among the highest in the world, especially when considering that the GDP per capita in 2017 was USD 434.21.[3,12] Most power companies do not have a formal metering system and instead charge by the number of light bulbs or the number of appliances powered within a household or business. Some independent providers have even utilized tiered rates, meaning that some public and private institutions like mosques or government facilities pay a lower rate as compared to other consumers or nothing at all.

Table 1. **Electricity Tariffs in Somalia**

Tariff type	*Price (USD/kWh)*
Nationwide average	0.80–1.20
Single-phase supply	0.60–1.20
Three-phase supply	0.65–0.80

Source: AfDB,[3] REEEP[13]

Regional variation in price is largely dependent upon the energy provider, the level of available infrastructure and the consumer's proximity to urban centres or the primary electricity generation source. In order to supplement its energy needs and to offset high tariffs, Somalia has tapped into power surpluses in neighbouring countries. In 2014, the Federal Government entered into a shared understanding with Kenya and Ethiopia to build a hydropower plant on their shared border on the Dawa River and has worked with Ethiopia to connect to its grid system in areas along the Somaliland border as well as in Puntland.[3] In the long term, there has also been discussion around utilizing the Eastern African Power Pool (EAPP) as a potential source of electric power, but the current load and lack of interconnection in Somalia suggest limited benefits for the required cost.[11]

SMALL HYDROPOWER SECTOR OVERVIEW

Somalia has no official definition for small hydropower (SHP). This chapter adopts the working definition of hydropower plants with an installed capacity of up to 10 MW. Currently there are no operational hydropower plants in the country; however, there is some potential to rehabilitate plants that were in place prior to the civil war. The current state of SHP does not reflect the historical development and use of hydropower in Somalia. Though it has fallen into disrepair, the Fanoole hydropower dam was completed in 1982 in partnership with China. The plant was designed to generate electricity for local communities in Jilil and Marere and to support an agricultural programme focused on sugar cane and rice irrigation.[16] In their 2016 Intended Nationally Determined Contributions (INDC) report, the Somali Federal Government announced plans to rehabilitate the dam's hydropower infrastructure for an estimated USD 28 million.[16] If completed, the refurbished plant would restore 4.6 MW of power as well as re-establish two standby generators with a capacity of 1,600 kW. This dam has the potential to reinvigorate the agricultural sector in the Middle and Lower Jubba Valley, but the project includes extensive repairs and rechannelling the path of the river which was diverted during the 1998 El Niño rainy season. The SHP potential of Somalia is unknown and is based only on known planned projects. Somalia remains a very challenged jurisdiction and no changes have occurred in its SHP sector since the *World Small Hydropower Development Report (WSHPDR) 2019* (Figure 3).

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

Source: AfDB,[3] REEEP,[13] *WSHPDR 2019*[17]

Note: Somalia was not covered in *WSHPDR 2013* and *WSHPDR 2016*.

Relative to the abundance of hydropower generation in Ethiopia, Somalia has a much more limited capacity. The country has an estimated economic potential capacity of 100–120 MW of total hydropower, which is concentrated along the Shabelle and Juba Rivers in the south.[3,11] Historically, there were also plans to construct the Bardheere plant upstream of the Fanoole plant with a capacity of 493 MW, but the civil war effectively halted the project.[16] This reflects many of the challenges faced by Somalia in initiating SHP projects, namely the lack of financing from the Government and international donors, the current unpredictable weather patterns affecting Eastern Africa, concentration of already scarce resources to combat the COVID-19 pandemic and the high degree of terrorist activity conducted by Al Shabaab in the region.

RENEWABLE ENERGY POLICY

As mentioned, charcoal currently represents the most cost effective and accessible energy source in Somalia. However, the proliferation of charcoal consumption and its export to international markets in the Middle East has resulted in widespread deforestation, environmental degradation and negative health outcomes. The rising cost of charcoal (which sits at approximately 50 per cent of household incomes) and the vast potential for solar and wind power generation have driven the Federal and regional Governments to integrate renewable energy into their development plans and policies (Table 2).[3]

Table 2. **Renewable Energy Potentials in Somalia**

Type	*Potential*	*Location/Region*
Solar power	200 kW/km²	Coastal south-central Somalia
Wind power	30–45 GWh/km²	Puntland and Somaliland
Hydropower	100–120 MW	Juba and Shabelle River region

Source: Federal Government of Somalia,[10] REEEP[13]

Given the lack of any regulatory frameworks, renewable energy has been integrated into the larger discussion and the legislative push towards formal energy policy in Somalia. The different regional Governments have committed to a number of energy and renewable energy policy objectives (Table 3).

Table 3. **Energy Policies in Somalia**

Source	*Year*	*Policy*	*Objective*
Federal Government of Somalia	2014	2014–2015 Economic Recovery Plan	Incorporated provisions for renewable energy integration
	2016	2017–2019 National Development Plan	Sustainable Energy Investment Policy and Energy Strategy provision
Somaliland Ministry of Energy and Mining	2010	Somaliland Energy Policy	Promotion of renewable energy technologies and reduction of taxes and duties on importing renewable equipment;
			Increased budget allocation to ministries overseeing renewable energy activities;
			Infrastructure resources (i.e., transportation and communications) to help administrators implement and monitor renewable energy–related activities;
			To develop and sustain efficient use of renewable energy resources as part of the energy mix, in ways that increase affordable access in urban and rural areas.
Puntland	2013	2014–2016 Puntland Government Plan	Identified renewable energy as one of four key priorities for the economy;
			Set a target of a 20 per cent increase in solar and wind power generation and usage over a five-year period.

Source: Federal Government of Somalia,[10] One Earth Future ,[11] REEEP,[13] Watanabe & D'Aoust[14]

COST OF SMALL HYDROPOWER DEVELOPMENT

There is very little data on the cost of potential SHP projects in Somalia now or in the future. However, a partial estimate of the costs of the refurbishment of the Fanoole plant is provided in Table 4.

Table 4. **Cost of the Refurbishment of the Fanoole Hydropower Plant**

Project component	*Cost (USD million)*
Initial cost of construction (1977–1982)	50.0
Refurbishment of dam and electrical facilities	17.0
Rehabilitation of canals and river channel	2.0
Rebuilding of offices, residential buildings and connected agricultural facilities	5.5
Contingency and administrative costs	3.7
Total (refurbishment)	**28.2**

Source: Federal Government of Somalia[16]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

As there is no current or projected SHP development in Somalia, it is difficult to gauge the possible impacts of climate change on its trajectory. While some increase in rainfall is expected over the next 30 years, precipitation and, thus, runoff are also likely to become less predictable and experience greater variation. However, the main aspect of climate change that is adversely affecting the prospects of SHP development in Somalia are the climate change impacts on the local population, including:

- Drought and land degradation undermining agricultural and pastoral livelihoods;
- Extreme weather displacing populations from affected regions;
- Increased confrontation between communities over dwindling resources.

These factors have led to continued social, political and economic instability in Somalia and have effectively made any kind of large-scale construction impossible in many parts of the country, particularly in the Shebelle and Juba River basins where much of the country's SHP potential is located.[7]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The key challenges that Somalia faces in developing SHP are as follows:

- Security concerns surrounding regional terrorist groups, such as Al Shabaab, and the potential for SHP infrastructure and energy grids to be targeted or attacked;
- Limited regulation and oversight of the electricity sector;
- Lack of field studies for SHP potential;
- Low domestic resource mobilization coupled with on-going efforts to combat the COVID-19 pandemic have deepened fiscal pressures;
- Limited Government capacity to administer and regulate the energy sector;
- Lack of a skilled workforce to design, build and maintain SHP and renewable energy infrastructure due to the protracted conflict;
- Absence of an interconnected grid system with high enough capacity to support transmission and usage of electricity for both urban and rural populations;
- Aging equipment and poor infrastructure in thermal generation, which contributes to up to 50 per cent of electricity loss;
- Scarcity of private sector financing for renewable energy projects and materials;
- Limited interconnection with regional power pools, particularly those in Ethiopia and Kenya;
- Low donor support for large-scale government projects, including those for rehabilitating SHP plants in poor condition and initiating a mini-grid system in key urban areas.

The main prospect for SHP development in Somalia remains the refurbishment of the Fanoole plant on the Juba River. The plant's infrastructure is still largely intact and preliminary plans for proposed works were drawn up in 2015. Refurbishment of the plant, if completed, is expected to have a major positive impact on local agricultural productivity.

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South Sudan

International Center on Small Hydro Power

KEY FACTS

Population	11,381,377 (2020)[1]
Area	633,907 km^2 [2]
Topography	South Sudan mostly consists of mountains, plains and plateaus. The central region is relatively flat and has multiple swamps, while the peripheral areas are higher in elevation. Near the southern border with Uganda lies the Imatong Mountain Range, home to the country's highest peak, Mount Kinyeti, which culminates at 3,187 metres.[3]
Climate	South Sudan has a tropical climate. Temperatures are generally high at an average of 25 °C, often exceeding 35 °C in the dry season (January-April). In the centrally-located capital city of Juba, temperatures reach an average high of 34.5 °C and an average low of 21.6 °C.[4]
Climate Change	South Sudan is affected by global warming. In recent years, the frequency and intensity of extreme climatic events has increased, including floods and droughts. Heatwaves and droughts have also been reported. Since the mid-1970s, the country has experienced a 10–20 per cent decrease in long rains. The agricultural areas, usually receiving the most rainfall in South Sudan, have experienced an 18 per cent decrease in precipitation. This country-wide decrease in precipitation is projected to reach a peak decrease, between 2010 and 2039, of 150 mm between June and September. Average temperatures in the country are projected to increase by 0.6-1.7 °C by 2030 and by 1.1-3.1 °C by 2060.[5]
Rain Pattern	South Sudan experiences a rainy season from April to November, although this can vary from region to region. The lowland areas of Jonglei, Bahr El Ghazal, Eastern Equatoria and the Upper Nile receive annual precipitations between 700 mm and 1,300 mm. However, the southern tip of Eastern Equatoria receives less rainfall (approximately 200 mm). The southern upland areas receive the most rain and the northern areas the least. Western Equatoria receives between 1,200 mm and 2,200 mm of precipitation annually.[4]
Hydrology	The hydrological landscape of South Sudan is dominated by the Nile River system, which runs from south to north and is joined by its tributaries: the Bahr Al-Arab, Sobat and Bahr El Ghazal. A large swampy area, the Sudd wetland, occupies the centre of the country and is one of the largest freshwater ecosystems in the world. It incorporates an area of about 57,000 km^2.[5]

ELECTRICITY SECTOR OVERVIEW

Due to the status of South Sudan as the newest nation in Africa, which it became after gaining independence in 2011, the electricity sector in the country is still undeveloped. The transmission system has not been updated nor has the country's renewable energy potential been exploited. The main source of electricity in South Sudan is thermal power, which accounted for 580 GWh, or 99.8 per cent, of the total electricity generation of 581 GWh in 2019 (Figure 1). Solar power accounted for 0.2 per cent, or 1 GWh, of the total electricity generated that year.[6]

Due to the country's history of civil war and its relatively recent cessation from Sudan, little electrical infrastructure has been built. There is no extensive electricity grid in the country and most businesses and individuals rely on their own diesel-powered generators for electricity. The total installed electricity capacity in South Sudan in 2020 was 175 MW, with thermal power and solar power accounting for approximately 99.4 per cent and 0.6 per cent, respectively (Figure 2).

Figure 1. **Annual Electricity Generation by Sources in South Sudan in 2019 (GWh)**

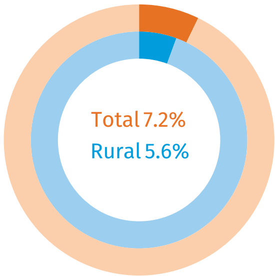
Source: IRENA[6]

Figure 2. **Installed Electricity Capacity by Source in South Sudan in 2020 (MW)**

Source: IRENA[6]

Due to the lack of an extensive electricity grid and overall electricity infrastructure, South Sudan has the lowest rate of electrification in the world. The total electrification rate in the country was 7 in 2020, with less than 6 per cent rate of access in rural areas (Figure 3).[7,8]

Figure 3. **Electrification Rate in South Sudan in 2020 (%)**



Source: World Bank[7,8]

South Sudan is endowed with considerable natural resources, including crude oil and natural gas. Crude oil exports form the backbone of the country's economy, with Sudan being one of the main importers.

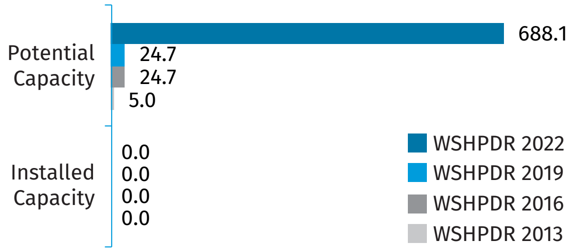
The South Sudan Electricity Corporation (SSEC) is the only electricity utility in the country and is mandated with the production, distribution and supply of electricity. It is overseen by the Ministry of Electricity, Dams, Irrigation and Water Resources. The SSEC has also undertaken the task of overseeing the rehabilitation of the few power plants damaged during the civil war through partnerships with other countries, particularly China. This partnership with China has also resulted in the construction of 33 kV transmission lines that are to supply 20,000 customers with electricity, as well as the production of 13,450 prestressed concrete poles for power plants that are being built for the purpose of creating an extensive national grid and establishing interconnections with neighbouring countries. A loan of USD 14.6 million from the African Development Bank has been approved for the grid project, supplementing the initial loan of USD 26 million issued in 2013. The new loan was approved in 2017 and construction began in 2018.[9]

Electricity tariffs in South Sudan were set in 2014 and reviewed in 2017 to reach an average of 0.43 USD/kWh.[10]

SMALL HYDROPOWER SECTOR OVERVIEW

South Sudan does not have an official definition of small hydropower (SHP). Despite abundant natural resources and considerable hydropower potential, there are no SHP plants in the country. There is an estimated SHP potential of 688.1 MW that is yet to be exploited.[11] This is a 2,686 per cent increase from the estimated SHP potential in the *World Small Hydropower Development Report (WSHPDR) 2019* and is based on a more recent study of SHP potential in Sub-Saharan Africa (Figure 4).

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



Sources: Korkovelos et al.,[11] *WSHPDR 2013*,[12] *WSHPDR 2016*,[13] *WSHPDR 2019*[14]

RENEWABLE ENERGY POLICY

South Sudan does not have a renewable energy policy framework. Despite considerable renewable energy potential, the developed renewable energy is in the form of individual rooftop solar panels. Plans have been discussed and technical evaluations have been completed for a 20 MW solar farm financed by the African Import-Export Bank. There are also plans to build hydropower plants. The SSEC is looking for investors to build a 120 MW hydropower plant near the capital city of Juba and a 1,080 MW Grand Fula Dam near the border with Uganda, with construction expected to start within five years of securing funding. The hydropower projects proposed by the Government are all large-scale.[9]

BARRIERS AND ENABLERS TO SMALL HYDROPOWER DEVELOPMENT

The development of new SHP projects is hampered mainly by:

- A lack of feasibility studies on potential sites due to civil war;
- Focus on developing the national grid and exploiting the natural crude oil and gas reserves;
- Lack of attention to SHP projects in favour of larger hydropower projects;
- Lack of private investors due to the volatile economy and concerns over renewed armed conflicts;
- Lack of a renewable energy policy framework.

Enablers for SHP development in South Sudan include:

- Considerable identified SHP potential;
- The particularly low rate of access to electricity might influence the Government of South Sudan to provide solutions to isolated peoples in the form of SHP.

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Tanzania

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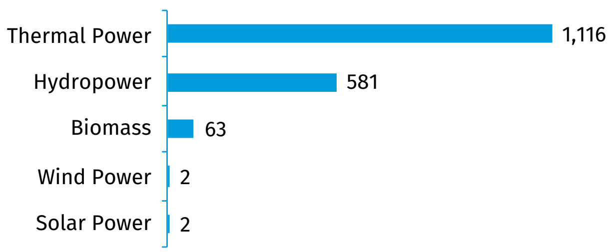
KEY FACTS

Population	57,637,628 (est. 2020)[1]
Area	948,740km^2 [1]
Topography	The landscape of mainland Tanzania is generally flat and dominated by plains along the coast, transitioning to a central plateau and highlands in the north and south. The highest peak in the country is Mount Kilimanjaro at 5,895 metres, located in the north-east.[2]
Climate	The climate in Tanzania is tropical. In coastal areas climate is hot and humid, while in the north-western highlands it is cool and temperate. There are two rainy seasons: the short rains are generally from October to December, while the long rains last from March to June. In the central plateau, climate tends to be dry and arid throughout the year.[3]
Climate Change	In 2020, annual precipitation in the country reached 1,227 mm, 198 mm above the long-term (1981–2010) average, making 2020 the fifth wettest year on record since 1970. Projections of climate change predict an increase in mean seasonal temperatures of over 2.0 °C by 2050 and of up to 3.8 °C by 2100 in various parts of the country, with increases most pronounced between June and August.[3,4]
Rain Pattern	Mean annual rainfall in Tanzania ranges from 500 mm to more than 2,500 mm. The average duration of the dry season is between five and six months. Rainfall patterns have recently become much more unpredictable, with some regions receiving extremely low or extremely high annual rainfall.[5]
Hydrology	Tanzania is surrounded by water bodies covering an area of 59,050 km^2, or approximately 6 per cent of the total area of the country. Major water bodies include the Indian Ocean on the east coast, Lake Victoria in the north-west, Lake Tanganyika in the west and Lake Nyasa in the south. River resources in Tanzania are divided into nine water basins: the Pangani River Basin, Rufiji River Basin, Lake Victoria, Wami-Ruvu, Lake Nyasa, Lake Rukwa, Lake Tanganyika, Internal Drainage and the Ruvuma and Southern River Basins. Major rivers in Tanzania include the Rufiji, Great Ruaha, Kagera, Ruvuma, Wami, Malagarasi, Mara and Pangani.[2,6]

ELECTRICITY SECTOR OVERVIEW

The total installed capacity of Tanzania as of 2022 amounted to 1,764 MW, with thermal plants (primarily gas-fired) providing 1,116 MW (63 per cent) of the total, hydropower providing 581 MW (33 per cent), biomass providing 63 MW (4 per cent) and other energy sources, including wind and solar power, providing 4 MW (less than 1 per cent) (Figure 1).[7]

Figure 1. **Installed Electricity Capacity by Source in Tanzania in 2022 (MW)**

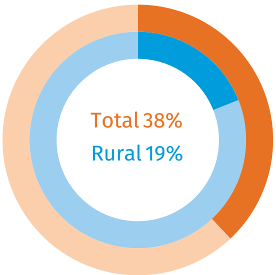


Source: USAID[7]

The country's electricity subsector is dominated by the grid network owned by the state-owned company Tanzania Electric Supply Company Limited (TANESCO). However, the 2009 Electricity Act opened the sector for private companies and ended the 40-year monopoly held by TANESCO. The penetration of independent power producers (IPPs) so far has been limited but steadily increasing.

Domestic generation of electricity in Tanzania during the 2019/2020 fiscal year reached 7,594.3 GWh, while imports amounted to 111.3 GWh. TANESCO accounted for 81 per cent of the domestically-generated electricity, while IPPs accounted for the remaining 19 per cent.[8] According to the World Bank, access to electricity in 2019 was approximately 38 per cent nationwide and 19 per cent in rural areas (Figure 2).[9] Peak electricity demand in 2018 was 1,045.7 MW and is projected to reach approximately 4,020 MW by 2025.[10,11]

Figure 2. **Electrification Rate in Tanzania in 2019 (%)**



Source: World Bank[9]

Despite the abundance of small hydropower (SHP) resources in most parts of the remote areas of Tanzania, the rural areas of the country remain virtually unelectrified. For many years the country's rural electrification efforts were focused on grid extension, which has proved to be economically unsustainable and financially prohibitive. Decentralized renewable energy has been considered as an alternative to shift the country's focus from grid extension to rural electrification. The Rural Energy Act of 2005 established the Rural Energy Board, Rural Energy Fund and Rural Energy Agency, which are responsible for the promotion of improved access to modern energy in rural areas. Standardized Power Purchase Agreements (SPPA) and Standardized Power Purchase Tariffs (SPPT) have been established specifically for small power producers. Since the country's energy sector reform in 2005, there has been a considerable increase in electrification rates in urban and rural areas, which has been largely underpinned by the efforts of the Government in deploying renewable energy technologies, including hydropower. These efforts have resulted in nearly 70 per cent of rural villages achieving electricity access by the end of 2021.[12]

In December 2020, TANESCO entered into an agreement with six renewable energy producers to purchase 19.16 MW of generation capacity to be connected to the national grid in various parts of the country. The agreement includes 10 MW from the Kahama solar power project, 5 MW from the Kigoma solar power project, 1.7 MW from the Madope hydropower project, 1.2 MW from the Maguta hydropower project, 0.9 MW from the Luponde hydropower project and 0.36 MW from the Ijangala hydropower project, developed by Nishati Lutheran Investment.[13] Furthermore, development of the privately-owned 5.39 MW Kitewaka SHP project is underway, with construction to commence in 2022.[14]

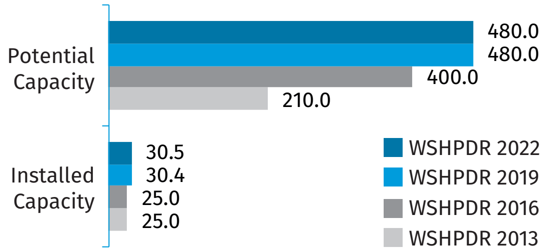
The biggest power infrastructure project in Tanzania in recent years is the 2,115 MW Nyerere hydropower plant, with construction ongoing as of 2021.[15] The project is expected to greatly boost electricity generation in the country upon completion, reducing both generation costs and end-user electricity tariffs.

Electricity tariffs for consumers in Tanzania are approved by the Energy and Water Utility Regulatory Authority (EWURA) and are divided into categories based on consumer type and electricity use. Service and energy charges were last reviewed in 2016, with the average tariff set at 250.62 TZS/kWh (0.11 USD/kWh).[16]

SMALL HYDROPOWER SECTOR OVERVIEW

Tanzania defines SHP plants as hydropower plants with an installed capacity below 10 MW. The installed SHP capacity of Tanzania is estimated at approximately 30.5 MW as of 2022, including isolated and off-grid SHP plants. The total estimated potential SHP capacity is 480 MW, indicating that approximately 6 per cent has been developed so far.[6,17,18,19] Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, installed SHP capacity increased marginally by less than 1 per cent due to a new SHP plant commissioned in 2019, while potential SHP capacity remained the same, owing to lack of up-to-date studies of SHP potential (Figure 3).[6]

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



Source: *WSHPDR 2019*,[6] Small Hydropower Centre Tanzania,[17] Michael,[18] Kassana et al.,[19] *WSHPDR 2013*,[20] *WSHPDR 2016*[21]

Most of the developed SHP projects in Tanzania are owned by private entities and are not connected to the national electricity grid. For many years, SHP development was promoted mainly by missionaries for provision of power to community facilities such as health centres, schools and vocational centres. Grid-connected SHP plants contribute just 15 MW of the total installed SHP capacity. Five SHP plants in the 300–8,000 kW range are owned by TANESCO, while faith-based groups operate more than 1,617 SHP plants, with a range of capacities from 15 kW to 800 kW and an aggregate capacity of 2 MW. A partial list of existing SHP plants in the country is displayed in Table 1, while several ongoing SHP projects are listed in Table 2.[17]

Table 1. **List of Selected Existing Small Hydropower Plants in Tanzania**

Name	*Location*	*Capacity (MW)*	*Operator*	*Launch year*
Tanapa-Arusha	Arusha	0.080	Arusha National Park	2019
Salala/Ludilu	Makete/Ludewa	0.068	Nishati Associate / Village Community	2017
Kiliflora	Arusha	0.280	Kiliflora Company LTD	2017
Tulila	Songea/Ruvuma	5.000	Benedictine Sisters of St. Agnes, Chipole	2016
Lilondo	Songea/Ruvuma	0.040	Village Community	2015

Name	*Location*	*Capacity (MW)*	*Operator*	*Launch year*
Iyovi	Kilosa/Morogoro	0.950	Private	2015
Mbangamao	Mbinga/Ruvuma	1.000	Andoya Hydroelectric Power Company	2015
Matombo	Matombo/Morogoro	0.020	Village community	2013
Mawengi	Ludewa/Njombe	0.300	RC Njombe diocese and village community	2013
Mwenga	Mufindi/Iringa	4.000	Mufindi Tea Company	2010
Mbingu	Ifakara/Morogoro	0.850	Mbingu Sisters Convent	2009
Kinko	Lushoto/Tanga	0.010	Village community	2006
Mavanga	Ludewa/Njombe	0.150	RC mission/Mavanga Village community	2002
Matembwe	Njombe	0.150	RC mission/CEFA/Matembwe Village	1986
Ngaresero	Arusha	0.015	M.H Leach	1982
Lugarawa	Ludewa/Njombe	0.140	RC Mission	1979
Kitai	Songea/Ruvuma	0.045	Prisons Dept/Government	1976
Ikonda	Makete/Njombe	0.040	RC Mission	1975
Nyagao	Lindi	0.016	RC Mission	1974
Isoko	Tukuyu/Mbeya	0.016	Moravian Mission	1973

Source: Small Hydropower Centre Tanzania,[17] Michael,[18] Kassana et al.[19]

Table 2. **List of Selected Ongoing Small Hydropower Projects in Tanzania**

Name	*Location*	*Capacity (MW)*	*Developer*	*Development stage*
Sunda Falls SHPP	Tunduru	3.000	Tunduru DC & CAMS SKY AFRICA	Feasibility study completed
Lupali SHPP	Njombe	0.640	Benedictine Sisters – Imiliwaha	Under construction
Ijangala SHPP	Makete	0.360	Tandala Diaconical Centre/Nishati Lutheran Investment	Under construction
Makurukuru SHPP	Lumeme River	0.350	Andoya Hydro Electric Company Ltd	Feasibility study completed
Mbulu SHPP	Mbulu	0.070	Arusha Technical College	Under construction

Source: Small Hydropower Centre Tanzania[17]

A number of surveys have been carried out assessing SHP potential in Tanzania. At least four different studies have identified hundreds of potential SHP sites in different parts of the country, with estimates of total potential capacity ranging between 77.76 MW and 408.12 MW. Considering a probable degree of overlap between these studies, the total potential SHP capacity in the country is somewhere in the 300–500 MW range, with 480 MW considered a reasonable upper limit.[17,18,19,22]

The most recent comprehensive assessment of the SHP potential in Tanzania was carried out by the World Bank in 2017 through its Energy Sector Management Assistance Program (ESMAP), under close supervision of the Rural Energy Agency. Several prospective SHP sites identified by ESMAP are listed in Table 3.

Table 3. **List of Selected Potential Small Hydropower Sites in Tanzania**

Name	*River*	*Connection*	*Potential capacity (MW)*
Momba I	Momba	Sumbawanga Minigrid	5.860
Mbagala	Mbagala	Masasi Minigrid	3.530
Mfizi II	Mfizi	Mpanda Minigrid	3.040
Lwazi	Lwazi	Sumbawanga Minigrid	2.100
Kitandazi II	Mbinga	Mbinga Minigrid	0.330

Source: ESMAP[23]

RENEWABLE ENERGY POLICY

While there is no comprehensive renewable energy policy in Tanzania, the Government has issued policy statements and legislation that include provisions in support of renewable energy. These include the Rural Energy Act of 2005, which established the Rural Energy Agency and Rural Energy Fund, as well as the Electricity Act of 2008, which established procedures for the diversification of generation sources. The SPPA/T framework established by EWURA provides additional regulatory support for small producers and is reviewed annually to reflect operating costs. As of 2018, a renewable energy feed-in tariff (REFIT) policy draft was under review by EWURA.[24]

Small-scale power producers (0.1–10 MW) based on RES are regulated by EWURA under the small power projects (SPP) framework, which assigns technology-specific standardized power purchase tariffs (SPPT) based on a capacity range. SPPTs effective as of May 2019 are displayed in Table 4.

Table 4. **Standardized Power Purchase Tariffs for Small Power Producers in Tanzania in 2019**

Capacity (MW)	*Price (USD/kWh)*				
	SHP	*Wind power*	*Solar power*	*Biomass*	*Bagasse*
0.10–0.50	0.1065	0.1082	0.1054	0.1015	0.0971
0.51–1.00	0.0990	0.0995	0.0984	0.0934	0.0909
1.01– 5.00	0.0895	0.0942	0.0924	0.0864	0.0856
5.01–10.00	0.0783	0.0888	0.0834	0.7600	0.0755

Source: EWURA[25]

Additionally, EWURA applies separate regulations to very small power projects (VSPPs) up to 100 kW, which are able to set retail tariffs without EWURA's approval. To qualify for the VSPP status, a project must meet several thresholds including a return on equity of 18.5 per cent, a debt-to-equity ratio of 70:30 and a depreciation period of 20 years, among others. SHP up to 100 kW must have a capacity factor of no less than 55 per cent to qualify for the VSPP status.[25,26]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

Tanzania has nine Basin Authorities, which in addition to other functions are responsible for issuing water permits to water users (including SHP developers and operators) as well as for annual fee collection from permit holders. The developer must submit project details to the relevant Basin Authority prior to the start of the project in order to receive the water use permit. After receiving the permit, the developer pays annual water use fees based on the volume of water used for power generation.

COST OF SMALL HYDROPOWER DEVELOPMENT

SHP projects in Tanzania are heavily reliant on imported technology and foreign expertise, driving up development costs. The 850 kW Ifumbo hydropower plant, constructed in 2008, carried a total project cost of USD 5.5 million, indicating a cost of USD 6,470 per installed kW. Funding for this project was largely provided by a Swiss donor.[27] The ongoing construction of the Kitewake SHP plant, with a total planned capacity of 5.39 MW, is expected to cost a total of USD 21 million, or 3,896 USD/kW. Meanwhile, two run-of-river cascades currently under construction in the Rift Valley and the Great Ruaha Basin, consisting of several plants and totalling 17 MW of planned capacity each, will cost USD 46 million and USD 65 million, with respective costs of 2,706 USD/kW and 3,824 USD/kW.[28] These numbers indicate a clear cost-saving trend as projects increase in scale.

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Observed and projected changes in the hydrological regime in Tanzania both point to an increase in surface runoff and precipitation in the coming decades. Climate projections under the RCP8.5 scenario indicate an increase of as much as 27 per cent in annual precipitation by the mid-21st century. Surface runoff is expected to increase by anywhere from 13 per cent to 94 per cent during the same period across the country, with certain watersheds experiencing an increase of up to 160 per cent.[29] While gradual increases in runoff could be beneficial for the long-term sustainability of hydropower generation in the country, extreme locally concentrated runoff events and flooding could pose a threat to hydropower infrastructure in those areas.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Tanzania is endowed with abundant SHP potential but most of the surveyed sites have not yet been developed. The major challenges hampering SHP development in the country are summarized below:

- Low financial sustainability for project developers including NGOs and municipal authorities;
- Lack of local expertise and human resource development in the SHP sector, additionally hampered by a framework that tends to concentrate knowledge and talent in government ministries and cause a lack of qualified third-party personnel at the local level, particularly in rural areas;
- Lack of local technology and manufacturing capacity for SHP;
- Inability of rural customers to bear the financial burden of power infrastructure development;
- Lack of long-term planning with regard to rural electrification;
- Insufficient information about potential sites and other hydrological data, with existing inventories not exhaustive or up-to-date;
- Inadequate development incentives and awareness of the benefits of SHP;
- Lack of joint ventures in the form of public-private partnerships.

Enablers for SHP development in Tanzania include the following:

- Substantial existing untapped SHP potential across the country;
- Abundant water resources and stable prospects for water resource exploitation even in the face of climate change;
- Existing studies and surveys mapping hundreds of potential SHP sites;
- Substantial national experience with SHP development and generation;

- Government policy supportive of off-grid generation and small power plants as the primary means of rural electrification.

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Uganda

George Kimbowa, Wageningen University and Busitema University

KEY FACTS

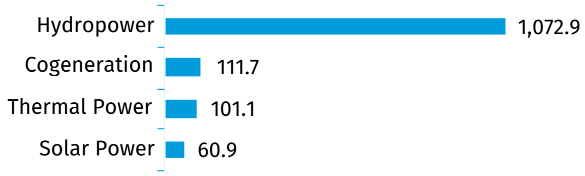
Population	44,269,594 (est. 2020)[1]
Area	241,551 km^2 [2]
Topography	The topography of Uganda mainly consists of a plateau with heights ranging from 800 metres to 2,000 metres. The country is bounded by several mountain ranges including the Rwenzori Mountains along the western border, with Margharita Peak on Mount Stanley, the third highest in Africa, rising to 5,109 metres, and Mount Elgon rising to 4,320 metres. The Western Rift Valley runs north to south through the western half of the country. The lowest point in Uganda is at 621 metres on the surface of Lake Albert.[3]
Climate	Uganda has a generally warm, tropical climate varying from a rainforest/monsoon climate in the south-east to a savannah climate in the north. The country's mean annual temperature is approximately 26 °C, with maximum temperatures between 18 °C and 31 °C and minimum temperatures between 15 °C and 23 °C. Temperatures are lower in the south-west and higher in the north and north-east, where the country experiences semi-arid conditions. Seasonally, temperatures are coolest between June and August and warmest from December to May.[4,5]
Climate Change	Climate change projections for Uganda vary according to different scenarios, but an increase by 1.5–2.0 °C is projected by the 2060s and by as much as 2.5 °C by the 2090s under RCP4.5, relative to the 2010s. Under RCP8.5, an increase of as much as 5.0 °C is projected by the 2090s.[6]
Rain Pattern	Uganda receives an annual rainfall ranging from 400 mm for the eastern Karamoja region to 2,800 mm for the Lake Victoria and Mountain Elgon regions, with an average of 1,180 mm.[6,7] The country experiences two rainy seasons, with heavy rains from March to May and lighter rains from October to December. The dry seasons are from December to February and from June to August.[4]
Hydrology	Most of Uganda belongs to the Nile drainage basin, except a small portion in the north-east of the country that drains into the Lake Turkana and Lotikipi basins in Kenya. Approximately 16 per cent of the total land area of the country is covered by wetlands and open water, with the south-east dominated by Lake Victoria, the source of the White Nile River, which extends into neighbouring Kenya and Tanzania.[7] The White Nile flows north, connecting Lake Victoria, Lake Kyoga in Central Uganda and Lake Albert on the border with the Democratic Republic of the Congo.[2] The Albert Nile flows northwards out of Lake Albert into South Sudan. Other major waterbodies in Uganda include Lake George and Lake Edward, located along with Lake Albert in the western arm of the East African Rift Valley. Most of the lakes in Uganda are transboundary, with the exception of Lake Kyoga and Lake George.[8]

ELECTRICITY SECTOR OVERVIEW

Uganda is endowed with a variety of natural energy resources, including both renewable and non-renewable energy sources such as hydropower, biomass, solar power, geothermal power, peat and fossil fuels. Biomass is the predominant energy type in Uganda, accounting for 94 per cent of the country's total energy consumption. In terms of power generation, the renewable energy power generation potential of Uganda is estimated at 5,300 MW. This includes over 2,000 MW of hydropower potential, 1,650 MW of biomass cogeneration potential and 450 MW of geothermal power potential. Uganda additionally has considerable peat reserves estimated at 250 million tons and an average daily irradiation of 5.1 kWh/m^2.[9]

The total installed capacity in Uganda was 1,346.6 MW in 2021, including hydropower with 1,072.9 MW (approximately 80 per cent of the total), bagasse-fired cogeneration plants with 111.7 MW (8 per cent), thermal power with 101.1 MW (8 per cent), and grid-connected solar power with 60.9 MW (5 per cent) (Figure 1).[10] Over the last 20 years the installed capacity of Uganda has more than tripled, amounting to just 400 MW in 2000. By mid-2022, total installed capacity in the country was expected to increase by another 600 MW with the upcoming commissioning of the Karuma hydropower plant.[11,12]

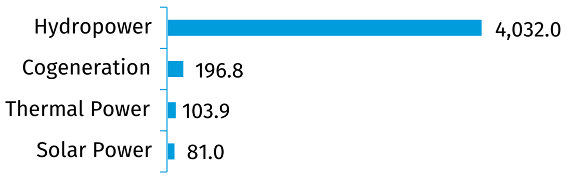
Figure 1. **Installed Electricity Capacity by Source in Uganda in 2021 (MW)**



Source: ERA[10]

In 2019, total generated electricity amounted to 4,413.7 GWh, with hydropower accounting for 4,032.0 GWh (91 per cent of the total), cogeneration for 196.8 GWh (4 per cent), thermal power for 103.9 GWh (approximately 2 per cent) and solar power for 81.0 GWh (less than 2 per cent) (Figure 2). While overall electricity generation has been rising steadily since 2015, the contribution of thermal power has been on the decline since 2017, underlining the ongoing shift towards renewable energy sources, particularly, the expansion of hydropower and solar power[13]

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

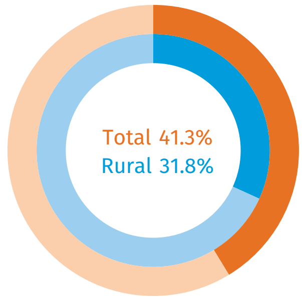


Source: ERA[13]

The single bulk supplier of electricity in Uganda, Uganda Electricity Transmission Company Limited (UETCL), purchased 4,329.4 GWh of electricity during the 2019/2020 fiscal year and sold 4,171.4 GWh, with transmission losses (approximately 4 per cent) accounting for the difference. Electricity sales are partially driven by exports to neighbouring countries including Kenya, Tanzania, Rwanda and the Democratic Republic of the Congo. During the 2019/2020 fiscal year, electricity exports amounted to 220.8 GWh, a 7 per cent decrease from the previous fiscal year.[14] The decline in exports was largely caused by declining demand in Kenya, which has been improving domestic generation and transmission capacities in the regions importing electricity from Uganda. The previous high demand in Kenya for electricity from Uganda was driven in part by an earlier price reduction of nearly 50 per cent on electricity from the latter. As such, Uganda has been gradually losing revenue from electricity exports.[15]

According to the World Bank estimates, the national rate of access to electricity in Uganda was 41 per cent in 2019, with almost 71 per cent access in urban areas and 32 per cent in rural areas (Figure 3). Access to electricity has been improving rapidly over the last few years, having stood at 19 per cent nationwide in 2015.[16] However, Uganda still has one of the lowest levels of per capita electricity consumption in the world at 215 kWh per year, compared to the Sub-Saharan Africa average of 552 kWh per capita and the world average of 2,975 kWh per capita.[17] Electricity consumption is dampened by significant electricity export volumes.

Figure 3. **Electrification Rate in Uganda in 2019 (%)**



Source: World Bank[16]

The demand for electricity has been growing at an average annual rate of 10–12 per cent. The number of customers connected to the grid has also been increasing rapidly, from a total of 801,667 in 2015/2016 to 1,620,505 in 2019/2020, driven primarily by the expansion of connectivity in the domestic sector.[17,18] Domestic peak demand had declined in 2020 from an average of 650 MW to approximately 530 MW due to the impact of the COVID-19 pandemic, but recovered later in the year and reached a maximum value of 689 MW in December.[15,19] In anticipation of growing demand, the Government has undertaken several large hydropower projects, including the aforementioned ongoing 600 MW Karuma hydropower project, as well as the 183-MW Isimba Falls hydropower plant commissioned in 2019.[20] A key element in the energy sector policy of Uganda is the Uganda Vision 2040 strategic plan, which identifies electricity generation as a key intervention for ensuring the socioeconomic transformation of the country. With Uganda having met the 2020 target of 30 per cent electricity access, the plan aims to reach 80 per cent access by 2040, targeting an increase of approximately 6 per cent year-on-year.[2]

Prior to 2001, all generation, transmission, distribution, sale, import and export of electricity in Uganda was managed by the Uganda Electricity Board (UEB), a mandated monopoly. In 2001, UEB was unbundled into three separate companies in line with the stipulations of the Electricity Act of 1999. The Uganda Electricity Generation Company Limited (UEGCL), the UETCL, and the Uganda Electricity Distribution Company Limited (UEDCL) are now each responsible for generation, transmission and distribution of electricity, respectively. In addition to UEGCL, generation is also carried out by a number of independent power producers (IPPs), including Eskom Uganda Limited and public-private partnerships (PPPs). Private companies also play a significant role in electricity distribution. These include Umeme Limited, West Nile Rural Electrification Company (WENRECo), Bundibugyo Electricity Cooperative Society (BECS), Kyegegwa Rural Energy Co-operative Society (KRECS), Pader-Abim Community Multi-Purpose Electric Co-operative Society (PACMECS), Kilembe Investments Limited (KIL), Hydromax and Kalangala Infrastructure Services Limited (KIS). The emergence of private distribution companies in recent years has been one of the factors behind the significant rise in electricity access across the country.[11,21]

The Electricity Regulatory Authority (ERA), established in 2000, is the legal supervisor of the electricity sector and is mandated by the Electricity Act of 1999 to issue licences for electricity generation, transmission, distribution, sale, import and export, in addition to establishing a tariff structure and approving rates of charges, among other functions. The UETCL negotiates prices with power generation companies through power purchase agreements (PPAs) subject to approval by the ERA. Power is sold to distribution companies at a bulk supply tariff (BST), reflective of the power purchase and transmission costs. The distribution companies then sell electricity to the end users in line with an ERA-approved tariff schedule. The setting and approval of end-user electricity tariffs considers changes in macro-economic factors such as fluctuations in international fuel prices, the variation of the currency exchange rate (UGK/USD), local and international inflation levels and energy generation mix.[1,21,22]

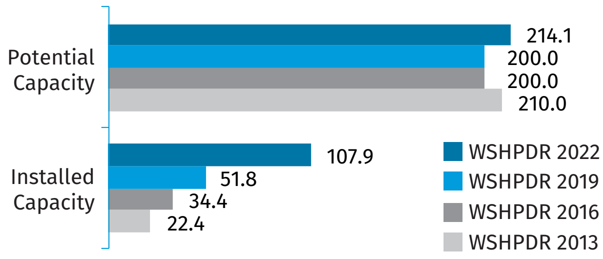
The largest electricity distribution agency in Uganda is Umeme Limited. Tariffs for end users purchasing electricity from Umeme Limited are updated quarterly, with tariffs for the period July–September 2021 ranging from 177.5 UGX/kWh (0.05 USD/kWh) to 816.9 UGX/kWh (0.23 USD/kWh).[23]

SMALL HYDROPOWER SECTOR OVERVIEW

The definition of small hydropower (SHP) in Uganda is hydropower plants with an installed capacity of up to 20 MW.[2] However, for the purposes of comparison with the *World Small Hydropower Development Report (WSHPDR) 2019*, the up to 10 MW definition of hydropower will also be referred to in the current chapter.

In Uganda, SHP plants are largely privately owned and operated by IPPs, with some supplying electricity to isolated grids. As of 2022, 25 SHP plants up to 20 MW were operating in Uganda with a total installed capacity of 186.0 MW. Of these, 20 plants were up to 10 MW, with a total installed capacity of 107.9 MW.[2,10,21,24] The most recent estimate of potential capacity for SHP of up to 20 MW was approximately 400 MW, while potential capacity for plants up to 10 MW is estimated at 214.1 MW, based on the combined total of existing SHP plants, ongoing projects and identified potential SHP sites.[2,21,25-27] This suggests that approximately 50 per cent of estimated SHP potential has already been developed in the country. Compared to the *WSHPDR 2019*, the installed capacity of SHP up to 10 MW in Uganda has more than doubled, due to the construction of many new SHP plants in recent years (Table 1). Meanwhile, the estimate of potential capacity for SHP up to 10 MW increased by approximately 7 per cent, due to more accurate data on existing SHP plants and planned projects (Figure 4).[27]

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



Source: Nabutsabi,[2] van der Ven,[21] *WSHPDR 2019*,[27] *WSHPDR 2013*,[28] *WSHPDR 2016*[29]

Note: Data for SHP of up to 10 MW.

Table 1. **List of Selected Existing Small Hydropower Plants in Uganda**

Name	*Location*	*Capacity (MW)*	*Plant type*	*Operator*	*Launch year*
Kikagati	Isingiro District	15.57	Reservoir	Kikagati Power Company (KPC)	2022
Nyamasagani 1	Kyarumba, Kasese District	15.00	Run-of-river	Rwenzori Hydro (PVT) Ltd	2021
Nyamasagani 2	Kyarumba, Kasese District	6.00	Run-of-river	Nyamagasani 2 HPP Ltd	2021
Siti II Hydroelectric Power Station	Chesowari, Bukwo District	16.50	Run-of-river	Elgon Hydro Siti (Pvt) Limited	2019
Ziba-Kyambura Hydroelectric Power Station	Rubirizi District	7.60	Run-of-river	Ziba (U)	2019
Ndugutu Hydroelectric Power Station	Bundibugyo District	5.90	Run-of-river	Sindila Power Company Uganda Limited	2019
Sindila Hydroelectric Power Station	Bundibugyo District	5.25	Run-of-river	Sindila Power Company Uganda Limited	2019
Nkusi power station	Kyangwali, Hoima District	9.60	Run-of-river	PA Technical Services	2018
Nyamwamba Power Station	Kilembe, Kasese District	9.20	Run-of-river	South Asia Energy Management Systems (EMS) LLC	2018
Lubilia Power Station	Kawembe, Kasese District	5.40	Run-of-river	Lubilia Kawembe Hydro Limited	2018
Waki Power Station	Butiaba, Masindi District	4.80	Run-of-river	Hydromax Ltd	2018

Name	Location	Capacity (MW)	Plant type	Operator	Launch year
Mahoma Power Station	Mahoma, Kabarole District	2.70	Run-of-river	Mahoma Uganda Limited	2018
Bwindi	Buhoma, Kanungu District	0.06	N/A	Bwindi Community Micro Hydro Power Ltd	2018
Muvumbe power station	Maziba, Kabale District	6.50	Run-of-river	Muvumbe Hydro (U) Ltd	2017
Rwimi power station	Rwimi, Bunyangabu District	5.54	Run-of-river	Rwimi EP Company Limited	2017
Siti I Hydroelectric Power Station	Siti, Bukwo District	5.00	Run-of-river	Elgon Hydro Siti (PVT) Limited	2017
Kabalega Power Station/ Buseruka	Buseruka, Hoima District	9.00	Reservoir	Hydromax Ltd	2013
Nyagak power station	Paidha, Zombo District	3.50	Run-of-river	WENRECo	2012
Mpanga Power Station	Mpanga, Kamwenge district	18.00	Run-of-river	Africa Energy Management Systems EMS Mpanga Ltd.	2011
Kanungu Hydroelectric Power Station/ Ishasha	Kanungu, Kanungu district	6.60	Run-of-river	Eco Power Uganda Limited.	2011

Source: Nabutsabi,[2] ERA,[10,30] van der Ven,[21] Frontier Energy,[31,32] AKDN,[33] KHPL,[34] African Power Platform[35]

Table 2. **List of Selected Ongoing Small Hydropower Projects in Uganda**

Name	Location	Capacity (MW)	Plant type	Developer	Planned launch year
Agbinika	Yumbe, Yumbe District	20.0	Run-of-river	N/A	2025
Nyagak II	Paidha, Zombo District	5.0	Run-of-river	UEGCL	2023
Achwa III	Achwa, Gulu District	10.0	Run-of-river	N/A	2022
Nengo Bridge	Nengo, Rukungiri District	6.7	Run-of-river	Jacobsen Elektro AS	2022
Nyagak III	Paidha, Zombo District	5.6	Run-of-river	UEGCL	2022

Source: van der Ven,[21] *WSHPDR 2019*,[27] Katutsi et al.[36]

In recent years, intensive SHP construction has been taking place in Uganda. As of 2020, there were 20 SHP projects in various phases of completion with a total potential capacity of 141.8 MW, of which 91.8 MW were for SHP of up to 10 MW; however, by 2022 three of these projects had been completed, including the 6 MW Nyamasagani-2 SHP plant, leaving the remaining undeveloped capacity up to 10 MW at 85.8 MW. Additionally, 20 potential SHP sites of up to 10 MW have been identified with a total estimated potential capacity of approximately 20.4 MW.[10,21,24-27] Several ongoing SHP projects and identified potential SHP sites are listed in Tables 2 and 3, respectively.

Table 3. **List of Selected Potential Small Hydropower Sites in Uganda**

Name	Location (district)	Potential capacity (MW)	Type of site (new or refurbishment)
Kaka	Kasese	7.20	New, preliminary technical studies carried out under Greenewus Energy Africa Ltd
Rwizi	Mbarara	1.00	New, preliminary technical studies carried out under Ntama Bamwine Hydropower Company Ltd.
Nyahuka	Bundibugyo	0.65	New, preliminary technical studies carried out under AERDP by MEMD
Sezibwa	Mukono	0.50	New, preliminary technical studies carried out under AERDP by MEMD
Tokwe	Bundibugyo	0.40	New, preliminary technical studies carried out under AERDP by MEMD

Source: ERA,[25] CSTD,[26] *WSHPDR 2019*[27]

The cost of SHP development in Uganda is considerable, averaging approximately USD 3–4 million per installed MW.[2] Nevertheless, SHP development is considered an important element of poverty reduction efforts in Uganda, especially for isolated rural communities suffering from poor or non-existent connectivity to the national grid.

RENEWABLE ENERGY POLICY

The Renewable Energy Policy of Uganda, adopted in 2007, aims to increase the use of modern renewable energy sources through the introduction of the feed-in tariff (FIT) remuneration mechanism and standardization of PPAs. The objective is to encourage both individual investors and companies to invest in renewable energy generation in Uganda. The policy mandated the publication of a standardized PPA with FITs determined periodically; the creation of a renewable energy department; promotion of biofuel cultivation, in collaboration with the National Forestry Authority (NFA) and Ministry of Agriculture, Animal Industry and Fisheries (MAAIF); and the development of appropriate legislation and financial incentives for the production of biofuels.[37]

Renewable Energy Feed-in Tariffs (REFITs) introduced under the Renewable Energy Policy apply to renewable energy power plants of installed capacity of 0.5–20 MW, including

SHP plants. However, to qualify for REFIT, renewable energy projects must be connected to the national grid and must represent the development of additional capacity, whether on existing power plants or through the construction of a new power plant. Existing capacities are thus excluded from applying for support under the REFIT programme. The REFIT should be able to translate into cash revenue that will not require the investor to resort to a capital subsidy and be included in the standardized PPA. Initially, REFITs were structured to differentiate between peak, shoulder and off-peak prices, to reflect the higher value of power in the peak period, as well as between short-to-medium and long-term prices to reflect the higher risk of load shedding in the short to medium term. Subsequently, REFITs were simplified to a single rate based on installed capacity only.[2,37,38]

For the period 2021-2023, base REFIT tariffs for hydropower of 0.5–20 MW were set as follows, with a 20-year guaranteed payment period:

- 0.5–5 MW: 0.0792 USD/kWh;
- 5–10 MW: linear tariff structure ranging from 0.0751-0.0792 USD/kWh, with each 0.1 MW increment assigned a progressively lower tariff;
- 10–20 MW: 0.0751 USD/kWh.[38]

Further financial support for renewable energy projects became available with the adoption of the Global Energy Transfer Feed-in-Tariff (GET-FIT) in 2013. The GET-FIT is applied on top of the REFIT as a result-based subsidy on a per kWh basis, to cover the difference between the REFIT and the Levelized Cost of Electricity (LCOE). GET-FIT is assigned in the form of grants through a competitive bidding process.[2,39] The significant recent improvements in the distribution and access to electricity in Uganda are in large part owed to the favourable regulatory environment created by the Renewable Energy Policy.

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

Developers of renewable energy sources apply for a generation licence or licence exemption with the ERA and applications are processed within a maximum of 180 days following submission. Additional licensing bodies include the Directorate of Water Resources Management (DWRM) for the water abstraction permit; the National Environment Management Authority (NEMA) for the environmental permit; and UETCL, which concludes the PPA agreement with the power producer. The licensing process for SHP also involves the publication of notices in the National Gazette and the national newspaper to solicit any potential objections to the project from other potential stakeholders. The Hydro Power Association of Uganda (HPAU), a non-profit organization that brings together private hydropower development companies in Uganda, is involved in the promotion of and lobbying efforts for SHP.[40,41]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Climate change projections for Uganda under RCP4.5 predict little change in annual precipitation, with fluctuation within the range of ±10 per cent by 2065–2095, relative to 2015. Seasonally, large increases in winter rainfall of upwards of 100 per cent are possible, while regionally, a decrease of up to 20 per cent is likely in the Lake Victoria area. Under RCP8.5, significant decreases of up to 30 mm per month are possible in the southern part of the country by 2065–2095.[6] As Uganda is heavily dependent on hydropower, fluctuations and changes in regional precipitation distribution could have potentially far-reaching effects. In 2003–2007, a particularly severe drought decreased hydropower generation in the country by over 60 per cent.[2] According to some calculations, available hydropower capacity may decline by as much as 26 per cent by 2050 relative to 2025, although other models predict an increase of approximately 15 per cent over the same period. The uncertainty of projections suggests that the impact of climate change on hydropower will be manageable as long as the Government maintains course with its current large-scale expansion plan in the sector.[6]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Although the development of SHP in Uganda has accelerated in recent years, it still faces a number of significant obstacles, including the following:

- Access to electricity primarily hampered by poor transmission and distribution infrastructure despite growth of generation capacity;
- Potential for adverse environmental impacts due to institutional and legal weaknesses, in particular poorly implemented environmental and social impact assessments (ESIA);
- Bureaucratic, complex and slow land acquisition process that affects overall project costs and timely construction of transmission line infrastructure;
- Limited local manufacturing capability for hydropower equipment as well as insufficient implementation experience and technical capacity;
- The need for substantial upfront investment capital;
- Social concerns including the resettlement and compensations for populations affected by development projects.

Factors enabling SHP development in Uganda include:

- The ‘unbundling’ of the state-owned Uganda Electricity Board (UEB);
- The establishment of a Rural Electrification Agency (REA) by the Government of Uganda to promote on-grid and off-grid rural electrification led by the private sector;
- Government investment in least-cost power technologies to provide adequate and reliable service;

- Collaboration with the East African Community on regional power interconnection;
- Conducive regulatory environment and incentives aimed at diversifying the country's generation mix.

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Zambia

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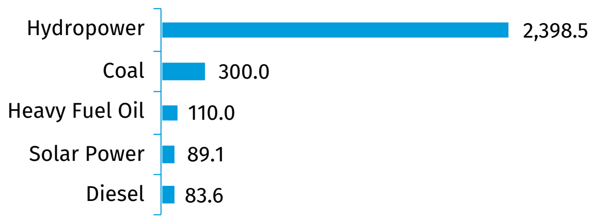
KEY FACTS

Population	17,885,422 (2020)[1]
Area	752,612 km²[2]
Topography	The country is located on the great plateau of Central Africa, at an average altitude of 1,200 metres and rises to a higher plateau in the east. The country has three main topographical features: mountains, with an altitude of at least 1,500 metres; a plateau, with an altitude ranging from 900 metres to 1,500 metres; and lowlands, with an altitude of 400–900 metres.[3]
Climate	There are three seasons in Zambia: cool and dry from May to August, hot and dry from September to November and warm and wet from December to April. In the warm wet season, frequent heavy showers and thunderstorms occur. Average temperatures are moderated by the height of the plateau. In the cool season maximum temperatures vary from 15 °C to 27 °C, with morning and evening temperatures as low as 6–10 °C and occasional frost on calm nights in valleys and hollows which are sheltered from the wind. During the hot season maximum temperatures range from 27 °C to 35 °C.[4]
Climate Change	Zambia has continued to experience climate change and climate variability. The projected climate change impacts include: rises in temperature, shifts in precipitation and possible increases in the frequency and intensity of weather events. The country has experienced some of its worst droughts and floods in the last two decades. The mean annual temperature in Zambia has increased by 1.3 °C since 1960, representing an average increment rate of 0.29 °C per decade. Meanwhile, the mean annual rainfall over the country has decreased by an average rate of 1.9 mm per month (2.3 per cent) per decade since 1960. The mean annual temperature is projected to increase by 1.2–3.4 °C by the 2060s and by 1.6–5.5 °C by the 2090s. The proportion of total rainfall coming from extreme precipitation events, sometimes resulting in flooding, is expected to increase. The future trends in the country are towards higher average temperature, erratic precipitation and possible decrease in total rainfall.[3]
Rain Pattern	Zambia receives moderate rainfall ranging from an annual average of approximately 600 mm in the south of the country to over 1,400 mm per year in the north. The country's annual average rainfall is 1,000 mm. The rainfall pattern over the whole country is similar, with most precipitation falling between November and March, but the amount of rain varies considerably. In the north of the country rainfall is 1,250 mm or more a year, decreasing southwards to Lusaka where it is approximately 750 mm annually. South of Lusaka rainfall is dictated more by the east and south-east trade winds. Rainfall in this area is 500–750 mm.[5]
Hydrology	The country has five main rivers: Zambezi, Kafue, Luangwa, Luapula and Chambeshi. The five main river basins incorporate the several small river basins at which small hydropower potential is vast. The country's major lakes are Tanganyika, Mweru, Mweru Wa Ntipa, Bangweulu and the artificial lakes include Kariba and Itezhi-tezhi. Large hydropower plants are mainly located in the lower areas of the above catchments, while the small hydropower potential is mainly concentrated in the upper areas.[3,6]

ELECTRICITY SECTOR OVERVIEW

The electricity generation mix in Zambia is predominantly made up by hydropower. In the fourth quarter of 2019, of the total installed capacity of 2,981 MW hydropower accounted for 80 per cent (Figure 1). The remainder of the generation mix was composed of coal (300 MW, 10 per cent), heavy fuel oil (110 MW, 4 per cent), solar power (89 MW, 3 per cent) and diesel (84 MW, 3 per cent).[7]

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

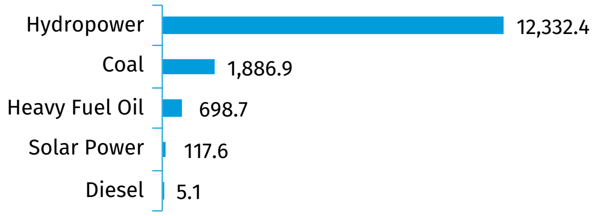


Source: ERB[9]

In 2019, the country's installed capacity increased to 2,981.2 MW from 2,898.2 MW in 2018, representing a near 3 per cent increase. This was mainly attributed to the commissioning of the 54.3 MW Bangweulu and 34 MW Ngonye solar power plants as well as the 67 kW of solar-powered micro-grids. On the other hand, the Zambia Electricity Supply Corporation (ZESCO) decommissioned 5.28 MW of diesel power plants, including: Kabompo (2.0 MW), Zambezi (1.4 MW), Mufumbwe (0.8 MW), Lukulu (0.3 MW) and Chavuma (0.8 MW). The diesel decommissioning was largely motivated by the connecting of the districts to the national grid.[9]

Despite the increase in installed capacity, the generation sent out to the grid declined from 16,189 GWh in 2018 to 15,040 GWh in 2019, reflecting a 7 per cent decrease. This was due to a poor rainfall pattern recorded in the 2018/2019 rainy season. Of the total generation in 2019, hydropower accounted for 82 per cent (Figure 2).[9]

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



Source: ERB[9]

The electricity industry in Zambia is governed by the Electricity Act of 1995 and the Electricity Amendment Act of 2003. The electricity industry was liberalized in 1995 to attract investment in power generation, transmission and distribution. Currently, it consists of the vertically integrated public utility company ZESCO Limited, independent power producers (IPPs) and power distribution companies. These entities are responsible for the generation, transmission, distribution and supply of electricity. Private sector players that provide services include Copperbelt Energy Corporation (CEC), Lunsemfwa Hydro Power Company, Maamba Collieries Ltd and Zengamina.

ZESCO owns the four main hydropower plants located in the southern part of the country: 990 MW Kafue Gorge, 720 MW Kariba North Bank, 108 MW Victoria Falls and the newly commissioned 120 MW ITT. A fifth large hydropower plant is owned by Itezhi Tezhi Power Corporation (120 MW). The country also has operational small hydropower (SHP) plants with a combined installed capacity of 89.8 MW and owned by ZESCO and IPPs.[9]

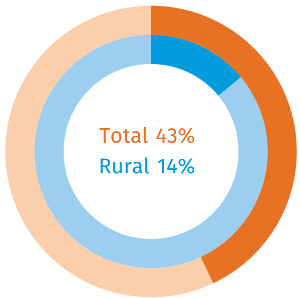
The electricity sector is overseen by the Ministry of Energy (MoE), which provides policy guidance, while the Office for Promoting Private Power Investment (OPPPI) has the role of promoting private investment in power projects. The sector is regulated by the Energy Regulation Board (ERB), which is responsible for licensing, tariff setting and monitoring the quality of supply and service standards. The Rural Electrification Authority (REA) is a statutory body that was created through the enactment of the Rural Electrification Act 2003 to increase access to electricity in rural areas.[9]

The general outlook for the electricity industry in Zambia is positive both in the short and long term. To address the current power deficit, ZESCO established a special purpose vehicle (SPV), Kafue Gorge Lower Power Development Corporation (KGLPC), to spearhead the construction of the 750 MW Kafue Gorge Lower hydropower plant at an estimated cost of USD 2.2 billion. The first unit of the plant was commissioned in July 2021.[8]

Zambia is divided into 10 provinces: Central, Copperbelt, Western, Eastern, Luapula, Lusaka, Muchinga, Northern, North-Western and Southern. Copperbelt and Lusaka are the only provinces with access to electricity above 50 per cent, while many other provinces have 10 per cent or less.[9]

In 1994, the Government established the Rural Electrification Fund (REF) by committing the sales tax to electricity and has been trying to increase the electrification rate in rural areas by executing projects funded by REF. At that time, the household electrification rate was approximately 20 per cent countrywide, and only 2–3 per cent in rural areas. As of 2019, 43 per cent of the population had access to electricity, and 14 per cent of rural population had access (Figure 3).[11]

Figure 3. **Electrification Rate in Zambia in 2019 (%)**



Source: World Bank[11]

The Government has been strengthening policies and institutions related to rural electrification. In December 2003, the Rural Electrification Act was ratified to establish the REA and to improve the management of the REF.[10] The Government, through the Rural Electrification Master Plan (REM), has set a target to increase electrification rates to 66 per cent of households by 2030, of which 90 per cent would be for urban areas and 51 per cent for rural areas.[12]

Despite the country's vast renewable and non-renewable energy sources, few of these have been developed to improve the attractiveness of the energy sector and to transfer the benefits for industrial expansion, employment creation and poverty reduction.[11,12] The development of large hydropower plants in Zambia has historically been driven by the industrial needs of energy for mining, whereas SHP development has historically been initiated to provide power to areas that are far from the national grid, areas that were extending from the Southern Province towards the Copperbelt.

ZESCO transmits power at various voltage levels, namely 330 kV, 220 kV, 132 kV, 88 kV and 66 kV.[13] These voltage levels are stepped down to 33 kV and 11 kV for distribution at substations. The main 330 kV transmission lines are running north to south in the middle of the country because the copper mines, which are the largest load centres, are located in the north and the main generation plants are located in the south. Copperbelt Energy Corporation (CEC) has most of the mining and large industrial customers, who are supplied at 66 kV or higher voltage in Copperbelt Province, while small customers within the CEC service area are supplied by ZESCO. In 2019, ZESCO recorded annual average transmission and distribution losses of 5 per cent and 11 per cent, respectively.[9] In off-grid locations, small IPPs and non-governmental organizations (NGOs) are supplying electricity with either SHP or diesel power plants through the isolated distribution network.

The country has made progress in gravitating towards cost-reflective electricity tariffs through an upward adjustment of tariffs by 75 per cent implemented in 2017, following the electricity crises of 2015 and 2016. This is after Zambia was identified as having the lowest electricity tariffs in sub-Saharan Africa in 2014.[13] In 2019, the ERB commissioned a cost-of-service study to establish the efficient cost of supplying power to various customer categories and determine the cost-reflective tariff levels.[7,14] The 2020 tariff rates for residential customers, commercial customers and social services are reflected in Table 1. Fixed monthly charges were abolished in 2020.[15]

Table 1. **Electricity Tariffs in Zambia in 2020**

Customer category	*Consumption band (kWh/month)*	*Final electricity price (ZMW (USD) per kWh)*
Residential	R1 < 100	0.47 (0.026)
	R2 101 – 300	0.85 (0.047)
	R3 > 300	1.94 (0.110)
Commercial	C1 < 200	1.07 (0.059)
	C2 > 200	1.85 (0.100)
Social Services	Schools, hospitals, orphanages, churches, water pumping & street lighting	1.19 (0.066)

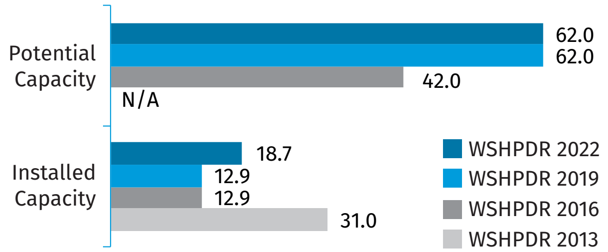
Source: Energy Regulation Board[15]

SMALL HYDROPOWER SECTOR OVERVIEW

Zambia classifies SHP plants as units between 0.5 MW and 20 MW. Plants less than 0.5 MW are regarded as micro-hydropower plants. Plants from 20 MW to 100 MW are classified as medium hydropower plants and those having installed capacities greater than 100 MW as large hydropower plants. Despite the national definition, this chapter takes the 10 MW definition, keeping consistent with previous editions of the *World Small Hydropower Development Report* (*WSHPDR)* for reasons of accurate comparison.

Based on the up to 10 MW definition, there are 18.7 MW of SHP capacity. The increase in installed capacity compared to the *WSHPDR 2019* is mainly attributed to the commissioning of the 10 MW Musonda and 0.64 MW Kasanjiku SHP plants in 2020. There has been no change in potential capacity estimates (Figure 4).

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



Source: ERB,[7,14,16] JICA,[10] Ministry of Energy and Water Development,[11] ZESCO LTD,[12] *WSHPDR 2013*,[17] *WSHPDR 2016*,[18] *WSHPDR 2019*[19]

Note: Data for SHP up to 10 MW.

The SHP sector in Zambia is currently undergoing a rehabilitation transformation, with the scaling-up of old plants and development of new plants being in various stages of project development. As of 2021, based on the local definition of SHP up to 20 MW, the total installed capacity for micro- and small hydropower plants stood at 60.5 MW (Table 2).[9] ZESCO Ltd is currently rehabilitating two SHP plants: the Chishimba plant is being rehabilitated and upgraded from 6 MW to 15 MW and the old Lusiwasi 12 MW plant is being replaced by new plants upstream and downstream with capacities of 15 MW and 86 MW. The Musonda plant was upgraded from 6 MW to 10 MW in 2020. In 2019, REA commissioned the 0.64 MW Kasanjiku plant in Mwinilunga district.[20]

Table 2. **List of Installed Small Hydropower Plants in Zambia**

Name	*Location*	*Capacity (MW)*	*Head (m)*	*Plant type*	*Operator*	*Launch year*
Musonda	Mansa	10.000	29	Run-of-river	ZESCO	2020
Lusiwasi Upper 11	Serenje	15.000	90	Run-of-river	ZESCO	2020
Kasanjiku13	Mwinilunga	0.640	10	Run-of-river	REA	2019
Lunzua	Mbala	14.800	248	Run-of-river	ZESCO	2015
Shiwang'andu	Shiwang'andu	1.000	14	Run-of-river	ZESCO	2012

Name	*Location*	*Capacity (MW)*	*Head (m)*	*Plant type*	*Operator*	*Launch year*
Zengamina	Ikelenge	0.750	17	Run-of-river	Zengamina Power Company	2007
Mporokoso	Mporokoso	0.005	3	Run-of-river	Private Local Developer	2007
Mayukwayukwa (not operational since 2015)	Kaoma	0.028	2	Run-of-river	UNHCR	1993
Mutanda	Solwezi	0.003	–	Run-of-river	Mutanda Evangelical Centre	1990
Sachibondu	Mwinilunga	0.015	–	Run-of-river	Private Local Developer	1987
Lwawu	Mwinilunga	0.050	–	Run-of-river	Lwawu Mission	1984
Mangango	Kaoma	0.017	–	Run-of-river	Mangango Mission	1960
Lusiwasi	Serenje	12.000	90	Run-of-river	ZESCO	1967 (1974)
Chishimba	Kasama	6.000	–	Run-of-river	ZESCO	1959 (1971)
Nyang'ombe	Mwinilunga	0.073	–	Run-of-river	Nyang'ombe Cooperative	–
Katibunga	Katibunga	0.080	–	Run-of-river	Katibunga Mission	–

Note: Based on Zambian SHP definition of up to 20 MW.

Source: ERB,[7,16] JICA,[10] Ministry of Energy and Water Development,[11] ZESCO LTD[14]

With electricity demand in Zambia projected to increase at a rate of approximately 4 per cent per annum and given the current national and regional power deficit, there is need to deal with various bottlenecks in the hydropower development process in Zambia.[21] ZESCO hydropower database, updated in 2016, indicates that the statistics of theoretical hydropower potential was on the order of 8,000 MW.[14] However, only 30 per cent of this potential has been developed to date.[11] Several SHP plants are in planning at various stages of development (Table 3).

Table 3. **List of Selected Planned Small Hydropower Projects in Zambia**

Name	*Location*	*Capacity (MW)*	*Head (m)*	*Plant type*	*Developer*	*Stage of development*
Mumburuma	Mporokoso	18.8	33.1	Run-of-river	ZESCO	Pre-feasibility
Chishimba	Kasama	15.0	–	Run-of-river	ZESCO	Implementation
Mbulumotuta	Mporokoso	12.3	87	Run-of-river	TBA	Pre-feasibility
Kapamba	Mpika	12.0	175	Run-of-river	TBA	Feasibility
Kakonko	Kawambwa	8.0	73	Run-of-river	ZESCO	Pre-feasibility

Source: ZESCO,[22] UNIDO,[23] OPPPI,[24] Hangzhou Guowang Technology Co. Ltd.,[25] JICA[12]

RENEWABLE ENERGY POLICY

The policy framework governing renewable energy in Zambia is driven by the National Energy Policy. It was formulated in 1994 and sought to promote optimal supply and utilization of energy for socioeconomic development in a safe and healthy environment. Due to the realization of the strategic nature and integrated nature of energy in economic development, the National Energy Policy 1994 has been revised to ensure that the role of energy in relation to other economic dynamics are taken care of. In particular, emerging cross-cutting aspects related to sustainable industrial development were not addressed in the National Energy Policy 1994.[26] The National Energy Policy of 2019 recognizes the critical role played by renewable energy in poverty alleviation and national development. The policy also considers the need for climate change mitigation and adaptation measures while advancing the sustainable development of the sector.[14]

The demand for renewable energy has seen significant growth in recent years as the market has been exploring alternative sources of energy, with renewable energy proving to be a viable alternative. In 2016, the ERB completed developing The Renewable Energy Regulatory Framework (RERF). The RERF was developed in line with the National Energy Policy (2008), the Biofuels Regulatory Framework, the Regulatory Framework for Off-Grid Systems, the Renewable Energy Feed-in-Tariff (REFIT) Strategy and other relevant legislation. These documents individually strive to facilitate the implementation and diversification of the energy sector to promote renewable energy technologies and improve access to modern forms of energy. The RERF puts all these requirements in one document covering renewable energy-based electricity generation with the aim of achieving the following:

- Facilitating implementation of the Government's policy to diversify the energy mix and provide modern forms of energy to rural communities;

- Consolidating and rationalizing existing regulatory frameworks;
- Promoting investment by having a clear regulatory framework that outlines entry requirements for the sector;
- Providing clear internal guidelines to facilitate renewable energy deployment.[14]

In 2016, the Government of the Republic of Zambia and Kreditanstalt für Wiederaufbau (KfW) initiated the Global Energy Transfer Feed-in Tariff (GETFIT) programme. The programme is designed to leverage private sector investment into renewable energy generation projects. It intends to fast-track a portfolio of small-scale renewable energy generation projects, up to a maximum of 20 MW each, including SHP projects promoted by private developers. It is envisaged that the full implementation of the GETFIT programme will be done as soon as the REFIT Strategy is launched and is also contingent on the finalization of the following support mechanisms:

- Development of the procurement guidelines;
- Development of the Standard Implementation Agreement;
- Agreeing on the quantum of the GETFIT subsidy on the REFITs.[8]

To develop a balanced REFIT, various methodologies and options were considered. Zambia shall apply a methodology following the cost-based approach, which implements a rate of return methodology and payment calculated using costs and return expectations of project investors.[27] In 2020 39 SHP sites were approved for feasibility study rights under the program.[15]

Licences to generate electricity from renewable energy sources are to be issued by the ERB. The generation licence essentially grants the producer the right to develop, finance, construct and operate the power plant, as well as the right to sell the electricity to the off-taker. ZESCO shall be the designated buyer of all the power delivered under the REFIT programme. The details of the off-take arrangement shall be set out in a standardized, technology-neutral power purchase agreement (PPA). The term of the PPA shall be at least 20 years from the commercial operation date.[26]

The greenhouse gas (GHG) emissions of Zambia are relatively low given the country's reliance mostly on hydropower for electricity generation. However, recently, more conventional energy sources have been commissioned such as the Maamba coal-fired power plant, which started operation in 2016. As a result, CO_2 emissions per capita have been slowly increasing since 2007. Furthermore, approximately 70 per cent of energy consumed in Zambia comes from firewood and charcoal, which is both unsustainable and unhealthy for consumers. Under the framework of the Intended Nationally Determined Contributions (INDC) to the 2015 Climate Change Agreement, Zambia intends to reduce its CO_2eq emissions by 25 per cent by 2030 compared to the baseline business-as-usual scenario through domestic efforts with limited international support, and by 47 per cent with substantial international support. This is equal to a total emissions reduction of 38 MtCO_2eq, which will require an investment of USD 50 billion by 2030. This will be achieved by implementing three programmes driven by the country's Climate Response Strategy and supported by the National Policy on Climate Change and national development policies, including energy, forestry, agriculture, water, town and country planning, sanitation and transport.[28]

Zambia does not have a national uniform tariff and developers may charge different tariffs subject to regulatory approval. However, retail tariffs must be approved by the ERB, which uses the revenue requirement or rate of return methodology. In principle, cost-reflective tariffs may be proposed by developers. The country does not yet have an electricity pricing regime for behind-the-meter storage applications. Apart from the tariff, ERB also approves customer connection charges. The ERB draws its mandate to determine electricity tariffs from the Electricity Act, Cap 433, Section 8.[29]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

The relevant policies and regulations in Zambia that govern developments such as SHP projects include the following:

- Zambia National Energy Policy (2019);
- Electricity Act No. 14 of 1995;
- Energy Regulation Act Cap 436 (2003);
- Rural Electrification Act (2003);
- Zambian Grid Code 2006;
- REFIT Strategy (2017);
- Water Resources Management Act (2011);
- Environmental Management Act (2011);
- Lands Act (2015);
- National Heritage Conservation Commission Act (1989).

The feasibility study rights for the development of SHP plants in Zambia are granted by the MoE through the following process:

- Application for the issuance of feasibility study rights to the Permanent Secretary;
- OPPPI/DOE assessment of the application;
- Interim rapid grid assessment and OPPPI/DOE recommendation;
- Permanent Secretary issues a letter granting feasibility study rights.

Permitting and licensing of SHP plants involves the acquisition of land that in most cases sits under customary tenure in Zambia. Hydropower projects also require water rights and stringent health safety and environmental standards are compulsory to prevent accidents during construction or operation of power plants. All projects must comply with requirements from the regulatory government agencies. The steps for obtaining a licence for combined generation, distribution and supply of electricity for solar and hydropower plants are as follows:

- Business registration with the Patents and Companies

Registration Agency (PACRA);
- Securing land tenure rights;
- Clearance from the Department of National Parks and Wildlife;
- Concession from the National Heritage Conservation Commission (NHCC);
- Environmental permit from the Zambia Environmental Management Authority (ZEMA);
- Water use permit for power generation from the Water Resource Management Authority (WARMA);
- Investment endorsement from the ERB;
- Tariff approval from the ERB;
- Issuance of a combined licence for generation, transmission, distribution and supply of electricity.

COST OF SMALL HYDROPOWER DEVELOPMENT

The capital cost of SHP development in Zambia depends on the size of the project and existing site conditions, such as topography, geology and hydrology. Based on the estimates of planned and recently commissioned plants, capital cost ranges from USD 8.7 million for a less than 1 MW plant to USD 76 million for an 18.8 MW plant. Costs per MW of installed capacity range from USD 2.4 million to USD 14.5 million.[10,16,21,22,23,24,25]

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

GETFIT Zambia has received significant contributions from the Government of Germany, which will ensure the successful implementation of the first phases of the programme. The largest share of the funds (approximately 70 per cent) will be used for subsidies for SHP projects. In the GETFIT Zambia context, such subsidies are referred to as Viability Gap Funding, designed to close the gap between the offered power tariffs and the tariff necessary for investors to achieve the required rate of return on investment. This way, substantial amounts of private capital can be leveraged to the Zambian power sector.[30]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Hydropower is directly affected by climate change in the sense that the latter alters the amount of water available for generation and potentially the seasonal distribution of runoff. Climate change has an impact on firm energy yield, the cost of energy production and plant operations. Furthermore, climate change will also affect design risks for new hydropower projects in terms of changes that will result in greater uncertainty concerning extreme weather phenomena such as flooding and droughts, which will in turn affect the project costs. Based on the report on the climate impacts on hydropower in Africa, the regional mean hydropower capacity factor is projected to decrease due to climate change by approximately 3 per cent by the year 2099 compared to the baseline period of 2010–2019.[31]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Notwithstanding the barriers and challenges highlighted, SHP development is expected to accelerate in response to recent initiatives, including studies highlighting the magnitude of the untapped SHP potential in Zambia, the transparent permitting processes, new financial incentives and the introduction of better policies. In many cases, SHP development can be achieved with minimal impact, thus supporting the country's economic and environmental goals. Further, it is anticipated that SHP will form part of the solution to the growing demand for a rural electrification programme in the country.

The Zambian hydropower industry presents great opportunities for investment and growth. However, the industry also faces challenges that include, among others, the following:
- Water resources development and management: Lack of the hydrological data necessary to adequately asses the available potential on the small river basins;
- Energy policy: Lack of a comprehensive energy policy to deal with the requirements of private plants interfacing with the national grid, for example, the feed-in-tariff has affected the process of private sector participation in hydropower generation especially SHP, which are vital for the sustainable development of rural districts;
- Transmission of power: The challenge of the cost of transporting electricity generated from renewable sources through the transmission system to the consumption centres of the country affects the bankability of projects considering that suitable hydropower potential is mainly located in remote areas of Zambia;
- Tariff structure and return on investment: The tariff structure in Zambia is still not cost-reflective;
- Financing: Access to capital markets remains a challenge for the general local private sector investors newly entering the hydropower industry. Due to the high capital investments required in hydropower, the development of SHP plants has not progressed at the pace required to meet various load requirements;
- Inability to attract investment: The challenges related to energy policies, feed-In-tariffs and cost-reflective tariffs directly affect the ability to attract investment;
- Access to sites: The poor road networks in rural areas make it difficult and expensive to carry out any work.

Despite of the barriers stated above, the hydropower industry presents great opportunities for investment and growth. In addition, the Government of Zambia has put in place enabling polices and regulations meant to attract investments in energy sector. The key enablers for the development of SHP include, among others, the following:

- The power sector was declared a priority sector under the Zambia Development Agency Act No. 11 of 2006 through the issuance of SI No. 15 of 2011. This regulation declares the building of mini-hydropower plants, solar power, thermal and hydropower plants eligible for fiscal incentives;
- The GEFIT Zambia programme aims to facilitate private sector investment in small- and medium-scale renewable energy IPPs in Zambia;
- The REFIT strategy is aimed at accelerating private investments in small- and medium-sized renewable energy projects in order to increase the number of players in the electricity subsector and ultimately increase access to clean energy services;
- Transparent project allocation procedures, with projects being committed to developers by way of feasibility study rights granted by the MoE;
- Economic incentives to encourage investment, including fiscal incentives (e.g., tax incentives), non-fiscal incentives (risk cost sharing, support of land acquisition) and a capital-smart subsidy (for projects developed under the REA);
- Migration towards cost-reflective tariffs from tariffs that were highly subsidized was commenced in 2017;
- Sufficient and sustained market for the generated electricity, with the demand for power growing at a rate of approximately 4 per cent per annum.

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Zimbabwe

Shorai Kavu, Ministry of Energy and Power Development

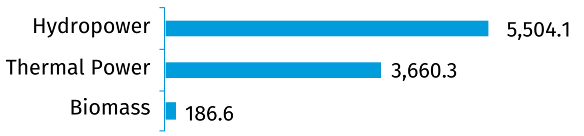
KEY FACTS

Population	14,645,000 (2019)[1]
Area	390,760 km²[2]
Topography	Zimbabwe is a landlocked country lying entirely within the tropics. It straddles an extensive high inland plateau that drops northwards to the Zambezi Valley, where it borders Zambia, and drops southwards to the Limpopo Valley and the border with South Africa. Zimbabwe has an average elevation of 1,500 metres above sea level and the highest peak is in the Nyangani Mountains to the north-east of the country at 2,592 metres.[3,4]
Climate	The hot season occurs from mid-August to mid-November, with daytime temperatures ranging from 26 °C to 36 °C. The rainy season is from mid-November to mid-March and can be interrupted by 4-5 dry spells. The cool season occurs from mid-May to mid-August with mild daytime temperatures ranging from 20 °C to 29 °C. The dry season occurs from mid-March to mid-May, with mild and sunny weather and temperatures ranging from 23 °C to 31 °C.[4]
Climate Change	Zimbabwe, like many other areas of Southern Africa, has increasingly been exposed to rising temperatures and increased rainfall variability due to a changing climate.[4]
Rain Pattern	The maximum rainfall is received in the eastern highlands, with annual rainfall of more than 1,000 mm. The Highveld receives an annual average of more than 500 mm of rainfall. The climate and rainfall patterns of Southern Africa have varied greatly for at least the last three centuries, leading to recurrent droughts of varying severity.[3,4]
Hydrology	Zimbabwe has six drainage basins. The largest being the Zambezi and the Limpopo basins. The western parts of the Matabeleland region are connected to the Okavango inland drainage basin through the Nata River. Parts of the Mashonaland and Masvingo regions drain through the Save River into the Indian Ocean. Two other drainage basins covering parts of the Manicaland region and draining into the Indian Ocean through Mozambique are the Pungwe River to the north and the Buzi River to the south.[3,5]

ELECTRICITY SECTOR OVERVIEW

The electricity sources in Zimbabwe include coal for thermal generation, large hydropower, small hydropower (SHP), solar power and diesel/petrol for backup systems.[6] In 2018, a total of 9,351 GWh of electricity was generated in the country, including by individual power producers (IPPs) (Figure 1). Generation from power plants owned by Zimbabwe Power Company (ZPC) increased by 25 per cent from 7,216 GWh in 2017 to 9,037 GWh in 2018, mainly due to the increased water allocation at the Kariba Dam.[7] Renewable energy generation made up 61 per cent of all electricity generation in 2018 (5,688 GWh).[7] This is a significant increase from 2017, when renewable generation made up 50 per cent. The individual contributions from the power plants in 2018 are depicted in Table 1.

Figure 1. **Annual Electricity Generation by Source in Zimbabwe in 2018 (GWh)**



Source: ZERA[7]

Note: Data for solar power generation from IPPs and off-grid sources is not publicly available and thus not included.

Table 1. **Annual Electricity Generation from ZPC and IPPs**

Power plant	*Energy source*	*Generation 2017 (GWh)*	*Generation 2018 (GWh)*
ZPC-owned plants			
Hwange	Coal	3,202.0	3,425.0
Kariba	Hydropower	3,850.0	5,377.0
Harare	Coal	75.0	66.0

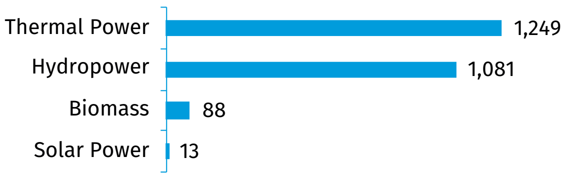
Power plant	*Energy source*	*Generation 2017 (GWh)*	*Generation 2018 (GWh)*
Munyati	Coal	38.0	81.0
Bulawayo	Coal	51.0	88.0
IPPs			
Nangani Renewable Energy	Mini-hydropower	111.0	112.0
Hippo Valley Estates	Biomass	0	63.2
Triangle Limited	Biomass	3.3	83.9
Border Timbers	Biomass	0	0
Chisumbanje	Biomass	10.8	39.5
Dema Emergency Peaking Plant	Diesel	48.2	0.2
Kupinga	Mini-hydropower	7.9	13.1
Claremont	Mini-hydropower	0.4	1.7

Source: ZERA[7]

As of 2021, Zimbabwe had a total installed capacity of 2,431 MW, of which 1,050 MW was from the Kariba South hydropower plant, 920 MW from the Hwange thermal power plant, a combined 329 MW from small coal-fired thermal plants (Harare, Bulawayo and Munyati) and 132 MW were contributed by IPPs and community-owned off-grid systems (Figure 2, Table 2). The capacity from bagasse was for the private use of sugarcane and ethanol producing firms. Available capacity stood at approximately 1,924 MW.[6,8]

The Kariba South hydropower plant extension project of 300 MW was completed in 2018 raising the plant's installed capacity to 1,050 MW.[9,10] The Hwange thermal power plant extension project with a capacity of 600 MW is under construction and expected to have the first 300 MW unit in operation by 2022 despite delays due to COVID-19 restrictions.[10,11]

Figure 2. **Installed Electricity Capacity by Source in Zimbabwe in 2021 (MW)**



Source: AfDB,[6] MoEPD[8]

Table 2. **Installed, Available and Achievable Capacities from Different Producers in Zimbabwe in 2021 (MW)**

Source	*Energy source*	*Installed capacity (MW)*	*Available capacity (MW)*	*Achievable capacity (MW)*
Kariba South hydropower plant	Hydropower	1,050.0	1,050.0	1,050.0
Hwange thermal power plant	Coal	920.0	750.0	715.0
Small thermal plants (Munyati, Bulawayo, Harare)	Coal	329.0	80.0	45.0
IPPs	Small hydropower	30.6	30.6	30.6
	Solar PV	10.0	10.0	10.0
	Bagasse	88.0	N/A	N/A
Community-owned (off-grid)	Hydropower	0.4	0.4	0.4
	Solar PV	3.0	3.0	3.0
Total		**2,431.0**	**1,924.0**	**1,854.0**

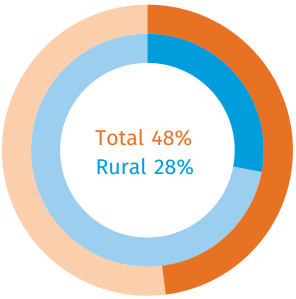
Source: AfDB,[6] MoEPD[8]

The capacity of IPPs from photovoltaic (PV) solar power plants includes the 2.5 MW Riverside power plant by Nyangani Renewable Energy Private Limited and the 2.5 MW Centragrid power plant. The Riverside power plant, commissioned in January 2018 to supply the national grid, is the first phase of the 10 MW project planned for a site in Mutoko, Mashonaland East Province of Zimbabwe.[12] The Centragrid plant is located in Nyabira, Mashonaland West Province of Zimbabwe, and was commissioned in October 2019.[13] Three planned solar power plants owned by ZPC, with 100 MW of capacity each, are yet to reach financial closure.[8]

The country imports electricity from the regional utilities to cover up for the local supply deficit: 50 MW of firm capacity from the Cahora Bassa Hydroelectric (HCB) of Mozambique and 50 MW of firm capacity from Eskom of South Africa. Variable imports operate on the Day-Ahead Market, managed by the Southern African Power Pool (SAPP) Coordination Centre. Zimbabwe has no firm capacity exports due to limited local generation capacity.[6]

According to the Zimbabwe National Statistics Agency (ZIMSTAT), the country's electrification rate was at 48 per cent in 2017 (Figure 3). Twenty-eight per cent of rural population had access to electricity and the urban electrification rate stood at 86 per cent.[14] Approximately 80–90 per cent of the rural population depend on wood fuel and kerosene for cooking and lighting according to the Zimbabwe Infrastructure Report published by the Africa Development Bank (AfDB) in 2019.[6] Food processing tasks, such as grain milling, are usually carried out with a diesel-powered system, with a few now using electricity. Although Zimbabwe is endowed with an abundance of renewable energy resources such as solar power, wind power, biomass and SHP, including run-of-river plants and inland dams, these are still not fully utilized.

Figure 3. **Electrification Rates in Zimbabwe in 2017 (%)**



Source: ZIMSTAT[14]

The energy sector in Zimbabwe is overseen by the Ministry of Energy and Power Development (MoEPD). Below MoEPD is the Zimbabwe Energy Regulatory Authority (ZERA), which ensures fairness in the sector. ZERA oversees the operations of the Zimbabwe Electricity Supply Authority (ZESA) Holdings Private Limited Subsidiaries, the oil companies and IPPs. The Zimbabwe Electricity Transmission and Distribution Company (ZETDC) and ZPC are subsidiary companies of ZESA Holdings, and the oil companies include both public and private companies. In addition, ZESA ensures fair tariffs and the quality of the provision of other services to the consumers.[7]

The national electricity grid has capacities ranging from 11 kV for low voltage to 33 kV, 36 kV, 66 kV, 360 kV and 420 kV for interconnections with the region. The grid is interconnected to the Southern African Development Community (SADC) region with the Zimbabwe grid being central. The operations of the regional grid are coordinated by the SAPP Coordination Centre, which is based in Zimbabwe.

To ensure the implementation of the country's pricing policy, Zimbabwe established the ZERA in 2012 in line with the SADC regional requirements. ZERA, in consultation with MoEPD, is responsible for the designing of the electricity pricing policy, as well as analyzing and approving tariff applications by both the state utility and the IPPs. ZERA may review tariffs for licensed operators when they apply, according to their needs. According to information recorded in the Zimbabwe Infrastructure Report of 2019 prepared by the AfDB, ZERA last reviewed the standard tariff schedule for the electricity sector in January 2013. An application for a 49 per cent tariff review was submitted by ZETDC as a bid to move from 0.099 USD/kWh to 0.147 USD/ kWh. However, after stakeholder consultations, it was resolved to keep the tariff at 0.099 USD/kWh.[6]

The tariff structure differentiates between domestic users who pay fixed charges and those who pay as per consumption levels. There is a lifeline support offered by subsidizing the first 50 kWh per month for all residents at approximately 0.02 USD/kWh. Low-demand non-residential consumers are charged both a fixed rate and flat variable rates depending on their consumption and metering system (Table 3). For comparison, the average electricity tariff in the SADC region ranges between 0.03 and 0.17 USD/kWh.[6]

Table 3. **Average Electricity Prices in Zimbabwe (USD/kWh)**

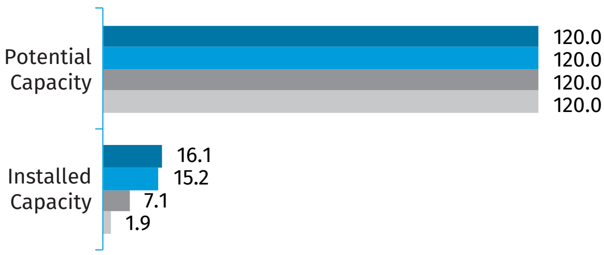
Sector	*2015*	*2016*	*2017*	*2018*
Industrial	0.0897	0.0940	0.0849	0.0804
Domestic	0.0980	0.0998	0.0996	0.0994
Overall approved	0.0991	0.1004	0.0966	0.0961
Average tariff	0.0986	0.0986	0.0986	0.0986

Source: AfDB[6]

SMALL HYDROPOWER SECTOR OVERVIEW

In Zimbabwe, SHP is defined as hydropower with an installed capacity of up to 30 MW.[4,15] Based on the up to 10 MW definition, Zimbabwe had an installed SHP capacity of 16.1 MW (grid-connected and off-grid) as of December 2020.[7] The total potential capacity for SHP up to 10 MW is estimated at 120 MW according to MoEPD, which includes both reservoir and run-of-river sites.[16] Compared to the *World Small Hydropower Development Report (WSHPDR) 2019*, the potential capacity remained the same, whereas the installed capacity increased by 6 per cent (Figure 4). The total installed capacity for SHP up to 30 MW in Zimbabwe is 31.35 MW, which includes a 15.25 MW power plant not included under the up to 10 MW definition of SHP.[9,16,17]

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



Source: MoEPD,[16] *WSHPDR 2019*,[17] *WSHPDR 2013*,[18] *WSHPDR 2016*[19]

Note: Data are for SHP up to 10 MW.

The off-grid systems, which are community-owned and have been sponsored by the non-governmental organizations Practical Action and Oxfarm, reached an operational capacity of approximately 400 kW by 2017.[18] The grid-connected SHP plants are privately owned by IPPs, which include Nyangani Renewable Energy (NRE), Kupinga Renewable Energy (KRE) and Bonemarrow Investments. These have separate Power Purchase Agreements (PPAs) with ZETDC as the sole owner and operator of the national grid (Table 4).[7,8]

A number of SHP projects are currently under development (Table 5).

Table 4. **List of Operational Small Hydropower Plants in Zimbabwe**

Name	*Location*	*Capacity (MW)*	*Plant type*	*Operator*	*Launch year*
Pungwe B	Nyanga	15.3	Run-of-river	Nyangani Renewable Energy (NRE)	2014
Pungwe C	Nyanga	3.8	Run-of-river	Nyangani Renewable Energy (NRE)	2016
Pungwe A	Nyanga	2.8	Run-of-river	Nyangani Renewable Energy (NRE)	2011
Hauna	Nyanga	2.3	Run-of-river	Nyangani Renewable Energy (NRE)	2017
Duru	Nyanga	2.2	Run-of-river	Nyangani Renewable Energy (NRE)	2010
Tsanga B	Nyanga	2.1	Run-of-river	Nyangani Renewable Energy (NRE)	2018
Kupinga	Nyanga	1.6	Run-of-river	Kupinga Renewable Energy (KRE)	2017
Nyamingura	Nyanga	1.1	Run-of-river	Nyangani Renewable Energy (NRE)	2010
Claremont	Nyanga	0.3	Run-of-river	Bonemarrow Investment	2017

Source: ZERA[7]

Table 5. **List of Ongoing Small Hydropower Projects in Zimbabwe**

Name	*Location*	*Capacity (MW)*	*Plant type*	*Developer*	*Stage of development*
Tsanga A	Nyanga	2.7	Run-of-river	Nyangani Renewable Energy (NRE)	Construction
Tsanga C	Nyanga	2.2	Run-of-river	Nyangani Renewable Energy (NRE)	Construction
Rusitu	Nyanga	1.0	Run-of-river	Rusitu Power Cooperation	Construction
Great Zimbabwe Hydro Power Plant	Masvingo	5.0	Inland dam	Great Zimbabwe Hydro Private Limited	Licensed

Source: ZERA[7]

SMALL HYDROPOWER PROJECTS AVAILABLE FOR INVESTMENT

Funding is required to update pre-feasibility and feasibility studies on several sites especially the inland dam sites. Partnerships and investors for the sites are welcome to boost electricity supply security in the country. Sites will be made available to potential investors and partners (Table 6).[8]

Table 6. **List of Selected Small Hydropower Projects Available for Development**

Name	*Location*	*Potential capacity (MW)*	*Type of site (new/ refurbishment)*
Tokwe Mukosi	Mwenezi	15.0	Inland dam, new
Orsbone	Nyanga	3.0	Inland dam, new
Odzani	Odzi	2.4	Run-of-river, new
Nyahonde	Nyanga	1.7	Run-of-river, new
Immaculate Technology	Masvingo	1.6	Inland dam, new

Source: ZERA[7]

Note: List compiled in 2021.

RENEWABLE ENERGY POLICY

Since the establishment of the Electricity Act of 2002, IPPs have been allowed to develop power generation plants.[20] There is also a National Energy Policy (NEP) that was launched in 2012, which summarizes the potential of SHP in the country and encourages the increased use of renewable energy sources in the country's energy supply mix.[21] The NEP is also supported by the country's economic blueprint, the Zimbabwe Agenda for Sustainable Socio-Economic Transformation (ZIMASSET). The ZIMASSET was succeeded by the Transitional Stabilization Programme (TSP), which was launched in 2018 and ran from October 2018 to December 2020. The focal areas of the TSP included: stabilization of the macro-economy and the financial sector; introduction of necessary policy and institutional reforms to transform to a private sector–led economy; and launch of 'quick-wins' to stimulate growth.[21] The TSP was underpinned by Vision 2030 Towards an Upper Middle-Income Country. Vision 2030 will be implemented in two phases with the first National Development Strategy launched in 2020 to run from 2021 until 2025.[22] The above documents do not elaborate much on the development of renewable energy sources, such as SHP. The country now has a National Renewable Energy Policy (REP) in place which was launched in 2019.[17] The REP promotes investment in renewable energy sources, including SHP as well as both on- and off-grid projects.[17]

Zimbabwe, through the Ministry of Environment, Water and Climate (MEWC), has prepared and submitted the Third National Communications to the United Nations Convention on

Climate Change (UNFCCC). A Climate Change Response Strategy was developed for the country, as well as a Climate Policy.[23] The country also ratified the Paris Agreement and has submitted Nationally Determined Contributions (NDCs), with hydropower development as one of the measures aimed at the mitigation of, and adaptation to, climate change effects. It is also worth noting that future hydropower development in Zimbabwe will need to ensure robustness and capability for survival against climate change effects.

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

There is no particular regulation or legislation targeting SHP development in Zimbabwe. The sector is governed by the same laws that apply to fossil fuels and other renewable energy sources. The principal law is the Electricity Act of 2002 supported by the Energy Regulatory Act of 2011. There are also the Electricity Licensing Regulations of 2008 amended by Statutory Instrument 55 of 2015. In 2018 the net-metering regulations also came into force.[21]

COST OF SMALL HYDROPOWER DEVELOPMENT

SHP projects in Zimbabwe have been developed mostly by private players and on a case-by-case basis. Therefore, the findings of feasibility studies as well as data on development costs are owned by the private developers.

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

The Infrastructure Development Bank of Zimbabwe (IDBZ) in 2019 called for a bid for consultancy to carry out feasibility studies for the Odzani power plant on the Odzani River.[24] However, there is no record of the finalization of the procurement process. ZERA developed some feed-in-tariffs (FITs), which have yet to be approved by the Government.[17] The REP has a policy statement for all SHP projects within a capacity of 30 MW to be procured through FITs once they are approved.[17]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Even though hydropower development is listed among the mitigation solutions for climate change, at the same time the sector is also at risk of being affected negatively by changes in rainfall patterns. Some negative effects have already been witnessed, as reduced water levels affected power generation at the Kariba hydropower plant during certain seasons over recent years.[25] Some climate records in the country have demonstrated that Zimbabwe is already experiencing the effects of climate change, especially rainfall variability. The induced water stress threatens to reduce the runoff necessary to sustain SHP plants, especially the run-of-river ones.[27]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Policies and regulations have a bearing on the rate of SHP development in the country. From 2011, when ZERA came into existence, followed by the NEP, the trend of SHP development has been on the rise. A greater impact is expected with the REP in place and a procurement framework being worked on by MoEPD.[8]

The following are the main barriers to SHP development in Zimbabwe:

- The effects of extreme weather conditions;
- Lack of FITs and standard procurement methods: currently tariffs are negotiated on a case-by-case basis;
- High costs of local funding: local banks offer short-term loans at high interest rates;
- Difficulties in accessing foreign funding by most potential developers: very few IPPs have managed to reach financial closure for an SHP project;
- Lack of funding for feasibility studies to ensure the bankability of projects: most project sites fail to attract funding due to the unavailability of bankable feasibility studies;
- No locally manufactured equipment: all turbines, generators and control equipment are imported.

The development of SHP in Zimbabwe is expected to be further enabled by the REP and the net-metering regulations which are now in place.[7]

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