Climate Compatible Growth

PART ONE OF A THREE PART SERIES FOR THE GoPRO-ZAMBIA RESEARCH PROJECT

STATUS QUO OF THE ENERGY SYSTEM AND CONSUMPTION IN ZAMBIA

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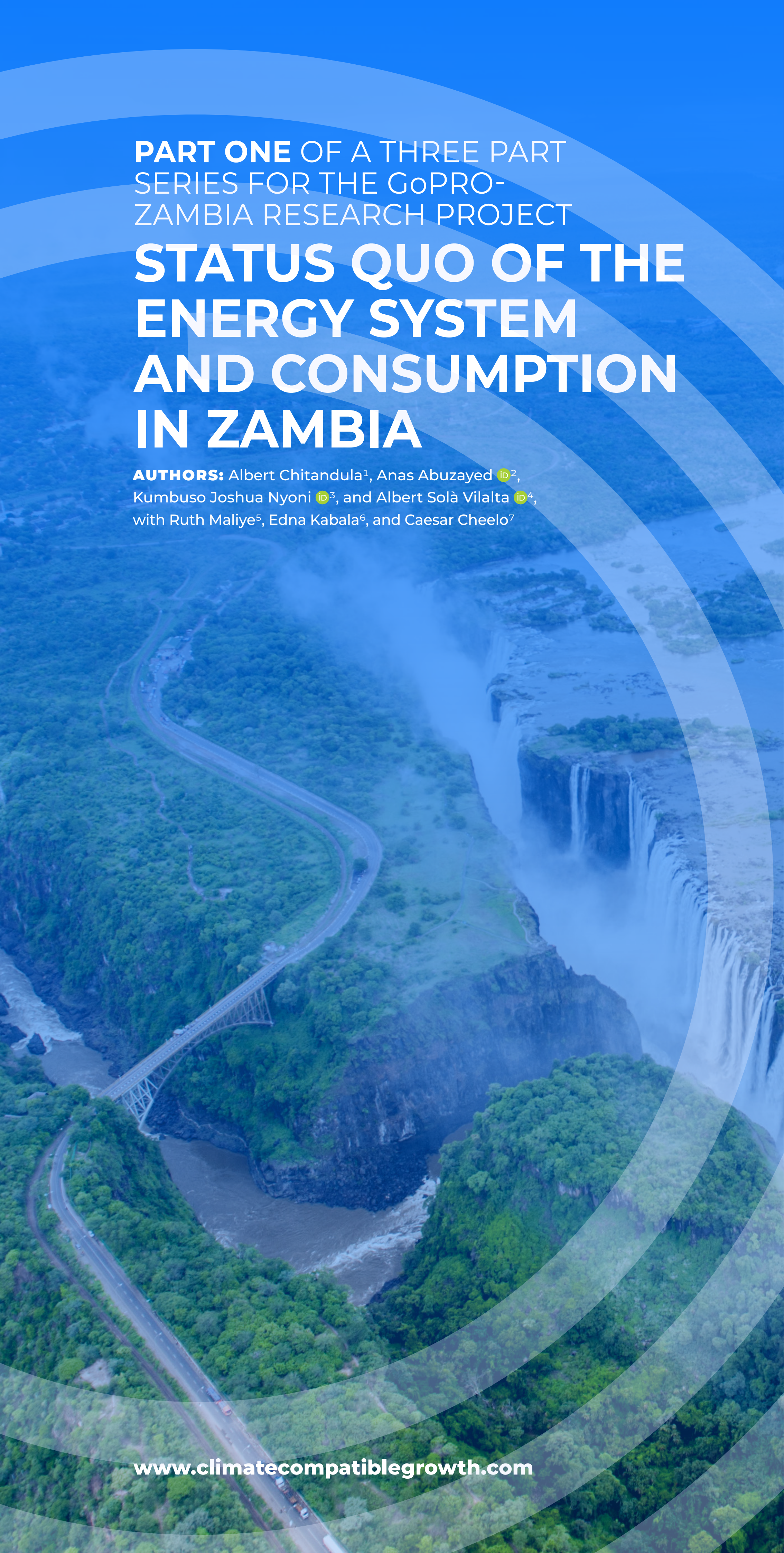

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Zambia Report Series

This three-part report series offers an in-depth exploration of Zambia's energy system, focusing on its current status, the pathways for transitioning to a low-carbon future, and the broader economic role of electricity within the country. This report, ***Status Quo on Consumption and Energy System in Zambia***, is the first in the series. It lays the groundwork by analysing Zambia's existing energy consumption patterns, production capacities, and the challenges associated with its heavy reliance on biomass and hydropower. Building on these insights, the second report, ***Measures and Technologies for a Low-Carbon Zambian Energy System***, explores the essential technologies and strategies that Zambia can adopt to reduce its carbon footprint, with a focus on renewable energy, energy efficiency, and carbon sequestration. Finally, the third report, ***Overview of the Electric Energy Economy in Zambia***, provides a detailed evaluation of the electricity sector's macroeconomic contributions, the regulatory framework, and the investment landscape, offering a forward-looking perspective on how Zambia can leverage its electricity resources to drive sustainable economic growth. Together, these reports provide a comprehensive roadmap for understanding and addressing Zambia's energy challenges and opportunities in the context of national development and global climate goals.

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Units of Measurement

gCO^2eq	Gram of carbon dioxide equivalent
GW	Gigawatt
GWh	Gigawatt hour
kg	Kilogram
kW	Kilowatt
kWh	Kilowatt hour
L	Litre
m	Metre
m^2	Square metre
m^3	Cubic metre
m ASL	Metres above sea level
MW	Megawatt
MWh	Megawatt hour
TJ	Terajoule
TWh	Terawatt hour
USD	United States Dollars
Yr	Year

Abbreviations

A2C	Alternatives to Charcoal
ATF	Alternative Technologies and/or Fuels
Avgas	Aviation gasoline
BEFS	Bio-Energy Food Security
CoSS	Cost of Service Study
CPP	Cost Plus Pricing
DNSP	Distribution network service provider
ERB	Energy Regulation Board
ESMAP	Energy Sector Management Assistance Programme
EU	European Union
FAO	Food and Agriculture Organization
HFO	Heavy Fuel Oil
IAEREP	Increased Access to Electricity and Renewable Energy Production programme
IDC	Industrial Development Corporation
IMF	International Monetary Fund
Indeni	Indeni Petroleum Refinery Company Limited
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
KGLDC	Kafue Gorge Lower Development Corporation Limited
LPG	Liquid Petroleum Gas
MYTF	Multi-year Tariff Framework
PV	Photovoltaic
REA	Rural Electrification Authority
REFIT	Renewable Energy Feed-in Tariff
RET	Renewable Energy Technology
SDG	Sustainable Development Goal
SE4ALL	Sustainable Energy for All
TNSP	Transmission network service provider
UN	United Nations
USAID	United States Agency for International Development
ZESCO	Zambia Electricity Supply Corporation Limited
ZRA	Zambezi River Authority

Executive Summary

This report offers a comprehensive overview of Zambia's energy system, focusing on consumption trends, energy production, and the associated challenges. The first in a three-part series, it serves as the basis for understanding Zambia's energy framework by highlighting the critical sectors that shape the nation's energy dynamics and the broader implications for sustainable growth.

Zambia's total energy consumption in 2021 amounted to 10,161 terajoules, with biomass accounting for a staggering 65% of the overall energy mix. This reliance on biomass, primarily used for cooking and heating in rural areas, presents significant challenges related to environmental degradation and sustainability. Meanwhile, petroleum products constituted 16% of the energy mix, with electricity and coal constituting 15% and 4% respectively. These figures reveal an energy landscape still heavily dependent on traditional, non-renewable sources, further highlighting the need for transformative interventions.

The petroleum sector plays an indispensable role in Zambia's energy economy. However, the country imports all its petroleum products, a factor that not only raises concerns over energy security but also results in inefficiencies in procurement and pricing, largely managed by the Energy Regulation Board (ERB). The current Cost-Plus Pricing model has led to irregular adjustments and considerable government subsidies, exacerbating fiscal pressures. Diesel and unleaded petrol remain the most consumed products in the sector, with modest growth in demand between 2021 and 2022.

In the electricity sector, hydropower is the predominant source of energy, contributing 84% to the country's installed generation capacity of 3.78 gigawatts. Despite this abundance of hydropower resources, Zambia's electricity access rate remains at just 51% of the population, with stark disparities between urban and rural areas. Urban centres benefit from access rates of 85.7%, while rural areas lag significantly at 14.5%. The reliance on hydropower has exposed the sector to vulnerabilities linked to climate variability, particularly droughts, which have led to frequent load-shedding and inconsistent electricity supply in recent years.

Zambia's renewable energy potential remains largely untapped, particularly in solar energy. Government initiatives such as the Renewable Energy Feed-in Tariff (REFiT) programme aim to attract private sector investment into the renewable sector, but progress remains slow. Wind and geothermal energy, though identified as promising resources, have only seen minimal development.

In conclusion, Zambia's energy system is characterised by a dependence on traditional energy sources, particularly hydropower and biomass, which has constrained the country's ability to achieve energy security and sustainability. The urgent need for reforms to diversify energy sources, modernise infrastructure, and implement cost-reflective tariffs is evident. Addressing these issues is crucial for improving energy access and supporting Zambia's broader development objectives.

1 INTRODUCTION

Access to a reliable and quality energy supply is vital to the economic development of any country (Bhatia and Angelou, 2015). The Government of Zambia is working towards achieving this goal, as exemplified by the work to achieve universal access to electricity by 2030 (Energy Market and Regulatory Consultants Limited, 2021; United Nations, 2015).

In Zambia, the Ministry of Energy is responsible for the development and management of energy resources in a sustainable manner for the benefit of the people. It does so by supervising the following public entities: Energy Regulation Board (ERB), Rural Electrification Authority (REA), Zambezi River Authority (ZRA), Indeni Oil Refinery, Tazama Pipelines Limited, and Zambia Electricity Supply Corporation (ZESCO) Limited (Ministry of Energy, 2023b).

As defined by the Energy Act 2019 (Government of Zambia, 2019b), the ERB is the regulator of the energy sector in Zambia. As such, its main tasks are to issue operating licences in the energy sector and monitor the performance of licensees; to develop and implement rules to promote competition in the energy sector; to design standards with regard to quality, safety, and reliability of energy supply; and to determine, regulate, and review charges and tariffs in the energy sector. The ERB defines three energy sub-sectors: petroleum sub-sector, electricity sub-sector, and renewable energy sub-sector (ERB, 2022). We also use this classification in this report.

The petroleum sub-sector is characterised by the fact that all petroleum products are imported, and the procurement of petroleum products is handled by the government. Tazama Pipelines Limited and Indeni Oil Refinery are responsible for transporting petroleum feedstock from Tanzania to Zambia and refining it, respectively. The ERB is responsible for setting prices for petroleum products (IMF, 2015). The main challenges of the petroleum sub-sector are the strong dependence on imports and setting cost-reflective pricing schemes in the local currency. The latter has not always been the case in the past, and this resulted in large government bills (IMF, 2015).

The electricity sub-sector is dominated by the vertically integrated utility ZESCO Limited, which plays a major role in power generation, transmission, and distribution. Through the Electricity Act 2019 (Government of Zambia, 2019a), the ERB obtained responsibility for electricity pricing and for securing a regular and economical universal supply of electricity. The two main characteristics of the Zambian electricity system are that, as of 2023, only half of the population has access to electricity (Ministry of Energy, 2023a), and that hydro constitutes about 80% of installed capacity and annual electricity generation (ERB, 2022).

Improving the low access to electricity rate is a challenge being addressed by the Government of Zambia, with the objective of reaching universal access to electricity by 2030 (Energy Market and Regulatory Consultants Limited, 2021; United Nations, 2015). In this regard, given the significantly lower access rates in rural areas, the REA has the overall responsibility for the planning and implementation of rural electrification. It works both on expanding the existing grid and on off-grid access programmes (Ministry of Energy, 2023a).

The dominance of hydro in the electricity system means that electricity in Zambia is relatively low-carbon. However, the over-dependence of hydro power is making the operation of the power system increasingly vulnerable to droughts exacerbated by climate change, leading to load-shedding during certain periods in the recent years (Kahiu, 2023). Given the increasing electricity needs, the presence of hydro infrastructure, and the high renewable potentials for solar and wind (SmartSolar Zambia,2019; World Bank, 2018), there seems to be a huge potential for green growth and sustainable development by increasing electricity access and electricity generation through clean energy resources (solar and wind), and using the existing hydro infrastructure to guarantee a reliable supply of electricity at all times.

The renewable energy sub-sector focuses on harnessing sustainable sources of energy which include solar, wind, biomass, hydro, and geothermal. This includes the generation of electricity from renewable resources, but also the production of biofuels and moving away from charcoal for cooking (ERB, 2022). Reductions in charcoal use have been identified as an important aspect for sustainable development, as it reduces the workload of individuals, especially women, as well as addressing health issues and reducing deforestation (Thiam, 2011; Behl *et al*., 2012).

> “Access to a reliable and quality energy supply is vital to the economic development of any country. The Government of Zambia is working towards achieving this goal, as exemplified by the work to achieve universal access to electricity by 2030”

This report has been prepared within the GoPRO-Zambia research project. This project is funded by the Climate Flexible Research Fund 2022 of the Climate Compatible Growth programme, a UK Aid-funded programme. The project's main objective is to identify green growth opportunities in Zambia and analyse its macroeconomic implications. To this end, we intend to investigate the decarbonisation potential using a power system capacity and transmission expansion model, along with an input-output model for macroeconomic analysis. This work will be used as the backbone for validation of the models used in the GoPRO-Zambia research project.

This report is part of the first steps of the GoPRO-Zambia research project, and it forms a coherent body of research together with two other reports. First, a report presenting a comprehensive classification of low-carbon measures and technologies, with special emphasis on their potential in Zambia (Chitandula *et al*., 2024). It also gives insights on the role these measures and technologies could play towards sustainable development and the energy transition in Zambia. Second, a report that gives an overview of the energy sector in Zambia focusing on the interactions between the electricity sector and the wider economy (Maliye *et al*., 2024). In particular, it summarises the Zambian energy regulatory framework, explores the macroeconomic contributions of the electricity sector, and highlights the importance of adequate investment in electricity infrastructure.

Following this introduction, this document is structured as follows. In Section 2, we present the total energy consumption in Zambia in recent years. Sections 3, 4, and 5 contain an overview of the petroleum, electricity, and renewable energy sub-sectors, respectively. Finally, we draw conclusions in Section 6.

2 ENERGY CONSUMPTION

The total energy consumption in Zambia in 2021 was 10,161 Terajoules (TJ) (African Union, 2023). The breakdown of energy consumption by source was as follows:

- Petroleum products: 16.0%
- Electricity: 15.0%
- Biomass: 65.0%
- Coal: 4.0%

Figure 1 illustrates the energy consumption percentages by source. Biomass is the most used energy source, with a 65% of total energy consumption in 2021. This dominance comes from its wide use for cooking and heating, specially in rural areas. This is a trend in most of sub-Saharan Africa (Stecher *et al.*, 2013).

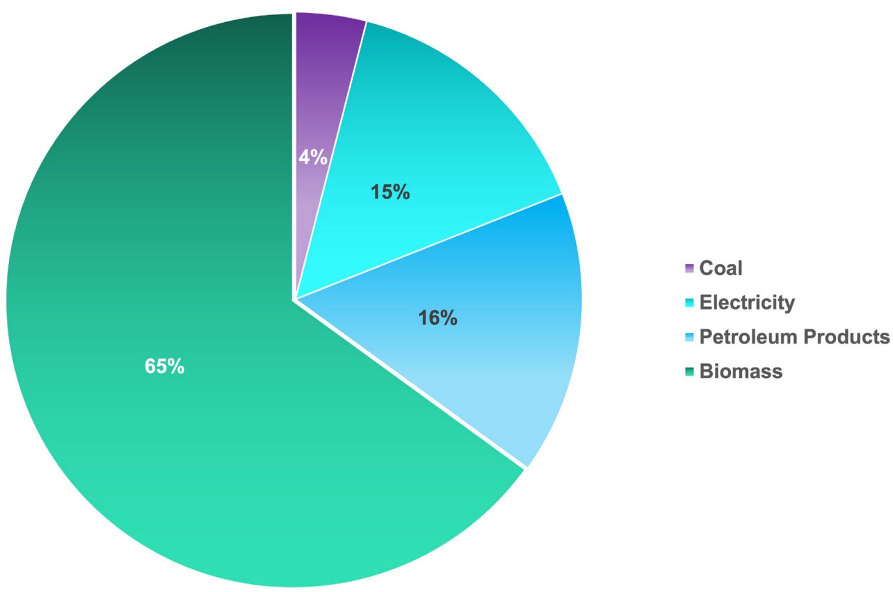
Petroleum products are the second-largest source of energy in Zambia, representing 16% of total energy consumption. They are used for road transport, industry (mining and non-mining industries), electricity generation, aviation, and lightning (ERB, 2022).

Electricity consumption accounts for about 15% of total energy consumption. The significantly lower electricity access rate in rural areas than in urban areas (SmartSolar Zambia, 2019) suggests that electricity is consumed mainly in urban areas. Electricity serves various purposes, including lighting, cooking, and powering appliances.

Finally, coal is responsible for a 4% of total energy consumption. Its main use is in electricity generation (ERB, 2022).

The Zambian government is actively working to increase the share of electricity and renewable energy in the country's energy mix (Sparkman and Tobin, 2023). This involves investments in the grid, new power generation capacity, and energy efficiency measures.

Figure 1: Energy consumption by source in 2021 in Zambia. Source: African Union, 2023



3 PETROLEUM SUB-SECTOR

3.1 Introduction

Zambia imports all its petroleum products. The bulk of fuel imports have traditionally been piped from the port of Dar-es-Salaam to the Indeni refinery in Ndola using the 1,710 km Tazama pipeline (IMF, 2015). These imports are in the form of spiked petroleum feedstock, which is a blend of crude oil, condensate, naphtha, and diesel. This blend is refined at the Indeni refinery to obtain the final market mix. Due to capacity constraints of the pipeline and refinery, refined products are also imported directly by road. As of 2015, road imports accounted for about half of the total. All procurement is handled by the Zambian Government and both the Tazama pipeline and the Indeni refinery are fully government-owned (IMF, 2015).

The remainder of this section is organised as follows. In Section 3.2, we describe the petroleum products pricing scheme currently implemented in Zambia and summarise some criticism it has received. In Section 3.3, we present and analyse the consumption of every petroleum product in Zambia during the years 2021 and 2022.

3.2 Petroleum Pricing

Since the Government of Zambia handles the procurement of petroleum products, it is also responsible for setting retail prices. The Electricity Regulation Board (ERB) is in charge of this task, and since January 2008 it uses the Cost Plus Pricing (CPP) model (IMF, 2015). This model operates on the principle that the final local currency price of petroleum products should cover all costs in the supply chain plus a fair profit margin.

In this context, the volatility of global petroleum prices and the local currency imply that the costs of petroleum products, in the local currency, are also volatile. Hence, if the objective of Cost Plus Pricing is to cover all supply chain costs, the retail prices have to be adjusted regularly to represent the true costs in the local currency.

The report by the International Monetary Fund (IMF, 2015) highlights that this adjustment mechanism has not been done regularly enough, and this has resulted in implicit fuel subsidies being the norm between 2010 and 2015, which produced large bills for the government. More recently, a further report by the IMF (2023) highlighted how the removal of market distortions (like implicit fuel subsidies) should bring financial stability to the petroleum sector.

3.3 Petroleum Consumption

Table 1 summarises the annual consumption of different petroleum products in Zambia for the years 2021 and 2022. The two most used petroleum products are diesel and unleaded petrol, with about 1.2 billion litres of diesel and 5 billion litres of unleaded petrol consumed annually. This did not change significantly between the two years considered.

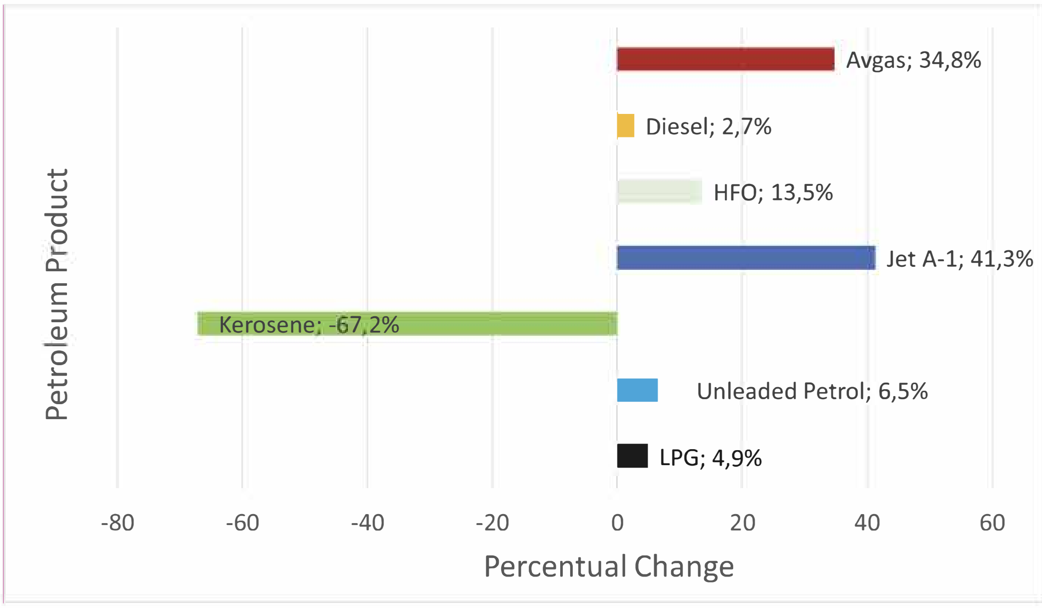
***Table 1:** Annual petroleum consumption in the years 2021 and 2022 in Zambia.Source: ERB, 2023.*

Product/Year	2021	2022	% change
Avgas (L)	881,672.79	1,188,438.00	34.8
Diesel (L)	1,214,524,979.99	1,247,633,326.29	2.7
Heavy Fuel Oil (kg)	15,384,942.00	17,454,848.00	13.5
Jet A-1 (L)	27,744,562.00	39,194,544.00	41.3
Kerosene (L)	3,171,055.73	1,041,301.24	-67.2
LPG (kg)	7,981,100.11	8,373,041.45	4.9
Unleaded Petrol (L)	528,881,823.65	563,430,608.23	6.5

Unleaded petrol is used for vehicles and electricity self-generation, and mostly sold in retail through oil marketing companies. Diesel is used in vehicles, electricity self-generation, and industry, including electricity generation (World Bank, 2011; ERB, 2023). Industrial diesel consumption accounted for about half of the total diesel consumption in Zambia in the years 2021 and 2022 (ERB, 2023).

Heavy Fuel Oil (HFO) also presents a stable use between the years considered at about 16 million kg. Since its density is around 1 kg/L (Speight, 2011), this quantity is comparable to the other fuels. Its use is only industrial, with a strong dominance of the mining sector (ERB, 2023). It is also used for electricity generation, see Section 4.1.

***Figure 2:** Annual variation in petroleum products consumption between 2021 and 2022 in Zambia. Source: ERB, 2023.*



Liquified Petroleum Gas (LPG) is mostly used for cooking and heating (World Bank, 2011) and also presents a stable consumption at about 8 million kg per annum. Kerosene is used for lighting, cooking, and heating, and its use has decreased significantly from 3 million litres to 1 million litres between 2021 and 2022. Both fuels are used in industry and households (ERB, 2023).

Finally, the aviation industry is a significant consumer of petroleum products in Zambia. Jet A-1 is the most used fuel in aviation, at about 39 million litres in 2022. The consumption of aviation gasoline (Avgas), used in smaller planes, is about 10 million litres annually (ERB, 2023).

Figure 2 highlights the percentage changes in annual petroleum consumption between 2021 and 2022. There is a sharp decline in Kerosene consumption, but one should take into account that Kerosene consumption is relatively small when compared to other fuels. Aviation fuels (Jet A-1 and Avgas) did experience a sharp increase in consumption from 2021 to 2022 of between 35–40%, which could be explained by the recovery of international travel after the COVID-19 pandemic. The remaining fuels presented moderate increases between 2021 and 2022.

4 ELECTRICITY SUB-SECTOR

Zambia's electricity sub-sector is vertically integrated, with the public utility company, ZESCO, as the major player in generation, transmission, and distribution (ERB, 2021). ZESCO's generating activities are supported by several Independent Power Producers (IPPs) that sell electricity to ZESCO.

The sector also comprises key players such as traders, distribution network service providers (DNSPs), and transmission network service providers (TNSPs), which mainly supply electricity to major end-use consumers, especially from the mining sector (ERB, 2022).

The Electricity Act 2019 (Government of Zambia, 2019a) is the main piece of regulation for the electricity sub-sector. This act gives the Energy Regulation Board (ERB) chief responsibility for the electricity sub-sector, including to "secure a regular, efficient, coordinated and economical supply of electricity and facilitate universal access to electricity supply", to "facilitate the efficient, effective, sustainable development and operation of electricity supply infrastructure, installation and facilities", and to "approve, determine, review and regulate tariffs".

In Section 4.1, we review the installed electricity generation capacity, and in Section 4.2 we analyse the hydrological situation in Zambia. Sections 4.3 and 4.4 analyse the annual electricity generation in recent years and electricity consumption, respectively. Finally, in Sections 4.5 and 4.6 we highlight the challenges faced by the electricity sub-sector and give an outlook for the sector, respectively.

4.1 Installed Electricity Generation Capacity

Table 2 and **Figure 3** present a comprehensive overview of the national installed generation capacity by technology in Zambia as of 31 December 2022 (ERB, 2023). The installed generating technologies in Zambia are hydro, coal, HFO, solar, and diesel. Table 2 presents the exact capacity values in megawatts corresponding to each technology, while Figure 3 shows the percentage share of each technology.

Table 2: *National installed generation capacity by technology as of 31 December 2022. Source: ERB, 2023.*

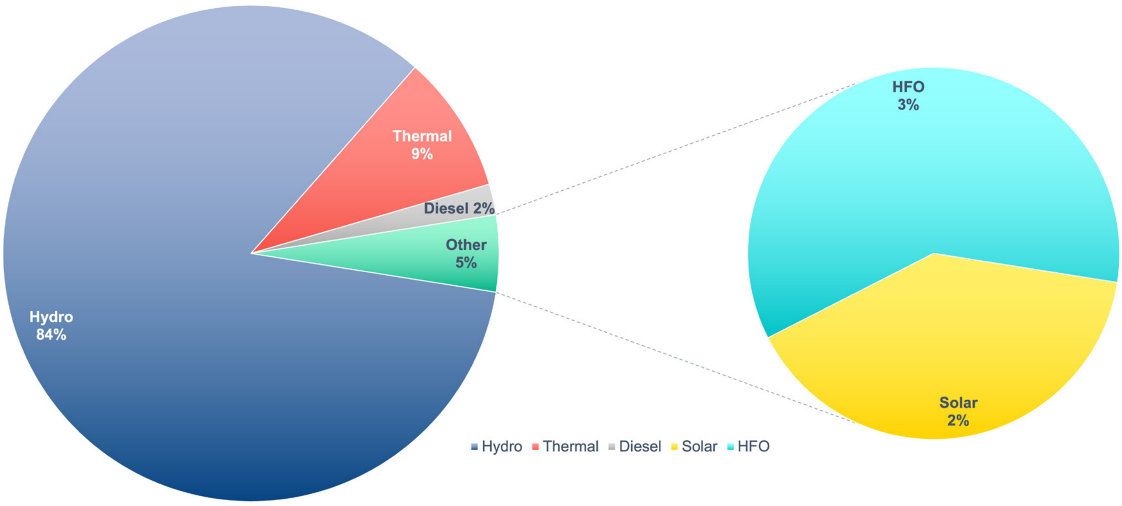
Technology	Capacity (MW)
Hydro	3163.44
Coal	330
HFO	110
Solar	89.06
Diesel	84.8
Total	3777.3

The total installed electricity generation capacity adds up to about 3.78 GW. Of this, 84% or 3.16 GW is hydro, making it the dominant source of electricity in Zambia. Hence, the Zambian power system contains a high percentage of renewable resources in its electricity mix, namely 86% of the total installed capacity or 3.25 GW. This makes electricity in Zambia relatively low-carbon intense, at 85 gCO^2eq per kWh in 2021 (Energy Institute, 2023). It compares to, for instance, 147 gCO^2eq per kWh in Uruguay, 268 gCO^2eq per kWh in the United Kingdom, 379 gCO^2eq per kWh in the United States, or 716 gCO^2eq per kWh in South Africa in that same year (Energy Institute, 2023).

However, as of 2023, only about 51% of Zambians have access to electricity (Ministry of Energy, 2023a). Moreover, the strong dependence of hydro makes the system vulnerable to droughts, which often lead to load-shedding, as experienced in late 2022 and early 2023 (Kahiu, 2023).

In summary, while present installed capacity guarantees a relatively green electricity generation, it is not enough to satisfy the electricity needs of all Zambians, nor to guarantee a secure supply at all hours. Hence, there is a big challenge to expand the electricity installed capacity in a cost-efficient and sustainable way.

Figure 3: *Share of national installed generation capacity by technology as of 31 December 2022. Source: ERB, 2023.*

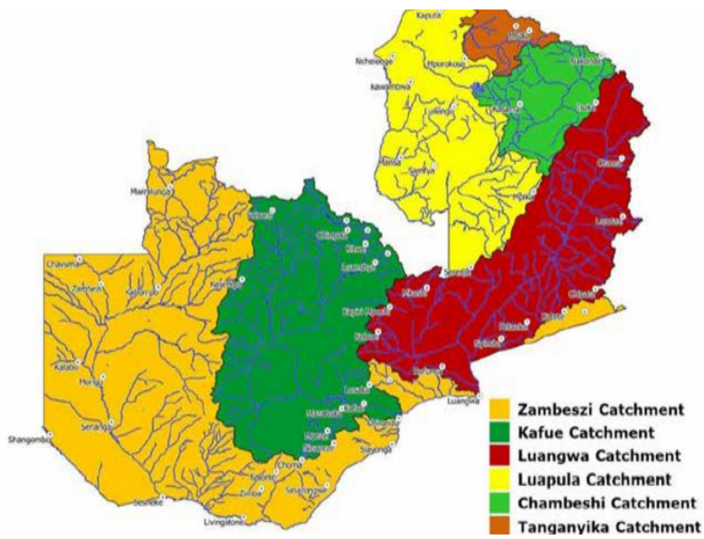


4.2 Hydrological Situation in Zambia

As highlighted in Section 4.1, hydro plays a crucial role in the Zambian electricity sub-sector, and the absence of water has created electricity load-shedding in the recent past. Therefore, the availability of water and how it is distributed across the country deserves a detailed analysis. In this section, we look into the Zambian river basins, rainfall patterns, and the use of dams.

Zambia has two main river basins: the Zambezi and the Congo River Basins. They are hydrologically divided into six main catchments. The Zambezi River Basin comprises the upper Zambezi, Kafue, and Luangwa catchments, while the Congo River Basin comprises the Chambeshi, Luapula, and the Tanganyika catchments. **Figure 4** shows the different catchment areas in a map.

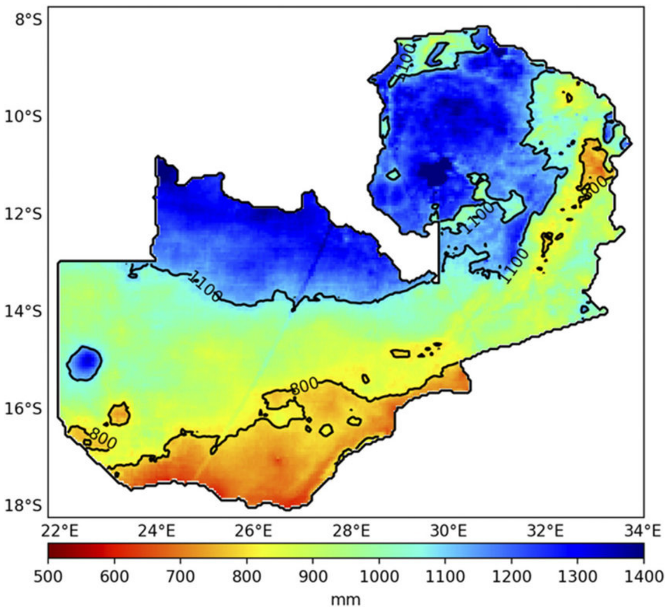
Figure 4: *River catchments in Zambia. Source: ERB, 2022.*



4.2.1 Rainfall in Zambia

Zambia is a relatively wet country, receiving an average of 1,020 mm of precipitation per year. This compares to 657 mm in Zimbabwe, 495 mm in South Africa, 1,220 mm in the United Kingdom, 2,702 mm in Indonesia, and 89 mm in Algeria (Our World in Data, 2024). Most of the precipitation in Zambia is in the form of rainfall. The distribution of rainfall is not uniform over the year. Most of the rainfall is concentrated in the rainy season, which usually starts in October and lasts until April of the next year (ERB, 2022).

***Figure 5:** Mean annual rainfall in Zambia between 2000 and 2016. Source: Waldman et al., 2019.*



The distribution of rainfall is also not uniform across the country. The southern regions are significantly dryer than the northern regions. They receive an average of, approximately, 700 mm of rainfall per year, compared to an average of about 1,400 mm in the northern regions (ERB, 2022). Waldman *et al.* (2019) identified three different rainfall zones in Zambia, based solely on rainfall data: the south (dry, < 800 mm), the centre (intermediate, 800–1000 mm), and the north (wet, > 1,000 mm). **Figure 5** summarises their findings, showing the mean annual rainfall in Zambia between 2000 and 2016 and the borders of the identified rainfall zones.

The 2021/22 rainfall season is the most recent season for which the authors of this report could find data. This data can be found in the Energy Sector Report 2022 (ERB, 2022), and shows that rainfall during the 2021/22 season is within the average of previous years.

For instance, during the 2021/22 rainfall season, Lusaka received 592.20 mm of rainfall and Livingstone 826.70 mm (south, dry). Kaoma received 907.25 mm and Chipata received 916.60 mm of rainfall (centre, intermediate). Finally, Kawambwa received 1,209.30 mm and Solwezi 1,143.70 mm (north, wet). These numbers are within the expected ranges, or very close to them. The only exception is the rainfall in Mbala (north, wet), at 2,389.2 mm. Since this behaviour was observed at only one measuring station, which is in the north wet region, we do not consider it to be significant. Hence, we can conclude that the 2021/22 rain season was average.

4.2.2 Trend Analysis of Dams

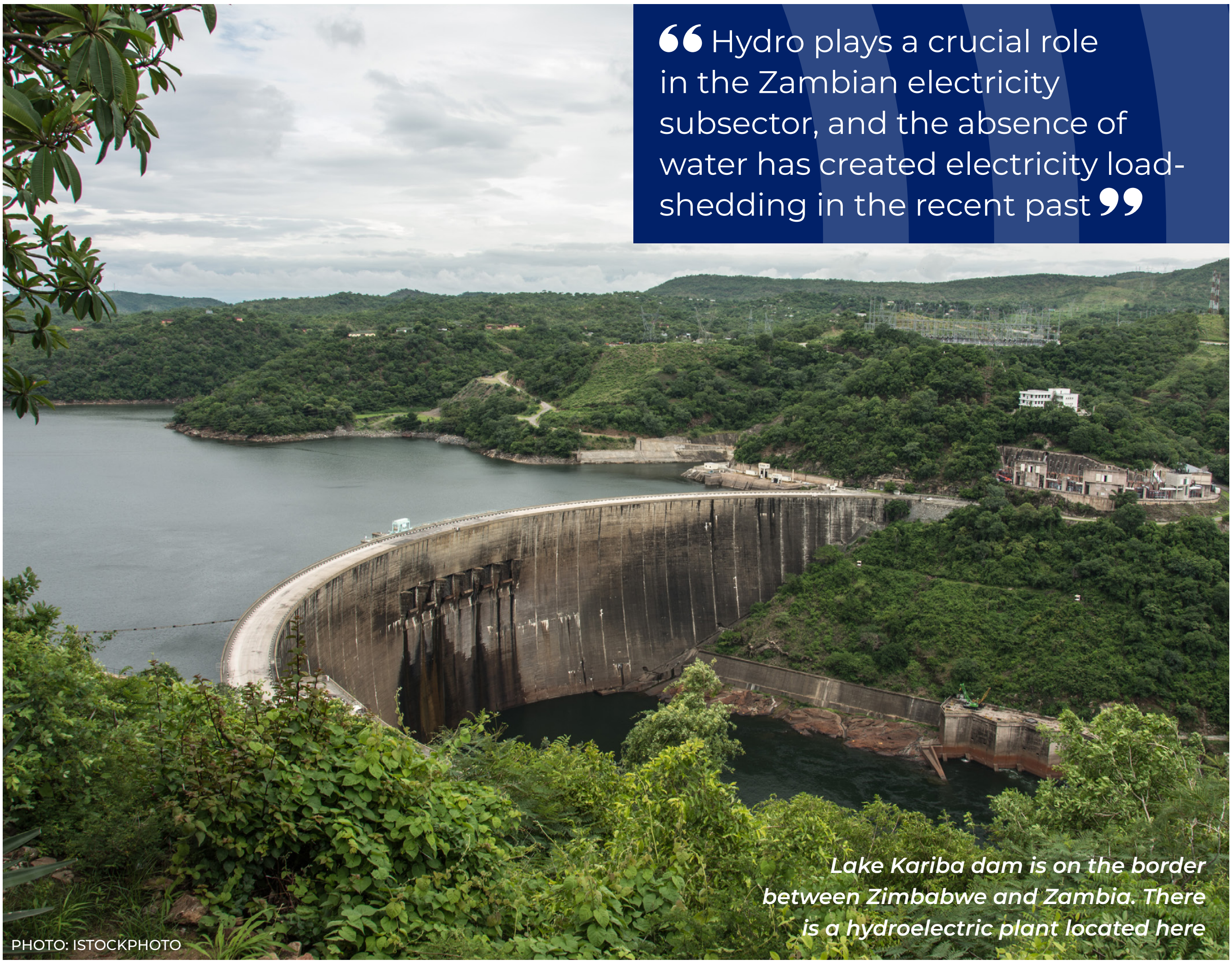
In this section, we analyse the annual water level patterns at the largest hydro dams in Zambia. **Table 3** summarises the dams considered and some key technical characteristics: the maximum head, storage capacity, and power output. The head of a dam is the height difference between where the water enters the hydro system and where the water leaves the system, usually measured in metres. It is used as an indicator of the production of each m^3 of water. The storage capacity is the amount of water that can be stored. Finally, the power output is the nameplate power capacity of the hydro station.

The report by the Southern Africa Energy Program (2018) presents a methodology to compute the value of water for electricity generation in Zambian power stations. In particular, it describes how to express the energy stored in hydro stations in power terms from the corresponding expression in water terms, taking into account the water head.

The water collection in dams in Zambia is linked to the rainy season, which runs from October to April. Hence, the water reservoir levels are expected to rise until May, as it takes some time for the water to flow to the dams (ERB, 2022). **Figures 6, 7, and 8** show the water levels in several years at the Kafue Gorge Upper, Itezhi-Tezhi, and Victoria Falls hydro stations, respectively. The water levels are expressed in metres above sea level (ASL).

Table 3: *Technical characteristics of the largest hydro power dams in Zambia. Maximum Head (Max. Head), Storage Capacity, and Power Output. Sources: ERB, 2022; Garret, 2023.*

Station	Max. Head (m)	Storage Capacity (m^3)	Power Output (MW)
Kafue Gorge Upper	2.60	2.85×109	900
Kafue Gorge Lower	49.75	1.07×108	750
Kariba North Bank	22.21		1,080
Itezhi-Tezhi	24.50	6.35×109	120
Victoria Falls	1.70		108



“Hydro plays a crucial role in the Zambian electricity subsector, and the absence of water has created electricity load-shedding in the recent past”

Lake Kariba dam is on the border between Zimbabwe and Zambia. There is a hydroelectric plant located here

PHOTO: ISTOCKPHOTO

Figure 6: *Water levels [metres above sea level] at Kafue Gorge Upper hydro station over several years. Source: ERB, 2022. NB FSL = Full Supply Level.*

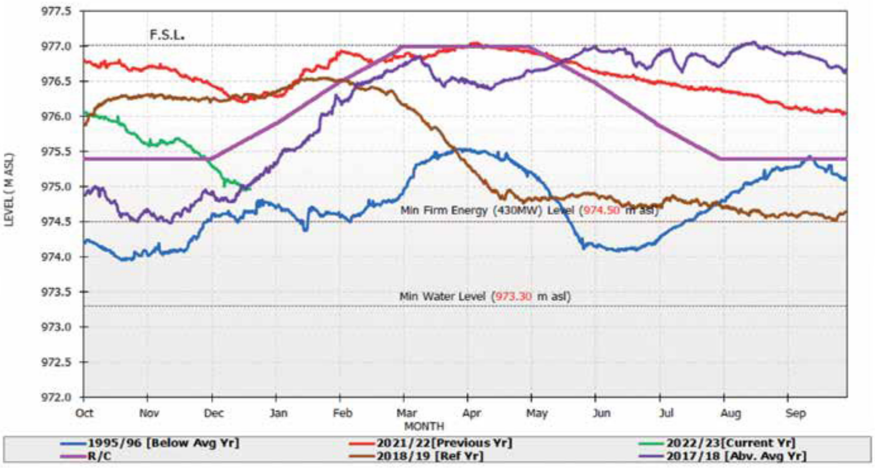


Figure 7: *Water levels [metres above sea level] at Itezhi-Tezhi hydro station in several years. Source: ERB, 2022.*

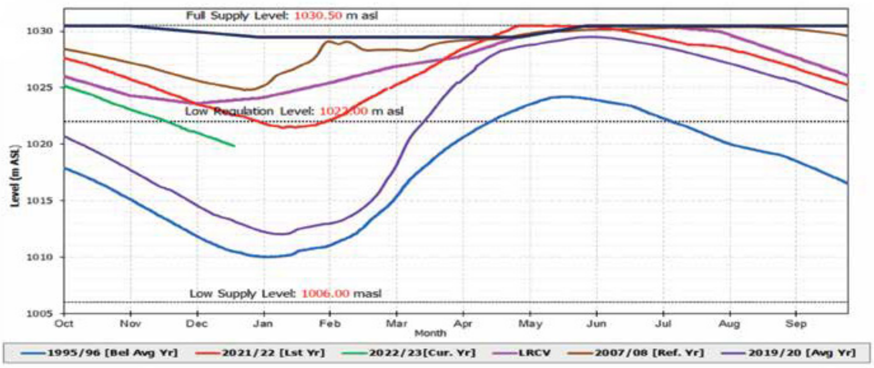
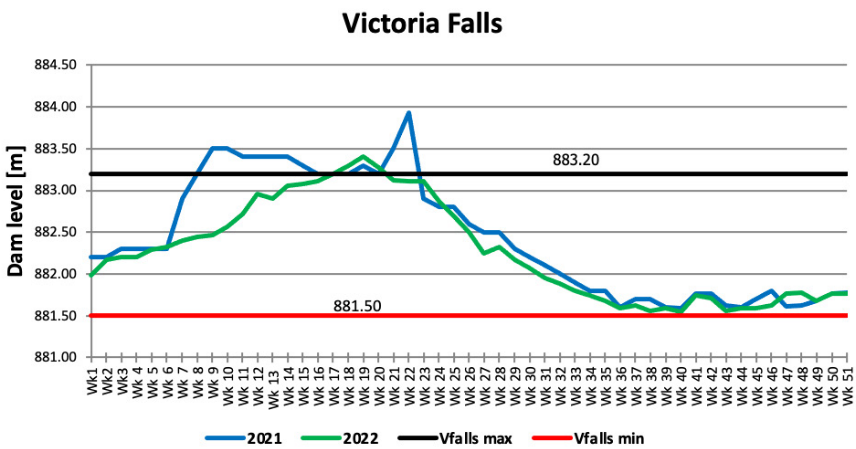


Figure 8: *Water levels [metres above sea level] at Kafue Gorge Upper hydro station over several years. Source: ERB, 2022. NB FSL = Full Supply Level.*



In these figures, it is interesting to notice the difference between the "Min Firm Energy Level" (Figure 6) or "Low Regulation Level" (Figure 7) and the "Min Water Level" (Figure 6) or "Low Supply Level" (Figure 7). The former is the minimum level required to produce electricity, while the latter is the absolute minimum level of the dam, that is, the metres above the sea level at which the ground of the reservoir lies.

In **Figure 6**, we observe that the water level at the Kafue Gorge Upper hydro station tends to increase during the rainy season. However, there have been rainy seasons where this pattern has not been followed, like the 2018/19 weather season. In that weather season, the water levels mostly reduced during the second half of the rainy season. The differences in water levels between the weather years 1995/96 (blue curve) and 2018/19 (brown curve) after May are also noteworthy. While the water levels in both years after May are relatively low, in the weather year 1995/96 the water levels dipped below the "Min Firm Energy Level", whereas in the weather year 2018/19 the water level was kept just above the "Min Firm Energy Level". This suggests that, in the weather year 2018/19, control measures were implemented to maintain the water level above the "Min Firm Energy Level" to guarantee that the water released generated electricity. However, it might have also been due to different rain patterns during those years.

In **Figure 7,** we observe that the water levels at the Itezhi-Tezhi hydro station consistently follow a yearly pattern, reaching the lowest level around January and highest in June. This aligns with the rainy season in Zambia. The level at which this pattern is observed varies between years, but the pattern does remain stable.

Similarly, in **Figure 8**, we can see that the water levels at the Victoria Falls hydro station follow a very similar pattern in the two years for which we have data (2021 and 2022). This pattern is also aligned with the rainy season, staying at its highest level from March to May (Week 10 to Week 23) and its lowest level from August to December (Week 36 to Week 51).

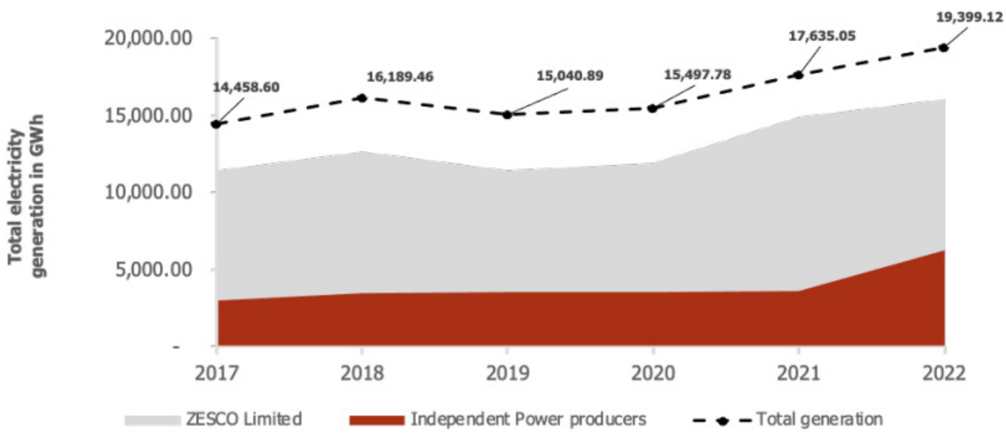
> "In 2022, per capita electricity generation in Zambia was around 1 MWh per year on average. However, as of 2023, the electricity access rate lies at only 51%, which significantly skews the distribution of electricity, uncovering massive inequality"

4.3 Annual Electricity Generation

A total of 19.4 TWh of electricity were generated in Zambia in 2022 (ERB, 2022). To put this number into perspective, we will estimate the electricity generated per capita and compare it to several countries. The census of 2022 (Zambia Statistics Agency, 2022) estimated the Zambian population at 19.6 million people. Therefore, the per capita electricity generation is around 1 MWh per year on average, but this number warrants some scepticism. As of 2023, the electricity access rate lies at only 51%, which significantly skews the distribution of electricity, uncovering massive inequality. Nonetheless, it compares to 3.2 MWh per capita in Brazil, 3.6 MWh per capita in South Africa, 4.8 MWh per capita in the United Kingdom, or 0.5 MWh per capita in Zimbabwe (Our World in Data, 2023).

In 2022, Zambia experienced a 10% increase in total electricity generation, rising from 17.6 TWh in 2021 to 19.4 TWh (see Figure 9). This growth can be attributed to the heightened generation capacity of the Kafue Gorge Lower power station, which saw the commissioning of three additional electricity generation units, each rated at 150 MW (ERB, 2022).

Figure 9: *Water levels [metres above sea level] at Kafue Gorge Upper hydro station over several years. Source: ERB, 2022. NB FSL = Full Supply Level.*



ZESCO plays a predominant role in electricity generation in Zambia, but it is supported by several IPPs. In the coming sections, we present and analyse the electricity generated by ZESCO's large hydro power plants, by ZESCO's small and mini hydro power plants, by ZESCO's diesel power plants, and by IPPs.

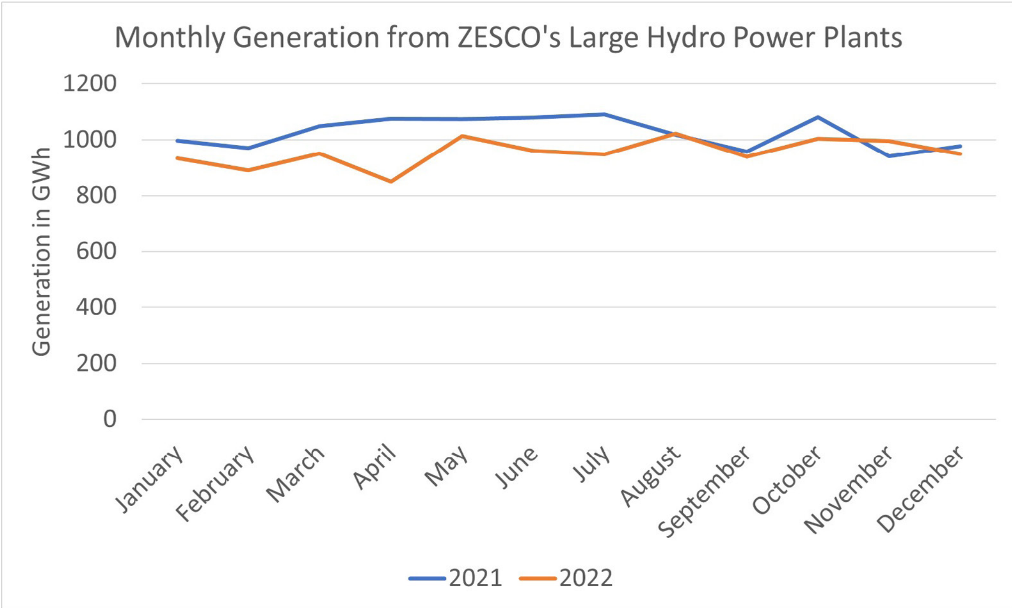
4.3.1 Generation from ZESCO's Large Hydro Power Plants

The 2022 Statistical Bulletin (ERB, 2023) identifies three large hydro power plants in Zambia: Kafue Gorge, Kariba North Bank, and Victoria Falls. They are all owned and operated by ZESCO. The monthly generation at each of these plants in 2021 and 2022 is presented in Table 4, and the aggregated monthly generation for those years is plotted in Figure 10. The Kafue Gorge power plant is the most productive, generating about 7.2 TWh of electricity per year, followed by the Kariba North Bank power plant at about 4.0 TWh annually. Finally, the Victoria Falls power plant generates about 0.7 TWh of electricity in a year.

Table 4: *Monthly electricity generation [GWh] by hydro power station in 2021 and 2022.Source: ERB, 2023.*

Station	Kafue | Gorge | Upper		Kariba North Bank		Victoria Falls		Grand Total	
Month	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
January	627.46	614.45	312.38	255.79	56.44	63.45	996.28	933.68
February	588.25	560.11	321.90	265.85	60.27	64.58	970.42	890.54
March	554.50	616.55	423.88	269.92	70.12	64.33	1,048.49	950.80
April	600.68	592.06	405.53	198.68	69.12	58.71	1,075.33	849.44
May	634.77	643.23	367.84	306.37	70.97	64.27	1,073.58	1,013.87
June	607.50	611.78	404.57	294.28	66.58	53.78	1,078.65	959.85
July	607.22	613.30	411.33	270.10	72.28	64.64	1,090.83	948.04
August	598.20	603.16	347.97	354.02	71.13	64.89	1,017.30	1,022.07
September	604.67	539.95	289.73	341.31	62.87	58.36	957.28	939.62
October	573.16	560.74	363.48	404.62	42.91	38.45	979.54	1,003.80
November	565.97	576.67	334.22	382.73	40.05	35.17	940.25	994.57
December	623.11	622.04	305.24	271.48	48.67	54.79	977.01	948.31
Grand Total	**7,185.48**	**7,154.03**	**4,288.07**	**3,615.15**	**731.40**	**685.42**	**12,204.96**	**11,454.60**

***Figure 10:** Total annual generation from ZESCO's Large Hydro Power Plants in 2021 and 2022. Source: ERB, 2023.*



We observe that electricity generation from these major hydro power plants in Zambia decreased slightly from 2021 to 2022. This decrease was mostly caused by the decrease in production at the Kariba North Bank power plant (see Table 4).

The most notable feature of Figure 10 is the lack of seasonal variation in the generation of electricity from ZESCO's large hydro power plants. The consistency of the generation in the two years is also noteworthy. The average monthly generation in 2022 was very similar to that in 2021. Hence, we can conclude that these generation figures are a robust estimate of the monthly generation capabilities of large hydro power plants in Zambia.

4.3.2 Generation from ZESCO's Small and Mini Hydro Power Plants

ZESCO's small and mini hydro power plants are Chishimba Hydro Power Station, Lunzua Hydro Power Station, Lusiwasi Lower Hydro Power Station, Lusiwasi Upper Hydro Power Station, Musonda Falls Hydro Power Station, and Shiwan'gandu Hydrod Power Station. They saw an overall generation decline from 220.5 GWh in 2021 to 160.8 GWh in 2022 (ERB, 2023).

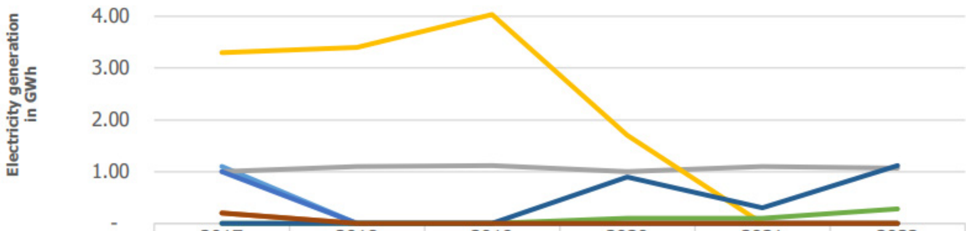
This decline in generation was observed in all small and mini hydro power plants. The most significant reduction was at Lunzua Hydro Power Station, which saw a 42.9% decrease from 72.0 GWh in 2021 to 41.1 GWh in 2021, making it responsible for about 50% of the overall generation reduction of power plants in this category. Moreover, the decline was spread over all months with the only exception of December. For more details on the monthly generation at these power plants, see Table 13 in the 2022 Statistical Bulletin (ERB, 2023).

The fact that the decline is widespread across all power plants and in most months suggests that the main reason for it is lower water levels in rivers and reservoirs across the country due to reduced rainfall. Additionally, maintenance activities and technical challenges faced by some hydro plants in 2022 might have also contributed to this decrease.

4.3.3 Generation from ZESCO's Diesel Power Plants

ZESCO uses diesel generators to supply power in Shang'ombo, Chama, and Lundazi, as these are not yet connected to the national grid. Electricity generation from diesel generators in Zambia has been on an upward trend in recent years, increasing by 64.67% from 1.50 GWh in 2021 to 2.47 GWh in 2022. This increase can be attributed to the increased generation from the Lundazi diesel plant, which more than doubled its output in 2022 (see **Figure 11**).

Figure 11: *Total annual generation from ZESCO's Large Hydro Power Plants in 2021 and 2022. Source: ERB, 2023.*



	2017	2018	2019	2020	2021	2022
Zambezi	1.10	-	-	-	-	-
Kabompo	0.20	-	-	-	-	-
Shang'ombo	1.00	1.10	1.12	1.00	1.10	1.07
Luangwa	3.30	3.40	4.03	1.70	-	-
Chavuma	1.00	-	-	-	-	-
Chama	-	-	-	0.10	0.10	0.28
Lundazi	-	-	-	0.90	0.30	1.12
Itezhi Tezhi	0.20	-	-	-	-	-

4.3.4 Generation from Independent Power Producers

The total generation from IPPs in Zambia increased by 49.37% from 2021 (5.21 TWh) to 2022 (7.78 TWh). This is shown in Table 5, which also contains the detailed annual production of every IPP in the years 2021 and 2022. The notable increase in total annual generation from IPPs was primarily driven by a significant rise in generation at Kafue Gorge Lower Power Station (234.9%) and Maamba Collieries Limited (66.8%).

The reason behind the increase in output at the Kafue Gorge Lower Power Station is the gradual commissioning of its 150 MW units between 2021 and 2023 (ERB, 2022). Hence, while these were not completed in 2022, it had more power available than in 2021. No reason for the increase in the Maamba Collieries coal power plant was evident.

The reduction in output of the Ndola Energy Company Limited is also noteworthy. It did not produce electricity during 2022. The rest of the IPPs produced similar quantities of electricity in 2021 and in 2022.

Table 5: *Annual generation of Independent Power Producers (GWh) in 2021 and 2022. Source: ERB, 2023.*

Station	2021 (GWh)	2022
Bangweulu Power Company	89.24	84.54
Itezhi-Tezhi Power Corporation	829.11	757.80
Kafue Gorge Lower Power Station	893.33	2,966.65
Kariba North Bank Extension	1,570.62	1,501.20
Lunsemfwa Hydro Power Company	354.09	247.78
Maamba Collieries Limited	1,296.62	2,164.70
Ndola Energy Company Limited	117.17	-
Ngonye Power Company	58.42	58.57
Grand Total	**5,208.60**	**7,781.23**

4.4 Electricity Consumption

4.4.1 Total Consumption

The national electricity consumption in Zambia has grown significantly, rising by 7% from 2021 to 2022 (ERB, 2023). This growth is expected to continue in the coming years due to population growth, economic expansion, urbanisation, and plans to increase electricity access rates.

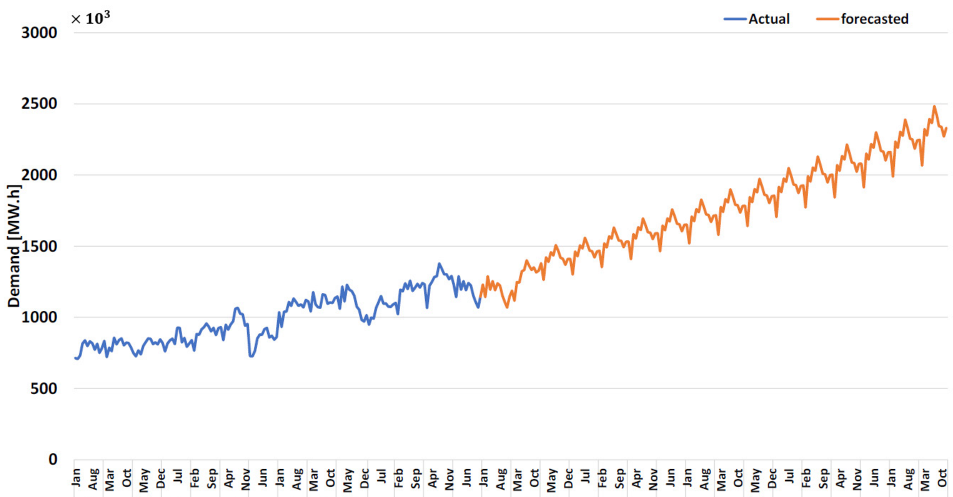
There is some seasonality in Zambia's electricity demand. Daka and Farzaneh (2023) conducted a time series analysis on monthly electricity demand for the period 2006–2019 to forecast future electricity demand. **Figure 12** shows the historic data they used to conduct their study (in blue) and the monthly electricity demand forecasts they obtained (in orange). Their forecasts have a clear yearly pattern, with the lowest electricity demand in winter and the highest in spring, suggesting that this is the expected demand seasonality.

However, since the work by Daka and Farzaneh (2023) is based on historical data analysis, it is not possible to determine whether the lower demand in winter is truly a lower demand or a result of load-shedding. The latter would result in lower electricity availability and hence lower consumption, but maybe not lower willingness to consume electricity by Zambian consumers. The fact that the load-shedding periods of 2015–2017 and 2022–2023 ended in March 2017 and February 2023, respectively, and thanks to higher levels at water reservoirs (at least partially) suggests that the effect of load-shedding might be significant (Ngoma et al., 2018; The Brief, 2023).

In the future, population growth is expected to lead to more households and businesses accessing electricity. Economic expansion is expected to increase electricity demand from all sectors of the economy and urbanisation to higher levels of electricity consumption in cities (World Bank, 2015; Ministry of Energy, 2023a). This is also supported by the forecasts by Daka and Farzaneh (2023), which have a clear upwards trend (see Figure 12).

The Zambian government has set a goal of universal electricity access by 2030 (Ministry of Energy, 2023a). This means that the government is committed to ensuring that all Zambians have access to reliable and affordable electricity. To achieve this goal, the government is investing in new generation and transmission capacity, as well as expanding the electricity grid to rural areas.

***Figure 12:** Historic [blue] and projected [orange] monthly electricity demand in Zambia. Source: Daka and Farzaneh, 2023.*



4.4.2 Sector-wise Consumption Changes

Table 6 shows the electricity consumption for each energy sector (ERB, 2023) for the years 2021 and 2022. In both years, the mining and domestic sectors accounted for most of the electricity consumption. The mining sector represented about 47% of the total electricity consumption in Zambia in both years, while the domestic sector represented about 34%.

The remaining electricity consumption is split across the following sectors: finance and property, manufacturing, agriculture, energy and water, trade, transport, and construction. None of these represent more than 10% of electricity consumption, with the largest consumer being the finance and property sector at about 6.5% of the total electricity consumption in both years considered (ERB, 2023).

There was a 7.38% increase in total electricity consumption from 2021 to 2022. Most sectors experienced an increase in electricity consumption in 2023, except the construction, energy and water, and agriculture sectors. Since they represent a small share of total electricity consumption, the decrease in consumption in these sectors did not significantly influence the total figures.

Among those sectors that increase their electricity consumption between 2021 and 2022, the mining sector experienced the most significant growth with an 11% increase. Domestic consumption remained relatively steady, with a 1.6% increase. From this, we can deduce that most of the increase in total electricity consumption from 2021 to 2022 was due to the mining sector, since mining and domestic are the largest electricity consuming sectors in Zambia. Finance and property experienced a 9% increase in electricity consumption, while manufacturing saw a modest 2% increase. The changes in the electricity consumption in several sectors suggest potential expansion and increased activities in the mining industry, ongoing industrial activities in the manufacturing sector, heightened economic activities in the finance and property sector, and a stable pattern of electricity use in households.

Table 6: *Annual Consumption (GWh) of electricity by sector in 2021 and 2022. The numbers have been rounded up to 2 decimal places. Source: ERB, 2023.*

Electricity Consumption (GWh)	2021	2022
Others	60.45	56.16
Agriculture	293.75	286.46
Mining (Quarries)	571.58	743.57
Manufacturing	375.44	384.64
Energy and Water	113.67	106.77
Construction	9.39	7.31
Trade	82.82	87.77
Transport	31.82	36.94
Finance and Property	835.43	908.28
Domestic (Including Households)	4,477.30	4,548.50
Mines (Total)	5,979.71	6,611.51
Total (National Demand minus Losses)	**12,831.36**	**13,777.90**

4.5 Challenges in the Electricity Sub-sector

In 2022, Zambia experienced another round of load-shedding due to a shortfall in electricity generation capacity, exacerbated by decreasing water levels at the primary electricity generation station in the Kariba North Bank power station. The electricity sub-sector faced challenges stemming from insufficient investment to meet the escalating demand for electricity, aggravated by non-cost reflective tariffs that contributed to the deterioration of ZESCO's financial position.

To address these issues, the ERB completed the Cost of Service Study (CoSS) in 2021 (Energy Market and Regulatory Consultants Limited, 2021). The objective was to establish benchmark cost-reflective tariffs for the electricity sub-sector. Additionally, the ERB is currently working on

Multi-year Tariff Framework (MYTF) regulations (ERB, 2022). These regulations aim to establish an appropriate tariff migration path from existing rates to cost-reflective tariffs over the predefined period of 2023 to 2027. Moreover, the MYTF regulations will incorporate provisions for automatic cost passthrough and adjustments. This ensures that any unusual fluctuations in exchange rates, inflation, or other economic factors are promptly considered in the electricity tariffs.

4.6 Outlook for the Electricity Sub-sector

The future of Zambia's electricity industry shows promising growth in both the short and long term. Key prospects for the electricity sub-sector are described in the coming sub-sections.

4.6.1 Affordable, Reliable, Sustainable and Modern Energy for All

The UN Sustainable Development Goal 7 (SDG7) aims to "ensure access to affordable, reliable, sustainable and modern energy for all" by 2030 (United Nations, 2015). Zambia, together with all UN member states, adopted the Sustainable Development Goals. Hence, it has the objective to achieve SDG7 by 2030.

To achieve this goal, multilateral development banks have designated funding towards developing countries. Zambia's Least Cost Geospatial Electrification Plan (Tractebel, 2022) was funded by the World Bank and developed on behalf of the Ministry of Energy in 2022. Its objective was to establish the least cost mode of universal electrification in Zambia by 2030. It used geospatial data to establish the least cost mode of electrification for each locality and household in Zambia.

4.6.2 Development of Multi-Year Tariff Framework

The ERB, with technical assistance from the EU through the Increased Access to Electricity and Renewable Energy Production (IAEREP) programme, developed the Multi-Year Tariff Framework (MYTF) for Zambia's electricity sector (ERB, 2023b), which came into force in 2023. The primary objectives of the MYTF framework include ensuring licensees' financial and economic viability, maintaining reasonable tariff stability, providing efficiency incentives, establishing a systematic and predictable basis for revenue/tariff setting, and ensuring a smooth transition between multi-year tariff control periods (ERB, 2022).

4.6.3 Open Access

To enhance power trade, the ERB is in the process of formulating open access regulations, along with a new market design and structure. Open access, as defined by the Electricity Act 2019 (Government of Zambia, 2019a), ensures the availability of spare transmission or distribution capacity to qualifying participants on non-discriminatory terms and conditions. Phase I of the study, completed in December 2021, covered open access market structure and market design. Phase II, initiated in July 2022, focuses on transmission and distribution pricing methodology and rules, guidelines, and regulations for an open access market, with implementation expected during 2024 (ERB, 2023c).

4.6.4 Kafue Gorge Lower Hydro Power Station

The Kafue Gorge Lower Hydro Power Station, located approximately 90 kilometres southwest of Lusaka, is owned and operated by the Kafue Gorge Lower Development Corporation Limited (KGLDC). Initiated to address growing electricity demand and diversify the energy mix, the power station aims to reduce reliance on fossil fuels. With a planned installed capacity of 750 MW from five generation units of 150 MW each, four units were commissioned and operational as of December 2022 (one unit in 2021, and three units in 2022). The remaining 150 MW generation unit was commissioned in March 2023 (ERB, 2022).

5 RENEWABLE ENERGY SUB-SECTOR

5.1 Introduction

Renewable energy, harnessed from hydro, solar, biomass, wind, and geothermal sources, holds significant promise for steering development towards an eco-friendly and sustainable trajectory. This potential is particularly pronounced due to technological advancements facilitating the conversion of these renewable resources into electricity—a crucial resource propelling social and economic development (Eltrop, 2013). This holds true, especially for numerous energy deficient developing nations, when considering the great benefits that renewable energy can extend to various sectors of the economy. In a broad sense, renewable energy technologies encompass technologies that supply electricity derived from renewable sources like water, wind, solar, tidal waves, and geothermal for activities such as household cooking, heating, space conditioning, and water pumping (United Nations Conference on Trade and Development, 2018).

Viewed from households' perspectives, the transition to renewable energy usage brings about numerous advantages. It alleviates for individuals, especially women and children, the time-consuming manual completion of household tasks in the absence of electricity (Thiam, 2011). Furthermore, it addresses health issues associated with the collection and use of woody fuels (Behl *et al*., 2012). Various studies also indicate positive outcomes, including enhanced livelihoods through productive energy use, sustainable urban planning and architecture, environmental sustainability, and equitable energy service provision (World Bank, 2017; Mahdavinejad *et al*., 2013).

The next sub-section discusses the status quo of the renewable energy sub-sector in Zambia.

5.2 The Current Status of the Renewable Energy Sub-sector

The 2022 Energy Sector Report highlights Zambia's dedicated commitment to sustainable energy practices, emphasising the exploration of abundant and renewable sources such as solar, wind, biomass, hydro, and geothermal power (ERB, 2022). This strategic emphasis serves as a pivotal element in broadening the nation's energy portfolio, fostering a transition towards reliable, environmentally friendly, and cost-effective energy solutions.

Within the existing regulatory framework, the Energy Regulation Board (ERB) has played a key role by granting licences for both grid-connected and off-grid photovoltaic (PV) plants (ERB, 2022). Noteworthy instances of grid-connected PV facilities include the collaborative efforts of Neon and the Industrial Development Corporation (IDC) in the Bangweulu 54 MW facility, the Enel and IDC partnership in the Ngonye 34 MW plant, and the Copperbelt Energy Corporation's 1 MW Solar Power Plant situated in Riverside, Kitwe. Additionally, the ERB has extended licences to entities engaged in the manufacturing, supply, installation, and maintenance of renewable energy equipment.

A significant milestone in 2021 was the inauguration of Surya Biofuels, a bioethanol production plant

> “Viewed from households' perspectives, the transition to renewable energy usage brings about numerous advantages”

> “The demand for electricity is growing, which shows the potential for generating more electricity. This gap can be filled by efficiently utilising the country’s solar potential”

Boy selling electronics and a solar panel at a rural African market

PHOTO: ISTOCKPHOTO

located in Chibombo District boasting an annual production capacity of approximately 3 million litres of biofuels. The bioethanol produced serves the purpose of blending within the fuel supply chain, contributing to a more sustainable and diversified energy mix.

Addressing concerns surrounding charcoal energy consumption and the associated deforestation challenges, the United States Agency for International Development (USAID) Zambia has collaborated with various stakeholders in the Alternatives to Charcoal (A2C) project (Tetra Tech/ARD, 2022). Under this initiative, the ERB, supported by USAID’s ongoing five-year A2C Project, established standards in 2022 for bioethanol and gel, as well as the associated cooking appliances. This proactive initiative seeks to encourage the adoption of Alternative Technologies and/or Fuels (ATFs), playing a crucial role in mitigating deforestation and fostering a more sustainable energy landscape for Zambia.

In this section, we will examine the current status of the following renewable energy technologies: solar, wind, geothermal, and biomass. For each technology, we will assess the potential and installed capacity.

5.2.1 Solar Energy

Solar Potential in Zambia

Zambia has a huge solar power potential. Although 51% of the population has access to electricity as of 2023 (Ministry of Energy, 2023a), this is likely to be lower in rural areas. According to SmartSolar Zambia (2019), the access rate was 31% in 2019, but was only approximately between 4% and 11% in rural areas. At the same time, the demand for electricity is growing, which shows the potential for generating more electricity. This gap can be filled by efficiently utilising the country’s solar potential.

Every year, Zambia has an average of 2,000–3,000 hours of sunshine, which is high compared to the rest of the world (see **Figure 13**). The average irradiation level is 5.5 kWh per m2 (each day), which makes it naturally suited for solar energy generation. The southern region experiences the highest solar irradiation, as shown in **Figure 14**.

Figure 13: *Solar power potential around the world. Source: SmartSolar Zambia, 2019.*

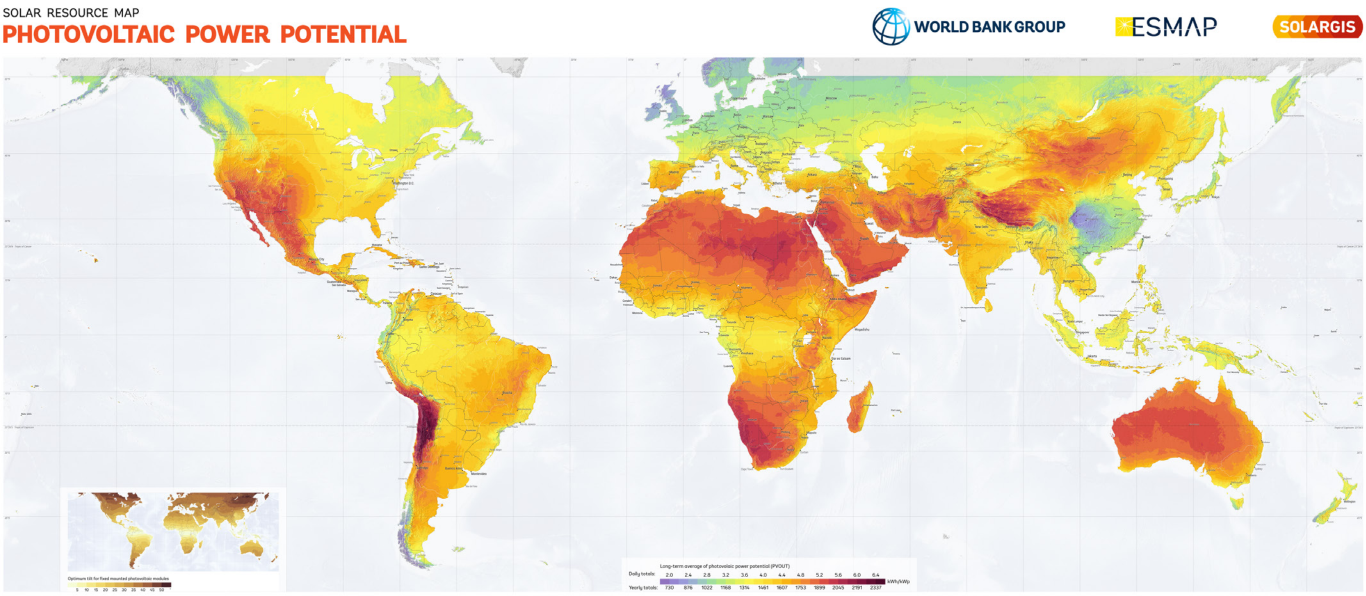
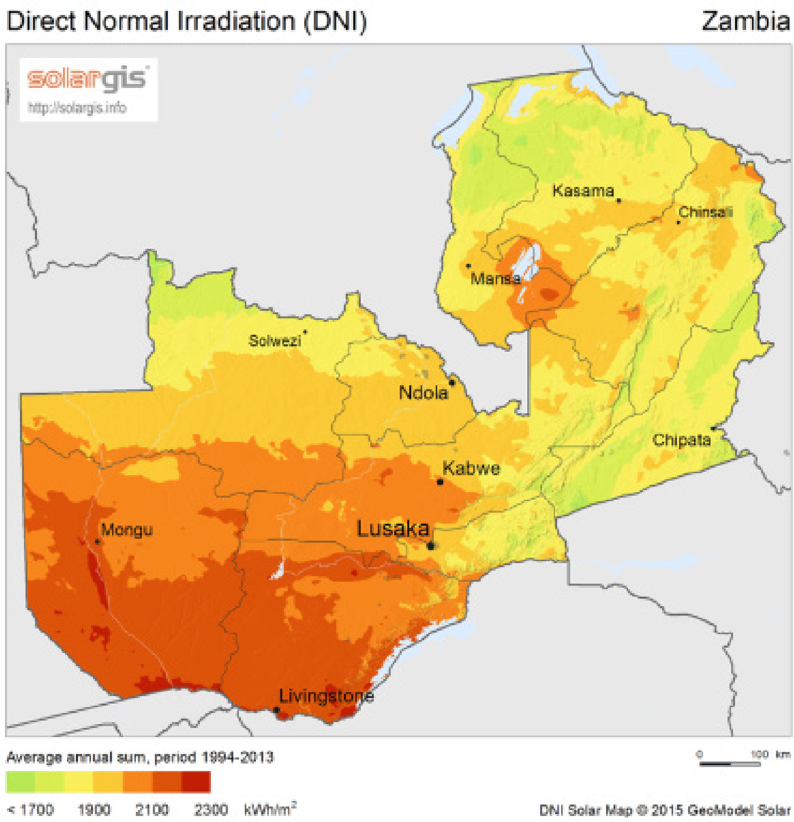


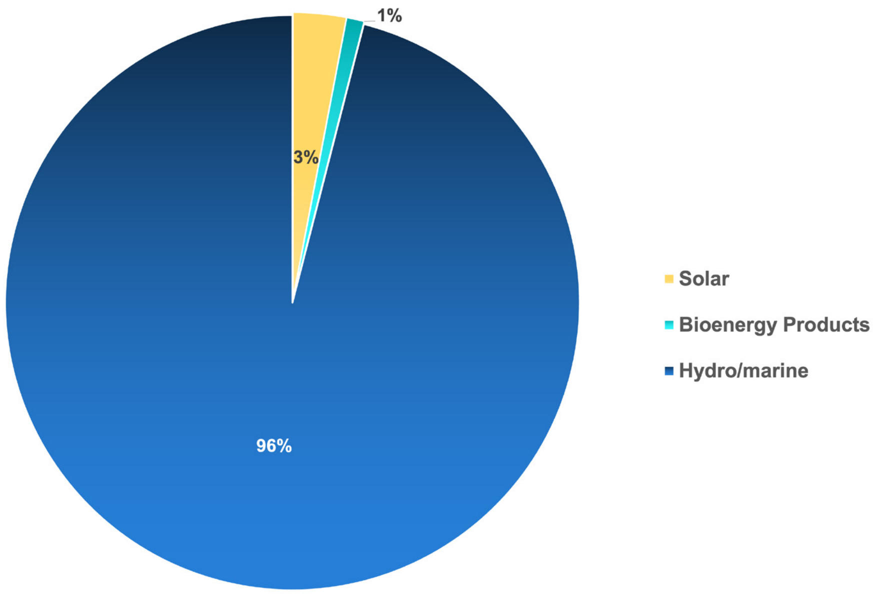
Figure 14: *Solar irradiation levels in Zambia. Source: SmartSolar Zambia, 2019.*



Solar Installed Capacity

According to the Ministry of Energy, the total installed capacity in 2022 was 89 MW (refer to Figure 2). According to the International Renewable Energy Agency's (IRENA) recent report, the installed capacity of solar energy accounts for only 3% of the total renewable capacity (IRENA, 2022), as shown in Figure 15, despite the huge potential for solar in the country.

***Figure 15:** Renewable capacity in 2022 in Zambia. Source: IRENA, 2022.*



Zambian Government Initiatives for Solar Energy Promotion

The Zambian government has established a number of policies and programmes aimed at promoting the use of renewable energy. These policies and programmes are designed to create an enabling environment for the development of the solar energy industry and to encourage investment in renewable energy projects. One of the key policies established by the Zambian government is the Renewable Energy Feed-in Tariff (REFIT) programme (Ministry of Energy, 2017). This programme provides a fixed tariff rate for electricity generated from renewable energy sources, including solar energy. The programme is intended to encourage investment in renewable energy projects by providing a guaranteed price for electricity generated from these sources. Under the REFIT programme, investors can receive a tariff rate of between 0.18 and 0.22 USD per kilowatt hour for electricity generated from solar photovoltaic (PV) systems, depending on the capacity of the system. The programme also provides a tariff rate of between 0.06 and 0.09 USD per kilowatt hour for electricity generated from small hydro power projects.

In addition to the REFIT programme, the Zambian government has also established the Rural Electrification Authority (REA) to promote the development of renewable energy in rural areas. The REA provides funding and technical assistance for the installation of solar panels and other renewable energy systems in rural areas, where access to electricity is limited (REA, 2020). The government of Zambia has also established the Sustainable Energy for All (SE4ALL) initiative (African Development Bank, 2017), which aims to increase access to modern energy services and promote the use of renewable energy. The initiative is supported by the United Nations Development Programme and IRENA, among others.

5.2.2 Wind Energy

A recent Energy Sector Management Assistance Programme (ESMAP) wind resource assessment showed that Zambia has significant wind energy potential (World Bank, 2018). The country now has a wind atlas and an established network of state-of-the-art wind measurement masts at eight locations across Zambia that can be used to support stakeholder wind analysis activities and future utility-scale wind development in the country. Measured wind speeds over a 24-month period at a mast height of 80 m are 5.6–6.4 m/s (Ministry of Energy, 2022).

Average windspeeds above 6.5 m/s at a mast height of 80m are generally considered commercially viable. New technologies, however, are expanding wind resources accessible for commercial projects (Center for Sustainable Systems, 2023). This is approximately the upper bound on average wind speeds in Zambia, indicating that there should already be places where onshore wind is commercially viable, and more will be in the near future.

Currently, there is no utility-scale wind power plant in Zambia, although a few investors are carrying out wind power feasibility studies. The most active are Mphepo Power and Access Zambia Wind One Limited. Mphepo has identified a number of sites across the Eastern Province and plans to develop the first plant at Unika I, with capacity of 150–300 MW. Access Zambia Wind One Limited intends to develop a 130–140 MW wind power project near Pensulo in the Central Province (Ministry of Energy, 2022).

5.2.3 Geothermal Energy

Zambia has a geological setting that is suitable for exploiting further geothermal energy expansion and investigation (Musonda and Sikazwe, 2005; Elbarbary *et al*., 2022). There are over 80 thermal springs in the country hosted in fault systems within Proterozoic basement rocks and associated largely with Karoo (Permian) era basins (Kachapulula-Mudenda *et al*., 2018). In addition, there are younger East African Rift structures in the northeast of the country. Surface temperatures of geothermal systems, largely hot springs, indicate the range of 35–93°C (Ministry of Energy, 2022).

There is currently no geothermal electricity generation in Zambia except for the 220 kW pilot plant at Kapishya Hot Springs, built in 1986. Due to the absence of market drive and the technical limitations of the site, the plant was eventually abandoned. Recently, Kalahari GeoEnergy has made significant progress towards establishing the first geothermal power plant in the Bweengwa River Geothermal Resource Area. The ongoing exploration has confirmed the existence of a geological setting conducive to the development of a low- to medium-enthalpy geothermal resource with an average temperature of production wells of about 110°C, which can support a power generation project of at least 10 MW. Kalahari plans to pilot a sub-250 kW demonstration unit to show proof of concept, generate interest, and attract funding for commercial-scale operations (Ministry of Energy, 2022).

5.2.4 Biomass Energy

Biomass supplies more than 90% of the country's fuel sources in rural areas (Czech Development Agency, 2022). Given the abundant agricultural and forestry biomass resources, Zambia has significant biomass energy potential (Kaoma and Gheewala, 2020). The country has large land

> “Currently, there is no utility-scale wind power plant in Zambia, although a few investors are carrying out wind power feasibility studies”

> "The country's commitment to universal electricity access by 2030 drives investments in new generation and transmission capacity"

areas, of which 58% are suitable for sustainably growing energy crops, such as cassava, sugarcane, soybean, and sunflower (FAO and Ministry of Energy of Zambia, 2020). Biomass residues and waste are significant resources that can be harnessed for various energy applications, including wood logging residue, crop harvesting residues, animal farm residues, agro-processing residues, wood processing residues, and municipal solid and liquid waste (Ministry of Energy, 2022).

A recent Bio-Energy Food Security (BEFS) study, supported by the Food and Agriculture Organization (FAO), quantified the biomass resource potential in the country. The study showed that the country has about 4.7 million tonnes of field crop residues and 133,000 tonnes of forestry residues that can support a power generation capacity of about 1,192 MW. In addition, there are 3.124 million tonnes of cattle, pig, chicken, and goat manure potentially available to produce about 2,370 TJ of biogas annually (Ministry of Energy, 2022).

5.3 Renewable Energy Targets

Zambia aims to add 2,015 MW of grid-connected renewable energy capacity to its power system by 2030, including 1,383 MW of hydro, 500 MW of solar, 130 MW of wind, and 3.2 MW of geothermal power (Ministry of Energy, 2022). This corresponds to increasing the grid-connected generation capacity by 53% from 3,777.3 MW and the renewable generation capacity by 62% from 3,252.5 MW at the end of 2022 (see Section 4.1). Particularly remarkable is the more than fivefold increase in grid-connected solar and the plan to install wind power for the first time in the country.

The national targets for off-grid renewable energy technologies are based on the estimated off-grid demand for electricity services by area through 2030 for both households and agriculture. These off-grid systems will be mainly solar PV mini grids and solar home systems. However, small hydro-based mini grids will also contribute to the off-grid renewable energy supply at a limited number of sites. By 2030, the target is to connect 4.82 million Zambians (19.1% of the expected population in 2030) to mini grids. This would be done by generating an extra 1,851 GWh per annum by 2030. In addition, the aim is to connect 8 million Zambians to solar home systems (31.6% of the expected population in 2030), which would need an extra of 35 GWh per annum by 2030 (Ministry of Energy, 2022).

By 2030, Zambia aims to blend both petrol and diesel with ethanol and biodiesel under its biofuel mandates of 10% and 5%, respectively. These targets are aligned with the projected transport fuel demand. To achieve the E10 (10% ethanol) blending mandate by 2030, Zambia aims to produce 52.5 million litres of bioethanol. For biodiesel, the aim is to produce 75.3 million litres by 2030 to fulfil the B5 (5% biodiesel) blending mandate. With a 10% capacity margin considered for the biofuel plants, the targeted plant capacities should be 105 million litres for ethanol and 85 million litres for biodiesel (Ministry of Energy, 2022).

There is potential for meeting 2,207 TJ of cooking energy using biogas, especially utilising cattle manure as feedstock, which is sufficient to supply the estimated annual target energy demand of 62,000 rural Zambian households by 2030. Increasing the contribution of biogas to cooking energy needs is possible by employing the co-digestion of cattle manure together with other feedstocks, such as crop residues. Using 50% livestock manure and selected crop residues, about 3,700 TJ of cooking energy can be derived from biogas annually, meeting the cooking energy demand of 100,000 rural households. However, a conservative target for the national dissemination of biogas digesters is 62,000 households by 2030 if only livestock manure feedstock is considered (Ministry of Energy, 2023a).

Targets for sustainable charcoal production are based on the amount of firewood saved by switching to improved charcoal production. The target is to improve charcoal production efficiency from the current 20% to 35% by the year 2030. This will result in the saving of 8.176 million tonnes of firewood in 2030, or a 37.7% reduction in firewood consumption. This also represents a saving of 64,150 hectares of land in 2030. The USAID-supported A2C initiative aims at a 25% reduction in charcoal consumption by 2026 through the promotion of fuel switching from charcoal to alternatives, such as LPG, sustainable biomass (e.g., pellets), ethanol, electricity, and biogas. Furthermore, the promotion of improved charcoal cookstoves, such as the EcoZoom charcoal stove, would reduce charcoal consumption by about 45% (Ministry of Energy, 2022).

> “The country has about 4.7 million tonnes of field crop residues and 133,000 tonnes of forestry residues that can support a power generation capacity of about 1,192 MW”

PHOTO: ISTOCKPHOTO

Cassava harvest in Africa

6 CONCLUSION

Zambia's energy landscape is multifaceted, encompassing electricity, petroleum, and renewable energy. Despite significant progress, the sector faces challenges such as limited electricity access, reliance on biomass, and a growing demand for energy. The government's efforts to increase the share of electricity and renewable energy in the energy mix involve investments in the grid, new power generation capacity, and energy efficiency measures.

The petroleum sub-sector, entirely reliant on imports, plays a crucial role in meeting Zambia's energy needs. The pricing mechanism, utilising the Cost-Plus Pricing model, has faced criticism for not being regularly adjusted, leading to implicit fuel subsidies. The consumption of petroleum products, particularly diesel and unleaded petrol, remains significant, with industrial uses of diesel being a major contributor.

In the electricity sub-sector, ZESCO dominates as a vertically integrated utility, supported by independent power producers. Hydro power remains the primary energy source, with the Kafue Gorge Lower power project contributing to a substantial increase in electricity capacity. However, challenges such as load-shedding and the need for cost-reflective tariffs persist. The analysis of dams, rainfall patterns, and electricity generation highlights the impact of hydrological conditions on Zambia's energy production. The country's commitment to universal electricity access by 2030 drives investments in new generation and transmission capacity.

Looking ahead, the outlook for Zambia's electricity sub-sector appears promising, with initiatives like the Multi-Year Tariff Framework and Open Access regulations expected to enhance efficiency and power trade. The completion of the Kafue Gorge Lower Hydro Power Station signifies a step towards reducing reliance on fossil fuels and diversifying the energy mix.

In the context of this complex energy landscape, this report is the first step of the GoPRO- Zambia research project towards building a power system capacity expansion model for Zambia using PyPSA-Earth (Parzen *et al*., 2023), and combine it with ZAMMOD, an input-output macroeconomic model to analyse the macroeconomic implications of green growth in Zambia (Geda *et al*. 2018). These models aim to address infrastructure cost, carbon emissions, future energy demand, socio-economic constraints, and implications in the wider economy, contributing to the sustainable development of Zambia's energy sector, and Zambia.

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References

[1] African Development Bank (2017). *Sustainable Energy for All - Africa Hub. Annual Report 2015 - 2016.* URL: https://www.se4all-africa.org/fileadmin/uploads/se4all/Documents/Annual_Report/SEforALL_Africa_Hub_-_ANNUAL_REPORT_2015-2016.pdf.

[2] African Union (2023). *Zambia Energy Balance*. URL: https://au-afrec.org/index.php/zambia.

[3] Behl, R.K., Chhibar, R.N., Jain, S., Bahl, V.P., and El Bassam, N. (2012). “Renewable energy sources and their applications”. In: *Proceedings of the International Conference on Renewable Energy for Institutes and Communities in Urban and Rural Settings*, pp 27–29.

[4] Bhatia, M. and Angelou, N. (2015). *Beyond Connections: Energy Access Redefined*. ESMAP Technical Report 008/15. The World Bank. URL: http://hdl.handle.net/10986/24368.

[5] Center for Sustainable Systems (2023). *Wind Energy Factsheet*. University of Michigan. Pub. No. CSS07-09. URL: https://css.umich.edu/publications/factsheets/energy/wind-energy-factsheet.

[6] Chitandula, A., Abuzayed, A., Nyoni, K.J., and Vilalta, A.S., (2024). *Measures and Technologies for a Low-Carbon Zambian Energy System*. Report. To appear in Climate Compatible Growth.

[7] Czech Development Agency (2022). *In Zambia, CzDA supports a project using biogas technology as a source of sustainable energy and organic fertilizer*. URL: https://www.czechaid.cz/en/our-work/news/in-zambia-czda-supports-a-project-using-biogas-technology-as-a-source-of-sustainable-energy-and-organic-fertilizer1.

[8] Daka, P.P. and Farzaneh, H. (2023). “Developing an Integrated Energy Demand Supply Modeling Framework for Scenario Analysis of the Low Carbon Emission Energy System in Zambia”. In: *Applied Sciences* 13.6. DOI: 10.3390/app13063508.

[9] Elbarbary, S., Zaher, M.A., Saibi, H., Fowler, A-R., and Saibi, K. (2022). “Geothermal renewable energy prospects of the African continent using GIS”. In: *Geothermal Energy* 10.8. DOI: 10.1186/s40517-022-00219-1.

[10] Eltrop, L. (2013). “Renewable Energy: Resources and Technologies”. In: *Glances at Renewable and Sustainable Energy: Principles, approaches and methodologies for an ambiguous benchmark*. Edited by T. Jenssen. London: Springer London, pp. 15–32. DOI: 10.1007/978-1-4471-5137-1_2.

[11] Energy Institute (2023). *Statistical Review of World Energy*. URL: https://www.energyinst.org/statistical-review.

[12] Energy Market and Regulatory Consultants Limited (2021). *Zambia Electricity Cost of Service Study. Final Summary Consolidated Report*. ERB. URL: https://www.erb.org.zm/wp-content/uploads/files/CoSS/ElectricityCost-of-Service-Study-Summary-Consolidated-Report.pdf.

[13] ERB (2021). *Energy Sector Report 2021*. URL: https://www.erb.org.zm/document/the-energy-sector-report2021.

[14] — (2022). *Energy Sector Report 2022*. URL: https://www.erb.org.zm/wp-content/uploads/files/esr2022.pdf.

[15] — (2023). *Statistical Bulletin January to December 2022*. URL: https://www.erb.org.zm/wp-content/uploads/statBullet2022.pdf.

[16] — (2023b). Multi-Year Tariff Framework Rule for Determining the Revenue Requirements for Distribution Network Service Providers. URL: https://www.erb.org.zm/document/multi-year-tariff-framework-rule-for-determining-the-revenue-requirement-for-distribution-network-service-providers.

[17] — (2023c). Energy Sector Report 2023. URL: https://www.erb.org.zm/wp-content/uploads/files/esr2023.pdf.

[18] FAO and the Ministry of Energy of Zambia (2020). *Sustainable bioenergy potential in Zambia - An integrated bioenergy food security assessment*. Environment and Natural Resources Management Working Paper 84. DOI: 10.4060/cb1528en.

[19] Garret, R. (2023). *Open Infrastructure Map*. URL: https://openinframap.org/stats/area/Zambia/plants.

[20] Geda, A., Weeks, J., and Moono, H. (2018). "Impact of macroeconomic reform on labour markets and income in Zambia: Assessing the Zambian Macroeconomic Model (ZAMMOD)". In: *ILO Working Paper* Working Paper No.245. URL: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_policy/documents/publication/wcms_633750.pdf.

[21] Government of Zambia (2019a). *The Electricity Act, 2019*. URL: https://www.erb.org.zm/wp-content/uploads/files/The-ElectricityAct-No.-11-of-2019.pdf.

[22] — (2019b). The Energy Regulation Act, 2019. Government of Zambia. URL: https://www.erb.org.zm/document/energy-regulation-act-2019.

[23] IMF (2015). *Zambia: Selected Issues*. IMF Staff Country Report 153. IMF. DOI: 10.5089/9781513556253.002.

[24] — (2023). *Zambia. Staff Report for the 2023 Article IV Consultation, First Review under the Extended Credit Facility Arrangement, and Financing Assurances Review*. IMF Country Report No. 23/256. IMF. URL: https://www.imf.org/en/Publications/CR/Issues/2023/07/13/Zambia-2023-ArticleIV-Consultation-First-Review-Under-the-Extended-CreditFacility-536340.

[25] IRENA (2022). *Energy Profile - Zambia*. International Renewable Energy Agency. URL: https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Africa/Zambia_Africa_RE_SP.pdf.

[26] Kachapulula-Mudenda, P., Makashini, L., Malama, A., and Abanda, H. (2018). "Review of Renewable Energy Technologies in Zambian Households: Capacities and Barriers Affecting Successful Deployment". In: *Buildings* 8.6. DOI: 10.3390/buildings8060077.

[27] Kahiu, M. (2023). *Load Shedding to "have negative impact on most vulnerable": Jesuit Scholars in Zambia*. URL: https://www.aciafrica.org/news/7466/loadshedding-to-have-negative-impact-on-most-vulnerable-jesuitscholars-in-zambia.

[28] Kaoma, M and Gheewala, S.H. (2020). "Assessment of the bioenergy policy for the sustainable development of rural-based bioenergy systems in Zambia". In: *IOP Conf. Ser.: Earth Environ. Sci*. 463. DOI: 10.1088/1755-1315/463/1/012012.

[29] Mahdavinejad, M., Rafsanjani, L.H., and Karimi, M. (2013). "Challenges and opportunities regarding adoption of clean energy technology in developing countries, in case of Iran". In: *International Journal of Smart Grid and Clean Energy* 2.2, pp. 283–288. DOI: 10.12720/sgce.2.2.283-288.

[30] Maliye, R., Kabala, E., and Cheelo C. (2024). *Overview of the Electric Energy Economy in Zambia*. Report. To appear in Climate Compatible Growth.

[31] Ministry of Energy (2017). *Renewable Energy Feed in Tariff Strategy*. URL: https://234878-www.web.tornado-node.net/wp-content/uploads/2019/07/FINAL_REFiTStrategy2017.pdf.

[32] — (2022). *Renewable Energy Strategy and Action Plan*. URL: https:// www.moe.gov.zm/wp-content/uploads/2022/08/Renewable-Energy_ final-file_for-web.pdf.

[33] — (2023a). *Integrated Resource Plan for the Power Sector in Zambia*. Summary Report. URL: https://www.moe.gov.zm/irp/.

[34] — (2023b). *About the Ministry - Mandate and Functions*. URL: https://www.moe.gov.zm/?page_id=2455 (visited on 11/27/2023).

[35] Musonda, G. and Sikazwe, M. (2005). "Geothermal Exploration and Development in Zambia". In: *Proceedings World Geothermal Congress 2005*. URL: https://www.academia.edu/88446501/Geothermal_Exploration_and_Development_in_Zambia.

[36] Ngoma, R., Tambatamba, A., Oyoo, B., Mulongoti, D., Kumwenda, B., and Louie H. (2018). "How households

adapted their energy use during the Zambian energy crisis". In: *Energy for Sustainable Development* 44, pp. 125–138. DOI: 10.1016/j.esd.2018.03.007.

[37] Our World in Data (2024). *Average annual precipitation*. URL: https://ourworldindata.org/grapher/average-precipitation-per-year.

[38] — (2023). *Per capita electricity generation, 2022*. URL: https://ourworldindata.org/grapher/per- capita-electricity- generation.

[39] Parzen, M., Hazem, A-K., Fedotova, E., Mahmood, M., Frysztacki, M.M., Hampp, J., Franken, L., Schumm, L., Neumann, F., Poli, D., Kiprakis, A., and Fioriti, D. (2023). "PyPSA-Earth. A new global open energy system optimization model demonstrated in Africa". In: *Applied Energy* 341, p. 121096. DOI: 10.1016/j.apenergy.2023.121096.

[40] REA (2020). *2020 Annual Report*. URL: https://rea.org.zm/wp-content/uploads/2023/03/REAAnnual-Report-2020-April-2021.pdf.

[41] SmartSolar Zambia (2019). *Solar Power Potential in Zambia*. URL: http://www.smartsolar-zambia.com/solar-sector-information/solar-powerpotential-zambia/.

[42] Southern Africa Energy Program (2018). *Establishing ZESCO water values. A preliminary review of concepts to support water valuation for hydro generation in Zambia*. United States Agency for International Development. URL: https://pdf.usaid.gov/pdf_docs/PA00X179.pdf.

[43] Sparkman, M. and Tobin W. (2023). Country spotlight: *Unlocking a High Energy Future for Zambia*. URL: https://www.atlanticcouncil.org/blogs/energysource/country-spotlight-unlocking-a-high-energyfuture-for-zambia/.

[44] Speight, J.G. (2011). "2 - Production, properties and environmental impact of hydrocarbon fuel conversion". In: *Advances in Clean Hydrocarbon Fuel Processing*. Edited by Khan., M.R. Woodhead Publishing Series in Energy. Woodhead Publishing, pp. 54–82. DOI: 10.1533/9780857093783.1.54.

[45] Stecher, K., Brosowski, A., and Thrän, D. (2013). *Biomass Potential in Africa*. IRENA. https://www.irena.org/Publications/2013/Aug/Biomass-Potential-in-Africa.

[46] Tetra Tech/ARD (2022). *Alternatives to Charcoal*. Annual Progress Report. USAID/Zambia. URL: https://pdf.usaid.gov/pdf_docs/PA00ZQVD.pdf.

[47] The Brief (2023). *Zambia Announces End to Load Shedding*. URL: https://archive.thebrief.com.na/index.php/component/k2/item/2388-zambiaannounces-end-to-load-shedding.

[48] Thiam, D.R. (2011). "Renewable energy, poverty alleviation and developing nations: Evidence from Senegal". In: *Journal of Energy in Southern Africa* 22.3, pp. 23–34.

[49] Tractebel (2022). *The Least Cost Geospatial Electrification Plan*.

[50] United Nations (2015). *Transforming our World: The 2030 Agenda for Sustainable Development*. URL: https://sdgs.un.org/publications/transforming-ourworld-2030-agenda-sustainable-development-17981.

[51] United Nations Conference on Trade and Development (2018). *Renewable Energy Technologies for Rural Development*. United Nations. URL: http://unctad.org/en/Docs/dtlstict20094_en.pdf.

[52] Waldman, K. B., Vergopolan, N., Attari, S.Z., Sheffield, J., Estes, L.D., Caylor, K.K., and Evans T.P. (2019). "Cognitive Biases about Climate Variability in Smallholder Farming Systems in Zambia". In: *Weather, Climate, and Society* 11.2, pp. 369–383. DOI: 10.1175/WCAS-D-18-0050.1.

[53] World Bank (2011). *Petroleum Product Markets in Sub-Saharan Africa : Comparative Efficiency Analysis of 12 Countries*. URL: https://ideas.repec.org/p/wbk/wboper/2743.html.

[54] — (2015). *Power Sector Pivotal to Inclusive Growth in Zambia*. Press Release. URL: https://www.worldbank.org/en/news/press-release/2015/12/09/powersector-pivotal-to-inclusive-growth-in-zambia.

[55] — (2017). *State of Electricity Access Report* 2017 (vol. 2). URL: http://documents.worldbank.org/curated/en/364571494517675149/fullreport.

[56] — (2018). *Renewable Energy Wind Mapping for Zambia: 12-month Site resource report*. URL: http://documents.worldbank.org/curated/en/528711526549758961/Renewable-energy-wind-mapping-for-Zambia12-month-site-resource-report.

[57] Zambia Statistics Agency (2022). 2022 *Census of Population and Housing*. Preliminary Report. URL: https://www.zamstats.gov.zm/wpcontent/uploads/2023/05/2022-Census-of-Population-andHousing-Preliminary.pdf.

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