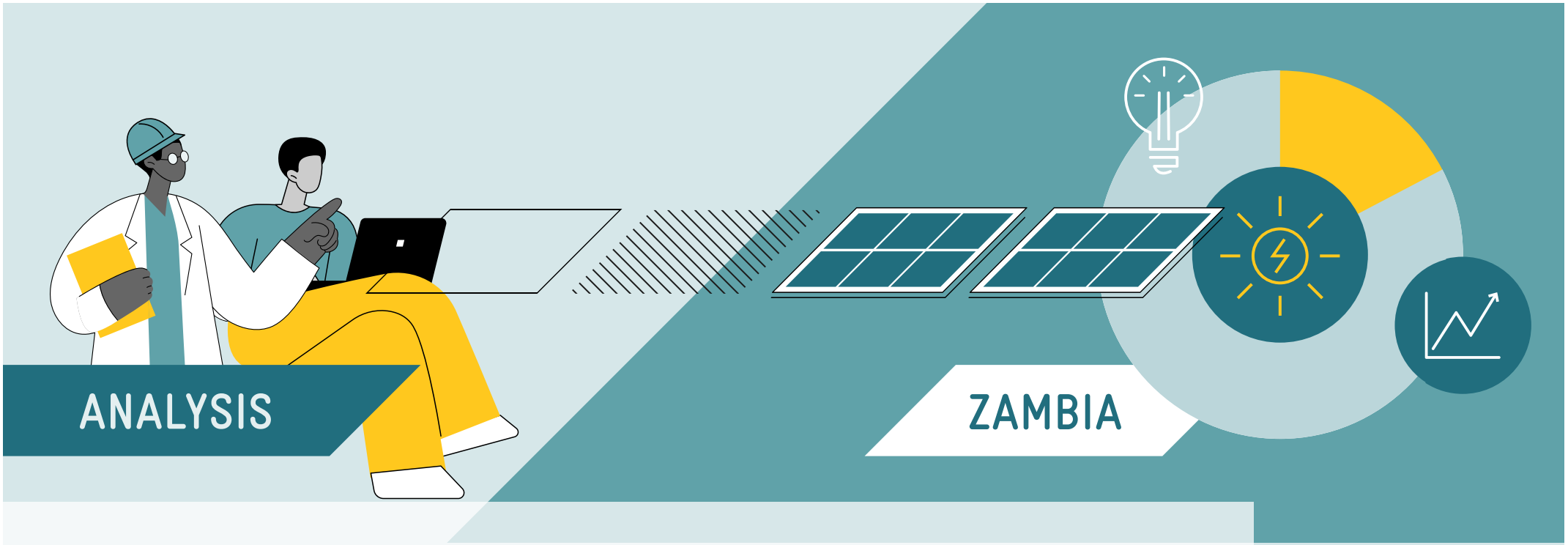

Sector Analysis Zambia

Renewable Power Generation and Energy Storage Systems in the Commercial and Industrial Sector

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

This publication was commissioned by the German Energy Solutions Initiative of the German Federal Ministry for Economic Affairs and Climate Action (BMWK)

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Currency units

ZMW	Zambian Kwacha
EUR	Euro
USD	United States Dollar

Conversion rate as of 20.10.2023

EUR 1 = USD 1.07
EUR 1 = ZMW 23.15

Source: https://www.finanzen.net/waehrungsrechner/euro_us-dollar

Technical units

GW	Gigawatt
GWh	Gigawatt hour
kV	Kilovolt
kVA	Kilovolt-ampere
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt peak
MW	Megawatt
MWh	Megawatt hour
MWp	Megawatt peak

Abbreviations/acronyms

2PT	Two-Part Tariff
8th FYP	Eighth Five Year Plan
AC	Alternate Current
ADB	Asian Development Bank
AFD	French Development Agency
AKDL	AKH Knitting and Dyeing Ltd.
APSCL	Ashuganj Power Generation Company Limited
BAU	Business-As-Usual
BB	Bangladesh Bank
BBS	Bangladesh Bureau of Statistics
BDT	Bangladesh Taka
BERC	Bangladesh Energy Regulatory Commission
BEZA	Bangladesh Economic Zones Authority
BGCCI	Bangladesh-German Chamber of Commerce and Industry
BGMEA	Bangladesh Garment Manufacturers and Exporters Association
BIDA	Bangladesh Investment Development Authority
BIFFL	Bangladesh Infrastructure Finance Fund Limited
BIN	Business Identification Number
BKMEA	Bangladesh Knitwear Manufacturers and Exporters Association
BOO	Build, Own and Operate
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board
BSTI	Bangladesh Standards and Testing Institution
BTMA	Bangladesh Textile Mills Association
CapEx	Capital Expenditure
CCI&E	Chief Controller of Imports and Exports
CEPZ	Chittagong Export Processing Zone
CMSME	Cottage, Micro, Small & Medium Enterprises
COVID-19	Coronavirus disease
CPGCBL	Coal Power Generation Company Bangladesh Limited
CPP	Captive Power Plant
DC	Direct Current
DESCO	Dhaka Electricity Supply Company
DEPZ	Dhaka Export Processing Zone
DPDC	Dhaka Power Distribution Company
DSCR	Debt Service Coverage Ratio
EA&CEI	Electrical Adviser & Chief Electrical Inspector
EBA	Everything But Arms
EGCB	Electricity Generation Company of Bangladesh Limited
EPRC	Energy & Power Research Council
E-to-E	Employee to Enterprise
EZ	Economic Zone
EPB	Export Promotion Bureau
EPC	Engineering, Procurement and Construction
EPZ	Export Processing Zone
EMI	Equated Monthly Installment
ERC	Export Registration Certificate
ESDD	Environmental and Social Due Diligence
ESMAP	Energy Sector Management Assistance Program
EV	Electric Vehicle
FDI	Foreign Direct Investment
FESIL	Far East Spinning Industries Ltd.
FI	Financial Institution
FSCD	Fire Service and Civil Defence
FY	Financial Year
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GOB	Government of Bangladesh
HT	High Tension
HVDC	High-Voltage Direct Current
I&C	Installation and Commissioning
IDCOL	Infrastructure Development Company Ltd.
IEC	International Electrotechnical Commission
AC	Alternating Current
AfCFTA	African Continental Free Trade Area
AfT	Aid for Trade
AGOA	African Growth and Opportunity Act

BESS	Battery Energy Storage System
BMS	Battery Management System
BTA	Bilateral Trade Agreement
BTS	Base Transceiver Station
C&I	Commercial & Industrial
CAPEX	CAPital EXpenditure
CEC	Copperbel Energy Corporation Plc
CES	Carbon Emissions Surcharge
COMESA	Common Market for Eastern and Southern Africa
COSS	Cost-of-Service Study
CRN	Core Road Network
CSP	Concentrated Solar Power
DC	Direct Current
DRC	Democratic Republic of Congo
ECF	Extended Credit Facility
EMS	Energy Management System
EPA	Economic Partnership Agreement
EPC	Engineering, Procurement and Construction
ERB	Energy Regulation Board
ESA	Eastern and Southern Africa
ESCOM	Electricity Supply Corporation of Malawi Limited
ESS	Energy Storage System
EU	European Union
EU-ZBC	EU-Zambia Business Club
FDI	Foreign Direct Investment
GBC	German Business Council
GDP	Gross Domestic Product
HVAC	Heating, Ventilation and Air Conditioning
IMF	International Monetary Fund
IPP	Independent Power Producer
IPPA	Investment Promotion and Protection Agreement
ISP	Internet Service Provider
IT	Information Technology
ITCZ	Inter-Tropical Convergence Zone
KNP	Kafue National Park
LNP	Lochinvar National Park
LZNP	Lower Zambezi National Park
MMD	Movement for Multi-Party Democracy
MNC	Multinational Corporations
MNO	Mobile Network Operator
MoE	Ministry of Energy
MP	Member of Parliament
MRT	Mineral Royalty Tax
NAPSA	National Pension Scheme Authority
NEP	National Energy Policy
NLNP	North Luangwa National Park
O&M	Operation & Maintenance
OPPPI	Office for Promoting Private Power Investment
PACRA	Patents and Companies Registration Agency
PF	Patriotic Front
PPA	Power Purchase Agreement
PSTN	Public Switched Telephone Network
PV	PhotoVoltaics
RE	Renewable Energy
REA	Rural Electrification Authority
SADC	Southern African Development Community
SAGCC	Southern African-German Chamber of Commerce and Industry
SAIDI	System Average Interruption Duration Index
SAPP	Southern Africa Power Pool
SLNP	South-Luangwa National Park
SNEL	Société Nationale d'ELectricité
TAZARA	Tanzania-Zambia Railway Authority
TMD	Trunk, Main and District
TOT	Transmission, Operations & Trade (ZESCO Directorate)
TPIN	Tax Payer Identification Number
UAE	United Arab Emirates
UPND	United Party for National Development
UPS	Uninterruptible Power Supply
VAT	Value Added Tax
WTO	World Trade Organization
ZACCI	Zambia Chamber of Commerce and Industry
ZDA	Zambia Development Agency
ZR	Zambia Railways
ZRA	Zambia Revenue Authority

ENERGY SOLUTIONS – MADE IN GERMANY

The German Energy Solutions Initiative

The German Energy Solutions Initiative, coordinated and financed by the German Federal Ministry for Economic Affairs and Climate Action (BMWK), aims to globalise German and European technologies and expertise in climate-friendly energy solutions.

Years of promoting smart and sustainable energy solutions in Germany have led to a thriving industry known for world-class technologies. Thousands of specialised small and medium-sized enterprises (SMEs) focus on developing renewable energy systems, energy efficiency solutions, smart grids and storage technologies. Cutting-edge energy solutions are also built on emerging technologies like Power-to-Gas, fuel cells and green hydrogen. The initiative's strategy is shaped around ongoing collaboration with the German business community.

THE PROJECT DEVELOPMENT PROGRAMME (PDP)

Implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, the Project Development Programme (PDP) is an integral part of the German Energy Solutions Initiative. The PDP combines development cooperation with private-sector engagement to promote climate-friendly energy solutions and facilitate market access for German and European small businesses in selected developing and emerging countries. This fosters economic growth and international cooperation, and contributes to climate change mitigation. The PDP works closely with the German Chambers of Commerce Abroad (AHK) to implement tailor made local solutions.

The PDP team keeps a constant eye on key market sectors in the target countries for providers of climate-friendly energy solutions. Using these insights, they generate sector analyses for areas where renewable energies or energy efficiency measures can compete effectively without extra subsidies.

PROJECT OPPORTUNITIES IN DEVELOPING AND EMERGING COUNTRIES

The markets in developing countries and emerging economies are promising, but also pose challenges for international business partners. The PDP team provides free and impartial advice to local companies, in particular, and puts them in contact with German or European business partners.

The team collects data from the energy consumer and evaluates it from a technical and economic perspective, thus developing financially viable projects focused on renewable energies and energy efficiency with local companies. It also offers business initiation opportunities with German or European small and mid-sized companies.

At the same time, the project provides training courses, analyses and studies on the risks and potential of renewable energies to help support market development. Visiting reference projects within the countries also promotes the creation of private-sector business partnerships.

In addition to commerce and industry, operators of refugee camps are a further target group for the transition to renewable energies as many still use diesel generators to supply energy or water.

The focus of activities currently lies in 15 countries across Southeast Asia, South Asia, Sub-Saharan Africa, and the Middle East.

Executive summary

The Zambian government has set a target to increase its installed solar and wind capacity to 600 MW by 2030. However, the current installed capacity for solar photovoltaics is only 90 MWp, indicating significant underutilisation of Zambia's potential in the renewable energy sector. As the market is still in its infancy, there is great potential for development in this renewable resource-rich country, particularly for German and European companies offering climate-friendly energy solutions with expertise in renewable energy and energy storage.

In recent years, Zambia has been able to improve its electricity supply but remains largely dependent on hydropower. This dependency represents a risk to the security of supply, as evidenced by the return of scheduled load shedding at the end of 2022 until February 2023, due to low water levels on the Zambezi River. Climate change is expected to exacerbate this issue.

This expected growth in renewable energy will create a need for energy storage on a large scale due to the intermittency of solar and wind energy. At present, the best business cases for energy storage complementary to the electricity grid as back-up or to improve power quality, or for off-grid energy uses, such as in remote areas.

ZAMBIA IS PLACING INCREASING IMPORTANCE ON RENEWABLE ENERGY

The regulatory context is evolving, with a cost-of-service study that has demonstrated the need for electricity tariff increases, which are expected to take place in 2024. A new regulation is also being prepared to pave the way for the remuneration of energy surpluses injected into the grid (the Net-Metering Regulations).

Zusammenfassung

Die sambische Regierung plant bis 2030 eine Steigerung der installierten Solar- und Windkapazität auf 600 MW, obwohl die aktuelle Solarphotovoltaik-Kapazität bei lediglich 90 MWp liegt. Der Markt für erneuerbare Energien ist noch in den Anfängen, bietet jedoch großes Potenzial für deutsche und europäische Anbieter von klimafreundlichen Energielösungen.

Sambia hat Fortschritte in der Stromversorgung gemacht, bleibt jedoch stark von Wasserkraft abhängig, was die Versorgungssicherheit gefährdet. Dies wurde während der Wiederkehr geplanter Stromabschaltungen aufgrund niedriger Wasserstände im Sambesi-Fluss Ende 2022 bis Februar 2023 abermals deutlich. Der Klimawandel wird dieses Problem voraussichtlich verschärfen.

Das erwartete Wachstum erneuerbarer Energien wird einen Bedarf an Energiespeicherung aufgrund der Unregelmäßigkeit von Sonnen- und Windenergie schaffen. Aktuell zeichnen sich die vielversprechendsten Geschäftsmodelle für Energiespeicher durch ihre Ergänzung des Stromnetzes als Reserve, die Verbesserung der Stromqualität und ihre Anwendung in netzunabhängigen Energiesystemen, beispielsweise in abgelegenen Gebieten, aus.

SAMBIA SETZT ZUNEHMEND AUF ERNEUERBARE ENERGIEN

Das regulatorische Umfeld entwickelt sich weiter: Stromtariferhöhungen wurden durch eine Betriebskostenstudie empfohlen und voraussichtlich 2024 angepasst. Eine neue Verordnung zur Ermöglichung von Net-Metering-Verordnungen für die Vergütung von ins Netz eingespeisten Energieüberschüssen ist in Arbeit.

This sector analysis provides more details on the different economic sectors of Zambia and their specific energy usage requirements. The mining sector has the biggest customers able to implement large, multi-megawatt projects. At the other end of the spectrum, remote tourism and telecom towers mostly exhibit small-scale applications (kW scale), with many projects already commissioned. Lastly, the remaining industrial sectors, including manufacturing and food processing, typically require 100 kW to 1 MW projects.

BUSINESS OPPORTUNITIES FOR GERMAN SMES IN THE ZAMBIAN RENEWABLE ENERGY SECTOR

Working with German and European companies offering climate-friendly energy solutions is a promising opportunity for many Zambian local businesses and energy providers. By collaborating with regional electricity suppliers, German and European service providers can create a network of local contacts and establish the necessary relationships for successful company operations in Zambia. Having such local connections is critical for navigating the complex business landscape in the country and understanding the unique challenges and opportunities in the renewable energy sector.

For German and European service providers active in the energy sector, Zambia presents significant potential for business development. There are clear needs across the solar energy and storage value chain, including project development and financing, equipment manufacturing, system integration and contracting. In this context, German and European suppliers can benefit from engaging with Zambian industrial companies directly or working through local EPC contractors to deliver their products and services. By leveraging their expertise and technological capabilities, German companies can help to bridge the gap between Zambia's underdeveloped renewable energy sector and the growing demand for clean energy sources.

Diese Sektoranalyse bietet Einblicke in die Energieverbrauchsanforderungen verschiedener Wirtschaftssektoren in Sambia. Der Bergbausektor kann größere, mehrere Megawatt umfassende Projekte realisieren, während abgelegene Tourismus- und Telekommunikationstürme hauptsächlich kleinere Anwendungen im Kilowatt-Bereich haben, viele Projekte werden bereits betrieben. Andere Industriezweige wie Fertigung und Lebensmittelverarbeitung benötigen in der Regel Projekte mit einer Leistung von 100 kW bis 1 MW.

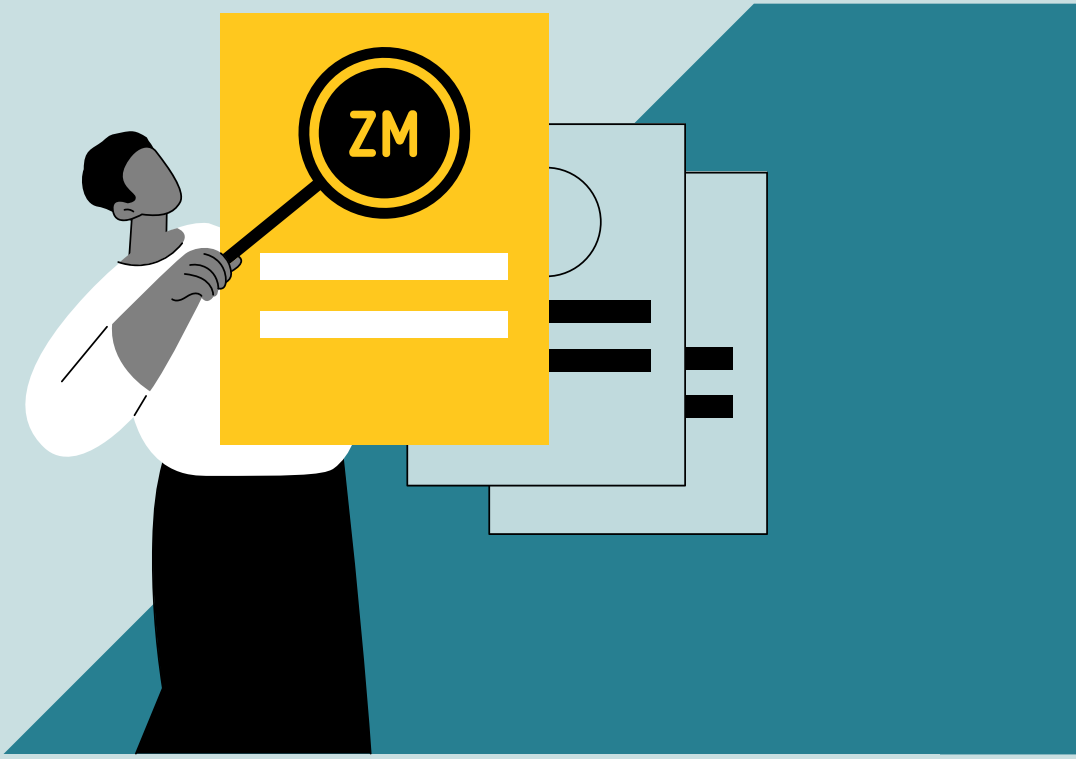
GESCHÄFTSMÖGLICHKEITEN FÜR DEUTSCHE ANBIETER IM SAMBISCHEN SEKTOR FÜR ERNEUERBARE ENERGIEN

Die Zusammenarbeit mit deutschen und europäischen Anbietern klimafreundlicher Energielösungen bietet vielversprechende Perspektiven für sambische Firmen und Energieversorger. Durch Partnerschaften mit regionalen Stromversorgern können deutsche und europäische Anbieter lokale Netzwerke aufbauen und Beziehungen für erfolgreiche Geschäftsaktivitäten knüpfen. Lokale Verbindungen sind entscheidend, um die komplexe Geschäftswelt des Landes im Bereich erneuerbarer Energien zu verstehen.

Für deutsche und europäische Anbieter im Energiesektor eröffnet sich in Sambia erhebliches Geschäftspotenzial entlang der gesamten Wertschöpfungskette von Solarenergie und Speicherung, einschließlich Projektentwicklung, Finanzierung, Herstellung oder Distribution von Ausrüstungen, Systemintegration und Vertragswesen. Anbieter können durch direkte Kooperation mit sambischen Industrieunternehmen oder die Bereitstellung ihrer Produkte und Dienstleistungen über lokale EPC-Vertragspartner von dieser Entwicklung profitieren. Ihr Fachwissen und ihre technologischen Fähigkeiten ermöglichen es Anbietern, die Kluft zwischen dem sambischen Sektor für erneuerbare Energien und der steigenden Nachfrage nach sauberen Energiequellen zu schließen.

1

Country profile – Zambia

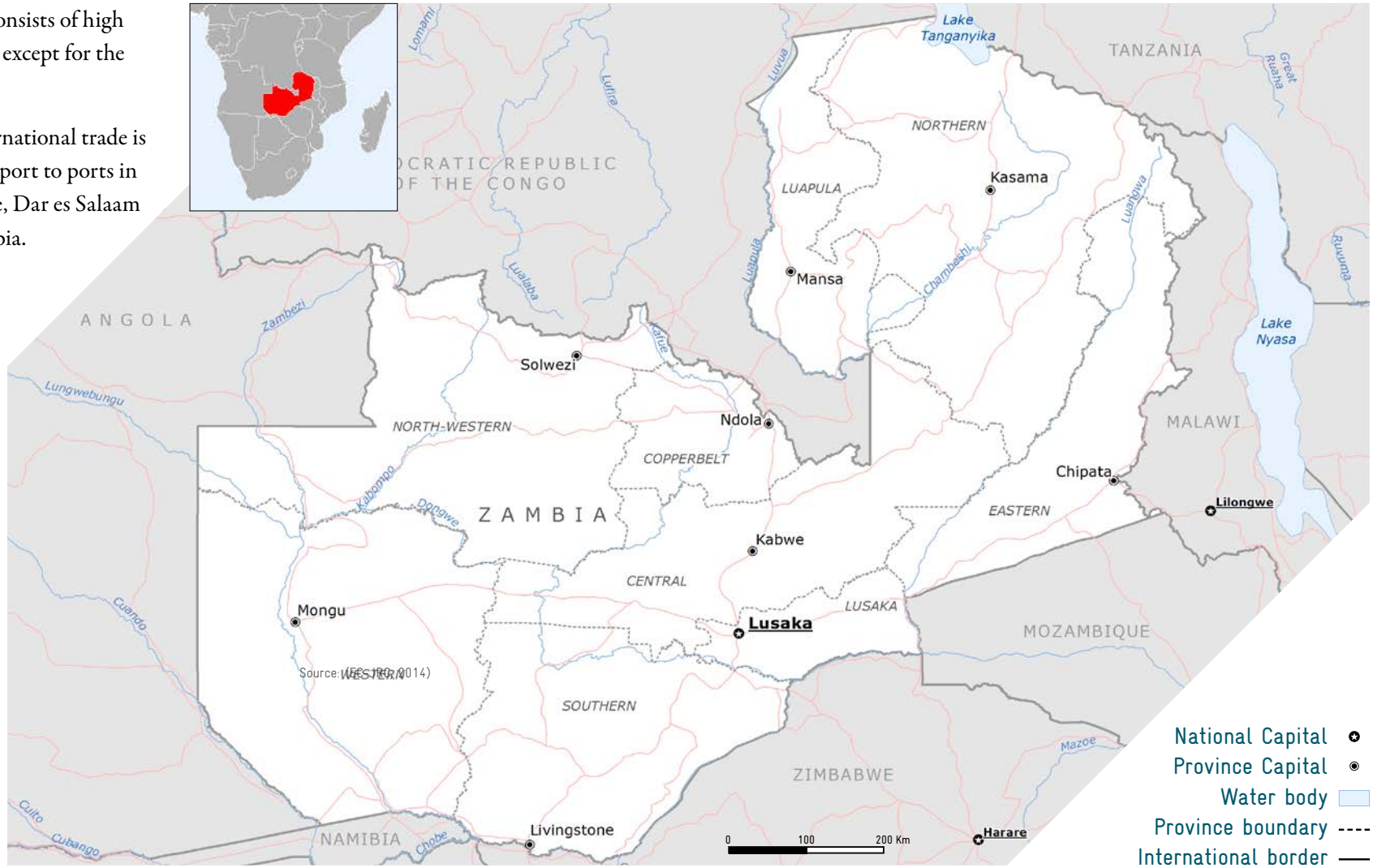


1.1 Geography

Zambia lies in a central position in southern Africa. It is a landlocked country with a total surface area of 752,617 km^2. The country mostly consists of high plateaus (above 1,000 m in altitude) except for the valley of the Luangwa River.

Due to its landlocked position, international trade is conducted via railways or road transport to ports in neighbouring countries, for example, Dar es Salaam in Tanzania or Walvis Bay in Namibia.

FIGURE 1. Map of Zambia

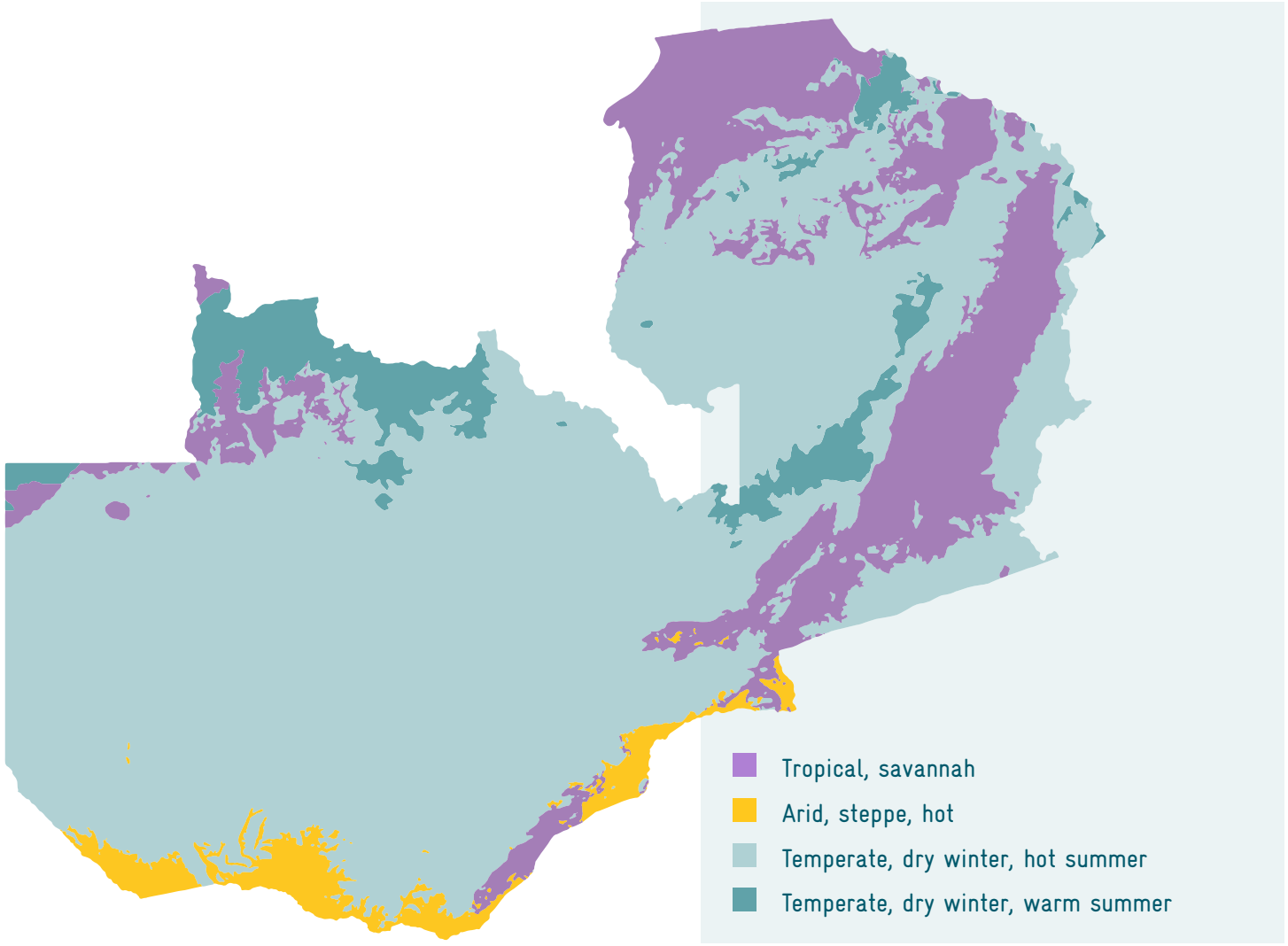


Source: (EC-JRC, 2014)

1.2 Climate

Although Zambia is located between the Tropic of Cancer in the Northern Hemisphere and the Tropic of Capricorn in the Southern Hemisphere, climatic conditions are generally suitable for human habitation and agricultural activities. Zambian seasons are characterised and influenced by movements in the Inter-Tropical Convergence Zone (ITCZ). The ITCZ is responsible for both dry and wet seasons that are experienced in the tropics, including Zambia. Average daily temperatures vary according to season and altitude. The highest daily temperatures of around 35°C are recorded during summer, while the lowest daily temperatures of around 8°C are recorded in winter. Zambia's sub-tropical climatic conditions are characterised by three main seasons: hot and dry season (August to November), wet rainy season (November to April) and cool dry season (May to August). The driest areas receive annual rainfall of not more than 800 mm, while the wettest regions receive rainfall in excess of 1,000 mm. The north-east part of the country occasionally receives rainfall in excess of 1,400 mm (Britannica, sd).

FIGURE 2. Map of Zambian climatic zones



Source: (Commons, 2018)

1.3 Population

According to the 2022 revision of the World Population Prospects (United Nations, 2022), the total population of Zambia is around 19.6 million. The proportion of children below the age of 15 in 2010 was 46.4%, 50.6% were between 15 and 65 years of age, while 3.1% were 65 years or older (Zambia). However, these demographics are likely to change once the 2022 census results are finalised.

Much of the population is concentrated in the country's most developed areas along the railway line: from Livingstone in the south on the border with Zimbabwe, through Lusaka and through the Copperbelt Province up to Kasumbalesa on the border with the Democratic Republic of Congo (DRC) and the Chipata area in the east.

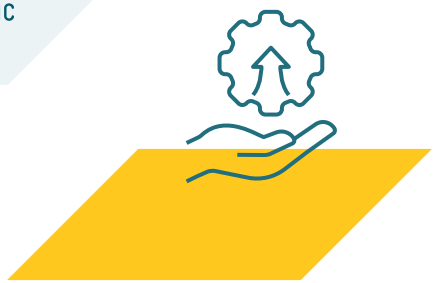
1.4 Political system

Zambia is a unitary republic whose legal system is based on the 1991 Constitution. The 1991 Constitution was amended in 1996 (Constitution Amendment No. 18 of 1996) and again in 2016 (Amendment No. 2 of 2016). The National Assembly (national legislature) comprises 156 Members of Parliament (MPs) that are elected by popular vote, serving a five-year term. The Head of State or President is also elected by universal suffrage, also for a five-year term. The President appoints their cabinet from MPs. In August 2021, the United Party for National Development (UPND) was elected and took over government, while the main opposition party is the Patriotic Front (PF).

1.5 Outlook on political stability

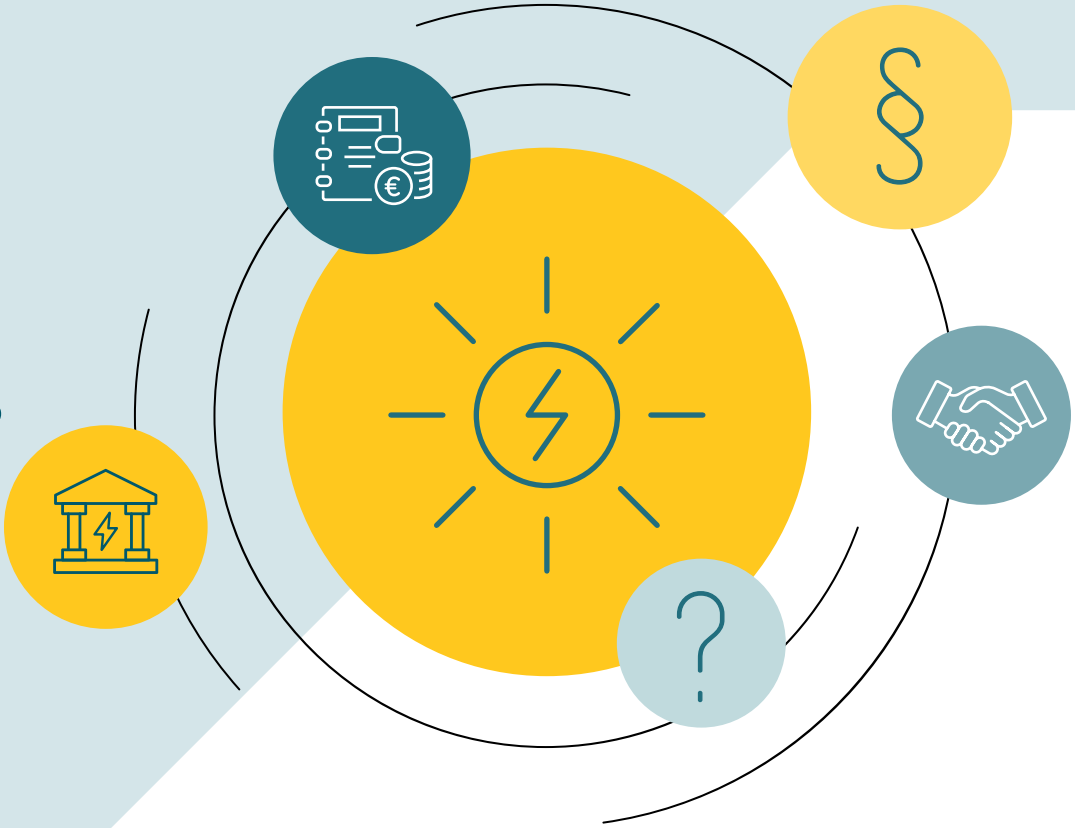
Zambia's next presidential and parliamentary elections are due in August 2026. In the August 2021 presidential and general elections, Hakainde Hichilema of the UPND won 59% of the presidential vote, compared to his predecessor's (Edgar Lungu) 38.7%. In the parliamentary or legislative election, the UPND won 82 seats out of 156 directly elected seats.

Zambia is politically stable and is expected to remain as such. Since it returned to multi-party democracy in 1991, it has had three transitions of power, all of which have been peaceful. The Movement for Multi-Party Democracy (MMD) was elected into power from 1991 to 2011 (having won the elections in 1991, 1996, 2001, 2006 and the 2008 presidential by-election), the Patriotic Front (PF) was elected into power from 2011 to 2021 and the UPND was elected into power in 2021.



2

Business policies, market access and market conditions



2.1 Key economic facts and figures

Globally, Zambia ranks among the countries with the highest levels of poverty and inequality. The persistent poverty levels are inconsistent with the fact that it is rich in natural resources, namely mineral wealth, arable land and water resources, as well as massive renewable energy resources. Zambia is the second largest producer of copper in Africa and its economy is heavily dependent on copper mining (at least 70% of total exports). Efforts to diversify economic activity or invest revenues from mining to other sectors of the economy have been limited.

The country's GDP is USD 27 billion (2022 estimates) and the GDP per capita is USD 1,350. The local currency, the Kwacha, has an exchange rate of approximately 19.25 kwacha to 1 euro as of December 2022.

2.2 Economic situation and outlook

The Zambian economy recovered by 3.3% in 2021 following a historical contraction of 2.8% in 2020. Poverty increased slightly by 0.2 percentage points to 60.3% in 2021, reflecting the impact of the COVID-19 pandemic. Economic activity has gradually been picking up in 2022 and is expected to continue to improve through to 2026 at a forecast average of 3.8%. However, risks stemming from low COVID-19 vaccination rates should be managed.

Zambia's current administration came to power in August 2021 in the midst of an external debt crisis and economic mismanagement, resulting in the country's challenge to honour its debt. As of December 2022, Zambia was rated SD (selective default) by S&P and RD (restricted default) by Fitch. In order to restore stability, revive and grow the economy, the current administration's top priority was aimed at repairing relations with Zambia's creditors.

TABLE 1. Key economic indicators

Economic Fundamentals	2021	2022	2023	2024	2025	2026
Real GDP growth (%)	3.6	3	3.9	4.5	5.5	5.8
Consumer price inflation (average %)	22	11	8.2	7.1	6.6	6.2
Government balance (% of GDP)	-10.9	-8.3	-7.1	-4.6	-4.1	-4.5
Current account balance (% of GDP)	9.5	9	8.3	6.6	4	2.1
Short-term interest rate (average %)	12.9	14.5	15.5	15.5	15	14.5
Exchange rate ZMW:USD (annual average)	20.02	17.04	15.92	16.1	16.98	17.21

Source: (IMF, 2022)

The government's economic policy focused on securing the USD 1.3 billion IMF Extended Credit Facility (ECF) programme and a debt-restructuring agreement with Zambia's various creditors. With the inflation rate at 22% at the end of 2021 and the local currency appreciation, there was still the risk of a balance-of-payments crisis and a debt crisis. However, inflation declined to a single digit for most of 2022 through to 2023.

On 31 August 2022, the IMF Executive Board approved an assistance package which is aimed at bringing the debt crisis to an end (IMF, 2022). IMF approval was secured after official bilateral creditors to Zambia pledged, as requested by the IMF, to negotiate a debt-restructuring deal with the government of Zambia.

The debt-restructuring agreement involves an austerity programme, but in order to minimise possible social unrest, the government sought to ring-fence social welfare spending and to recover public funds previously stolen through corruption.

2.3 Economic development strategy and key sectors

2.3.1 Structure of the economy

In a bid to become a full middle-income nation by 2030, the government's focus has been on selected sectors of the economy to drive forward the economic transformation agenda anchored in the Economic Transformation Programme (overarching framework for implementing various interventions in different sectors of the economy).

According to official statistics from the Zambia Statistics Agency (ZamStats, 2022), the main industrial and commercial activities are mining (12% of GDP and at least 70% of Zambia's export receipts), agriculture (20% of GDP), services (48% of GDP), manufacturing (8% of GDP) and tourism (7% of GDP).

2.3.2 Exports

Other than copper, which accounts for 70% of the country's total exports, Zambia exports sugar, tobacco, gemstones, cotton and electricity. Based on data from ZamStats, Zambia's main export trading partners are Switzerland (45% of total exports), China, DRC and South Africa. Zambia's main import products are refined copper, refined petroleum, crude petroleum, nitrogenous fertilisers and mixed mineral or chemical fertilisers. The main source countries for Zambia's imports are South Africa, China, United Arab Emirates (UAE), India and DRC.

2.4 Investment climate and market entry for foreign companies

2.4.1 Treaties and trade partnerships

As a member of the multilateral trade system, Zambia is signatory to several regional and global trade arrangements. This includes the Common Market for Eastern and Southern Africa (COMESA), Southern African Development Community (SADC), African Continental Free Trade Area (AfCFTA), Economic Partnership Agreement (EPA), African Growth and Opportunity Act (AGOA) and the World Trade Organization (WTO) Aid for Trade (AfT). Zambia has signed several bilateral trade arrangements or agreements with a number of countries such as Double Taxation Agreements (DTAs).

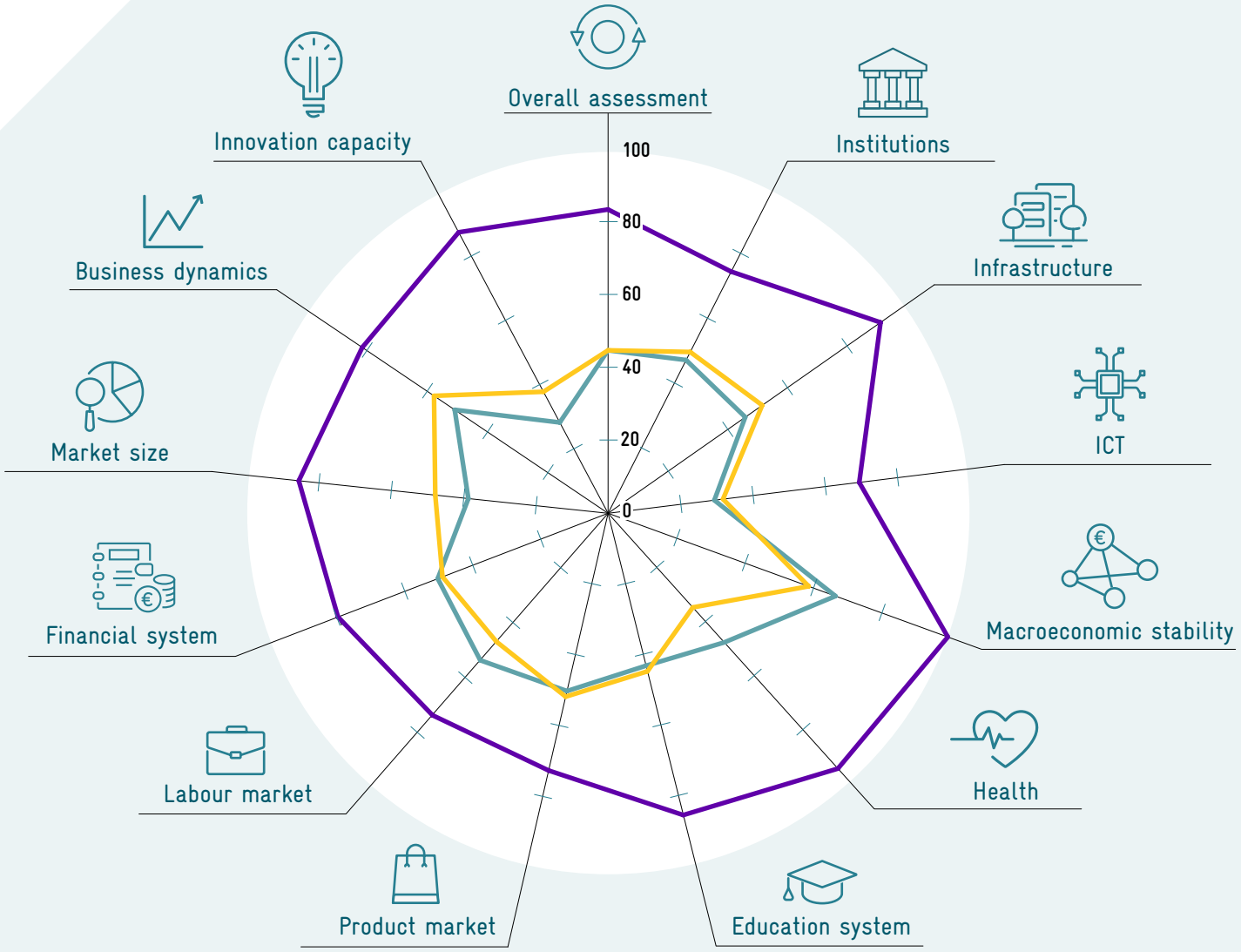
Figure 3 shows several competitiveness indicators for Zambia, compared to the average for sub-Saharan countries, and compared to Germany (2018 data).

FIGURE 3. Competitiveness indicators

Zambia

Sub-Saharan Africa

Germany



Source: (Msimang, 2019)

2.4.2 Business registration, licensing and permits

Establishing a business in Zambia begins with registering the company with the Patents and Companies Registration Agency (PACRA). The first step requires company name clearance, followed by delivery of documents such as: application for incorporation, articles of association if the standard articles will not be used, certificate of incorporation in the case of foreign or local corporate shareholders and signed consent to act as director or secretary by each named person. The minimum share capital of a company limited by shares is ZMW 15,000. Specific regulated sectors like the financial and insurance sectors have higher prescribed nominal share capital. According to Companies Act No. 10 of 2017, at least half of the company's directors need to be resident in Zambia but they need not be Zambian nationals. There are generally no restrictions on foreign shareholding for companies in Zambia.

In addition to registering with PACRA, businesses are also required to register with the Zambia Revenue Authority (ZRA) in order to obtain a corporate tax number or Tax Payer Identification Number (TPIN) (Zambia Revenue Authority, sd), file VAT Registration Form with the ZRA to obtain a VAT number (Zambia Revenue Authority, sd) and register with the National Pension Scheme Authority (NAPSA) for social security. Companies may also register as investors with the Zambia Development Agency (ZDA) to be eligible for a range of incentives that come with obtaining a ZDA investment licence (see Section 5.2 for more details). To obtain a ZDA licence, a foreign investor must invest a minimum of USD 250,000 while a local investor must invest at least USD 50,000 (Zambia Development Agency, sd).

2.4.3 Taxation and duties

Zambian taxes are broadly categorised into three groups as follows:

1. income taxes,
2. consumption taxes and
3. trade taxes.

These taxes contribute up to 70% to the overall national budget. The tax system also comprises non-tax instruments which include royalties and fees. These include a fuel or road levy, rural electrification fund levy, medical levy, Carbon Emissions Surcharge (CES), motor vehicle licensing fees, skills development levy and tourism levy.

2.4.4 Transport and logistics

Road transportation: Zambia has a total road network of 67,671 km. 87% of the paved Trunk, Main and District (TMD) road network in Zambia is in good condition, while 8% is in fair condition and 5% in poor condition. Zambia is generally well-connected to international markets thanks to several trade corridors and has routes connecting it to the ports on both the eastern and western coasts of Africa. Several corridors branch out from the country to all neighbouring countries and beyond.

Rail transport: Zambia has a total railway network of 2,217 km compromising Zambia Railways (ZR) and Tanzania-Zambia Railway Authority (TAZARA). TAZARA is a bi-national rail line which is jointly owned by the governments of Zambia and Tanzania. The ZR line is connected and linked to many ports in Eastern and Southern Africa (ESA).

Air transport: Furthermore, Zambia has four international airports, which have all seen efforts to modernise and renovate in the past few years.

Water transport: Zambia does not have direct access to the sea and Mpulungu port (Lake Tanganyika) is the only water-based port in the country.

2.5 International integration in economic trade relations with Germany

2.5.1 Trade between Zambia and Germany

The Federal Republic of Germany is not currently among Zambia's leading trading partners. However, Zambia's exports to Germany have been steadily increasing with a yearly average of 4.3% from USD 27.4 million in 1995 to USD 78.5 million recorded in 2020. Zambia's leading export products to Germany over these years include copper cathodes, tobacco, ferro-alloys (iron and steel), fresh fruits and vegetables, coffee, cotton, etc. (OEC, sd).

During the same period, Germany's main exports to the Republic of Zambia increased from USD 35.5 million in 1995 to USD 60.9 million in 2020, at an average rate of 2.2% per annum. Zambia's leading import products from Germany are machinery, nuclear reactors, boilers, industrial printers, documents of title, chemicals and laboratory reagents, pharmaceutical products, leather, footwear, mineral fuels, essential oils, perfumes, cosmetics, toiletries, electrical and electronic equipment, plastics, ceramic products, articles of iron and steel, milling products, malt, starches, wheat gluten, soaps, paper and paperboard, rubbers, etc.

2.5.2 Overview of German companies in Zambia

Various German-owned companies are registered and operating in Zambia. These businesses include SMEs and relatively big companies or multinational corporations (MNCs). These companies are engaged and involved in various business operations in different sectors of the economy: general trade, motor vehicle dealership, education and training, chemicals and agricultural solutions, mechanised solutions, sales and service of printing machines and photocopiers and other machinery and equipment, meat processing and distribution and catering services, developers of Renewable Energy (RE) projects, electrical and mechanical contractor services, healthcare, handicraft, art and culture, various types of consulting services (such as IT, engineering, business and management, etc.) and accommodation and tourism (German Business Circle in Zambia, sd).

The list of German companies registered and operating in Zambia is presented in Annex 1.

2.5.3 Representative trade bodies for German companies

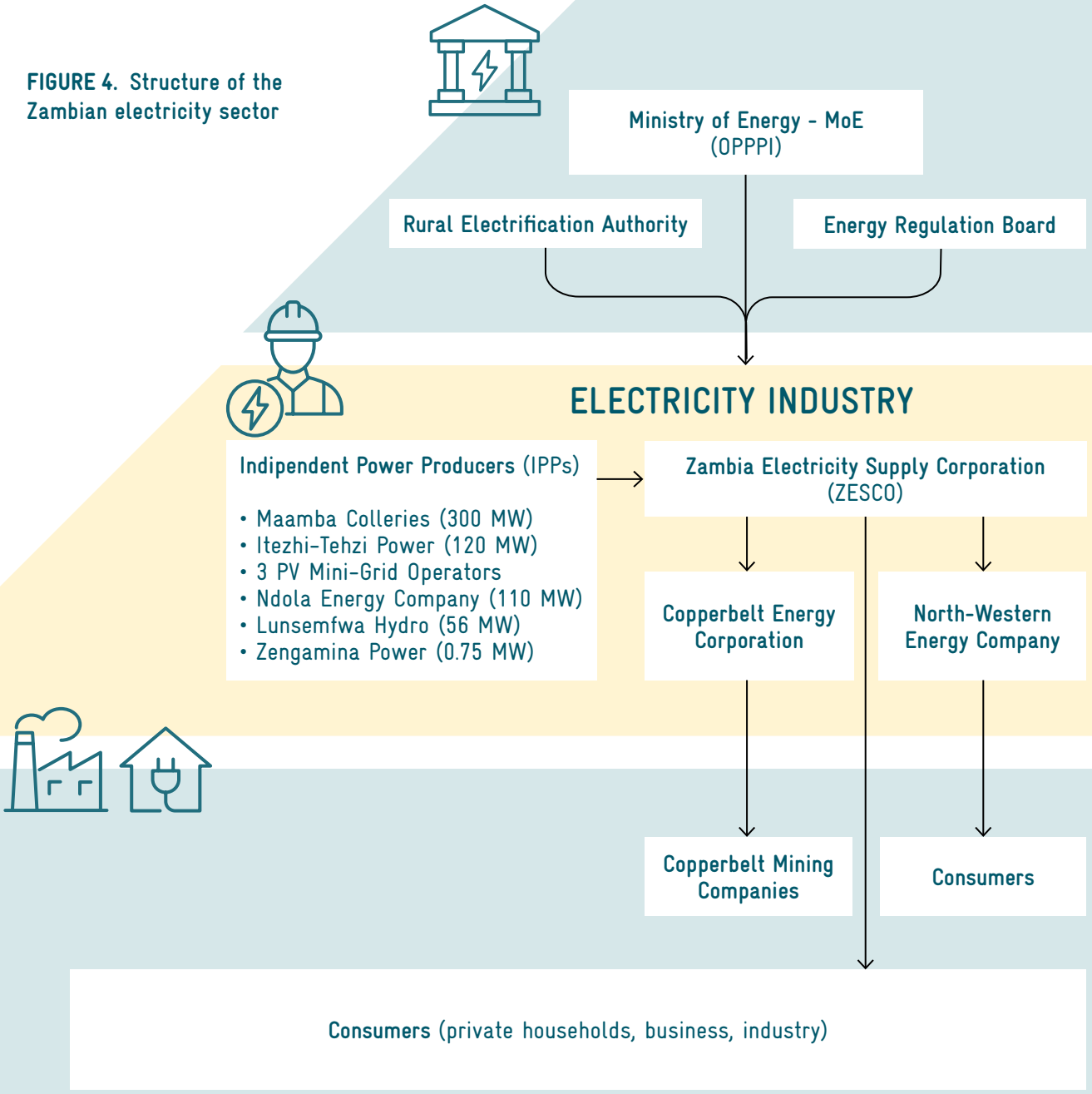
German companies are represented by several business associations such as the German Business Circle (GBC), Zambia Chamber of Commerce and Industry (ZACCI), EU-Zambia Business Club (EU-ZBC) and Southern African-German Chamber of Commerce and Industry (SAGCC). These representative trade bodies are key for:

- networking and information exchange
- market and business intelligence
- business facilitation: conferences, trade missions, delegations, business leads and match-making
- research, consulting services and conducting feasibility studies, etc.

3

Zambia's power sector overview

FIGURE 4. Structure of the Zambian electricity sector



Source: Authors' own illustration, Integration (2022), based on (Msimang, 2019)

3.1 Administrative division of responsibilities in the energy sector and regulatory framework

Political responsibility for the energy sector lies with the national Ministry of Energy (MoE). Its Department of Energy is responsible for developing the electricity sector, renewable energy resources and formulating the National Energy Policy. Another department of the MoE is the Office for Promoting Private Power Investment (OPPPI). It promotes the development of power projects by the private sector and recommends approvals for feasibility studies to the Minister of Energy. Furthermore, it facilitates negotiations for implementing agreements between private sector developers and the government, primarily for projects involving ZESCO as offtaker.

The Energy Regulation Board (ERB) is a statutory body established under the Energy Regulation Act and is responsible for the issuance of licences under the Energy Regulation Act. It also monitors the efficiency and performance of licensed enterprises, receives and investigates complaints from consumers and approves charges and tariffs in the energy sector.

The Rural Electrification Authority (REA) is a statutory body created pursuant to the Rural Electrification Act of 2003. REA's mandate is centred around

the development and promotion of electrification technologies in rural areas to contribute to the development of agriculture, mining, industry and other commercial and economic activities in these areas.

ZESCO Limited is the national utility company established pursuant to Companies Act No. 10 of 2017. ZESCO is a vertically integrated company in which the Transmission, Operations & Trade (TOT) Directorate manages transmission assets and is mandated to operate the Interconnected Power System (IPS) as a system operator. The company has the task of generating, transmitting, distributing and supplying electricity in Zambia. ZESCO undertakes almost 85% of the country's power plant capacity and produces about 90% of the electricity. It is the main offtaker from most of the IPP (Independent Power Producer) projects in Zambia and enters into power purchase and connection agreements with IPPs that connect to its grid.

The Zambezi River Authority is jointly owned by the Zambian and Zimbabwean governments to regulate water usage at Lake Kariba. The Kariba North Bank Hydro Power Station operated by ZESCO on the Zambian side has an installed capacity of 1,080 MW. The Kariba South Bank Hydro Power Station is operated by Zimbabwe and has an installed capacity of 1,050 MW.

Private companies also trade in electricity in Zambia. The largest of these, Copperbelt Energy Corporation Plc (CEC), buys electricity primarily from ZESCO and sells it to the various mines in the Copperbelt Province. It also operates its own generators, most of which run on fossil fuels. Private utilities such as CEC currently operate in niches and, at times, under unclear legal conditions (Msimang, 2019). However, the government is seeking more private investments, which should be limited to power generation and possibly distribution (Msimang, 2019).

Africa GreenCo Power Services Limited (Africa GreenCo) is an intermediary offtaker licensed by ERB to purchase renewable electricity from IPPs and sell it to utilities and private offtakers in Zambia and the SAPP region. It is the first private company acting as a pure trader in Zambia, i.e. without owning generation assets (GreenCo, 2022).

Zambia's power sector is primarily regulated by the following legislation:

- Electricity Act No. 11 of 2019
- Energy Regulation Act No. 12 of 2019
- Energy Regulation (General) Regulations, 2021
- The Zambian Distribution Code 2016
- the Electricity (Grid Code) Regulations, Statutory Instrument No. 79 of 2013.

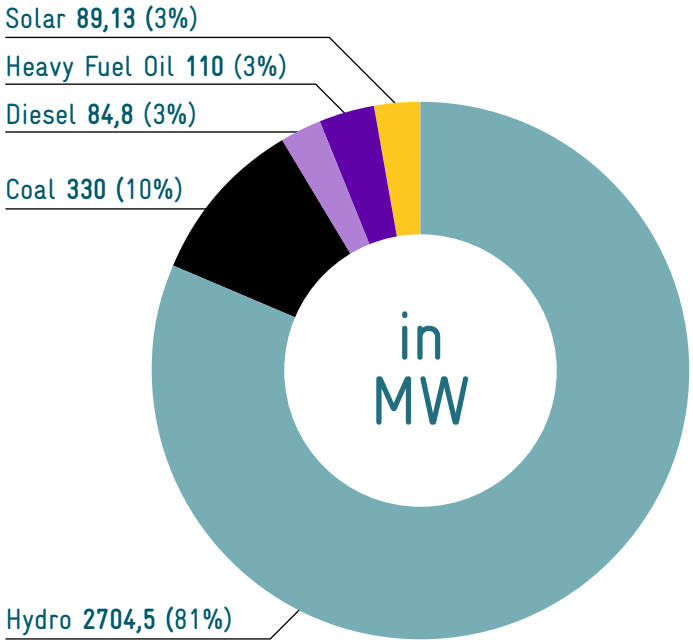
3.2 Electricity generation and consumption

At the end of 2021, Zambia had an installed generation capacity of 3,318 MW, compared to 3,011 MW in 2020. The increase in capacity was due to the commissioning of 300 MW of the 750 MW Kafue Gorge Lower Hydro Power Station and 6 MW of the 15 MW Lusiwasi Upper Hydro Power Station capacity in 2021. Thus, the installed capacity in Zambia in 2021 is composed as follows: 2,705 MW in hydropower (including 1,080 MW for the Kariba complex and 990 MW for Kafue Gorge), 330 MW in coal, 85 MW in diesel, 110 MW in heavy oil and 89 MW in solar. In total, about 84% of the installed capacity is renewable. This data is presented in Figure 5 (Energy Regulation Board, 2021).

The complete list of licensed generation units in Zambia is available at Annex 2

Zambia primarily relies on hydropower for its electricity supply. The high share of installed hydropower capacity is naturally also reflected in the amount of electricity generated. The share of hydropower generation was 81.5% in 2021 compared to 79.6% in 2020, due to improved rainfall patterns in the 2020/2021 season and the mentioned increase in installed capacity (Energy Regulation Board, 2021).

FIGURE 5. Installed production capacity in Zambia, 2021

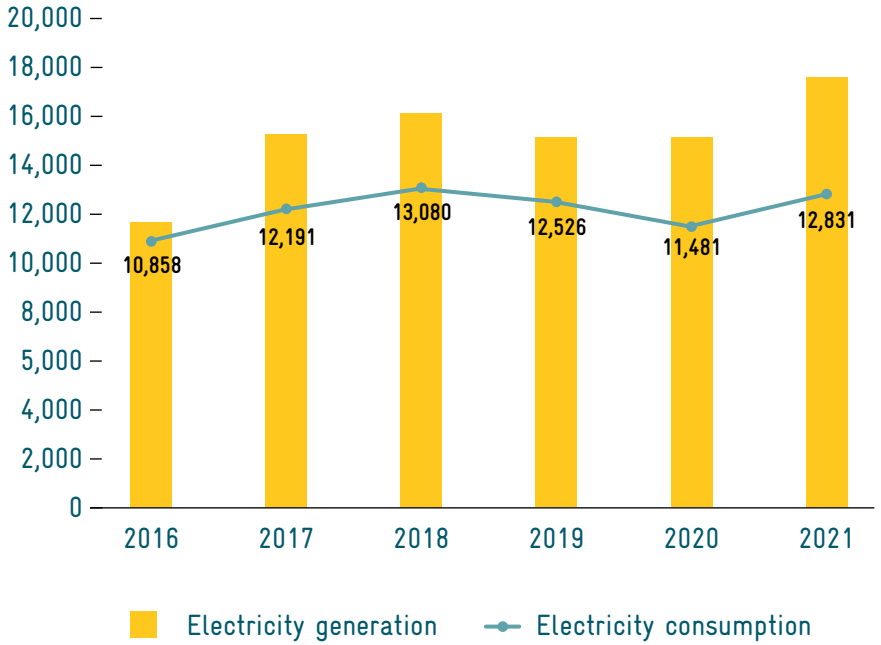


Source: Authors' own illustration, Integration (2022), based on (Energy Regulation Board, 2021)

However, not only the share of hydropower generated but also the total electrical energy generated grew to 17,636 GWh in 2021 compared to 15,159 GWh in 2020, representing a 16% increase. Consumption increased from 11,481 GWh in 2020 to 12,832 GWh in 2021, representing a 12% increase. After the decline in consumption in 2020 due to the COVID-19 pandemic and the associated slump in economic activity, it again follows the pattern of pre-pandemic years and records a clear increase.

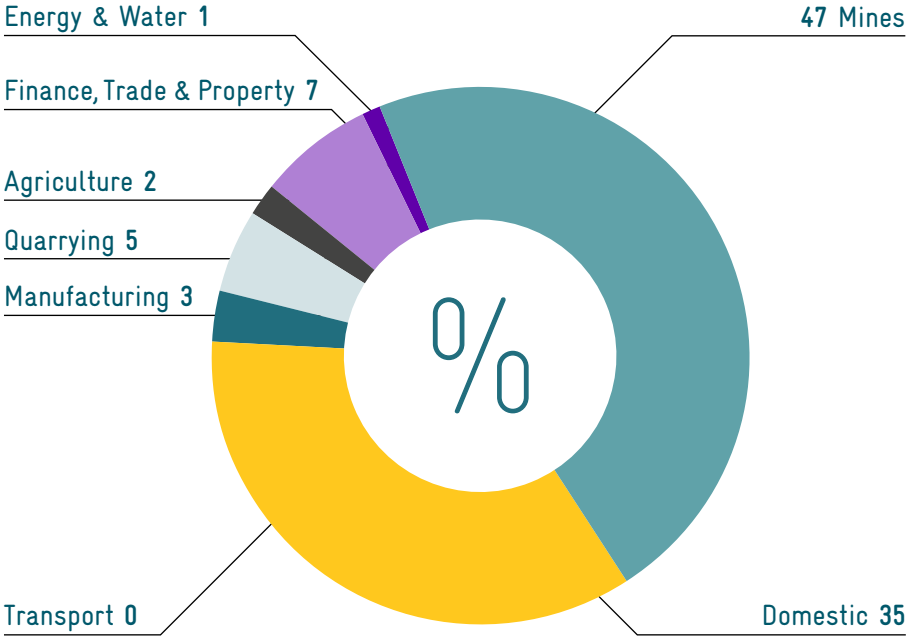
The breakdown of electricity consumption in Zambia in 2021 is as follows. The mining sector is by far the largest consumer with 5,980 MWh, private households following in second place with 4,477 MWh in 2021. Other important sectors include quarrying (572 MWh), manufacturing (436 MWh) and finance, trade and real estate (918 MWh) (Energy Regulation Board, 2021).

FIGURE 6. Electricity generation and consumption in GWh, 2016-2021



Source: (Energy Regulation Board, 2021)

FIGURE 7. Electricity consumption by economic sector in 2021



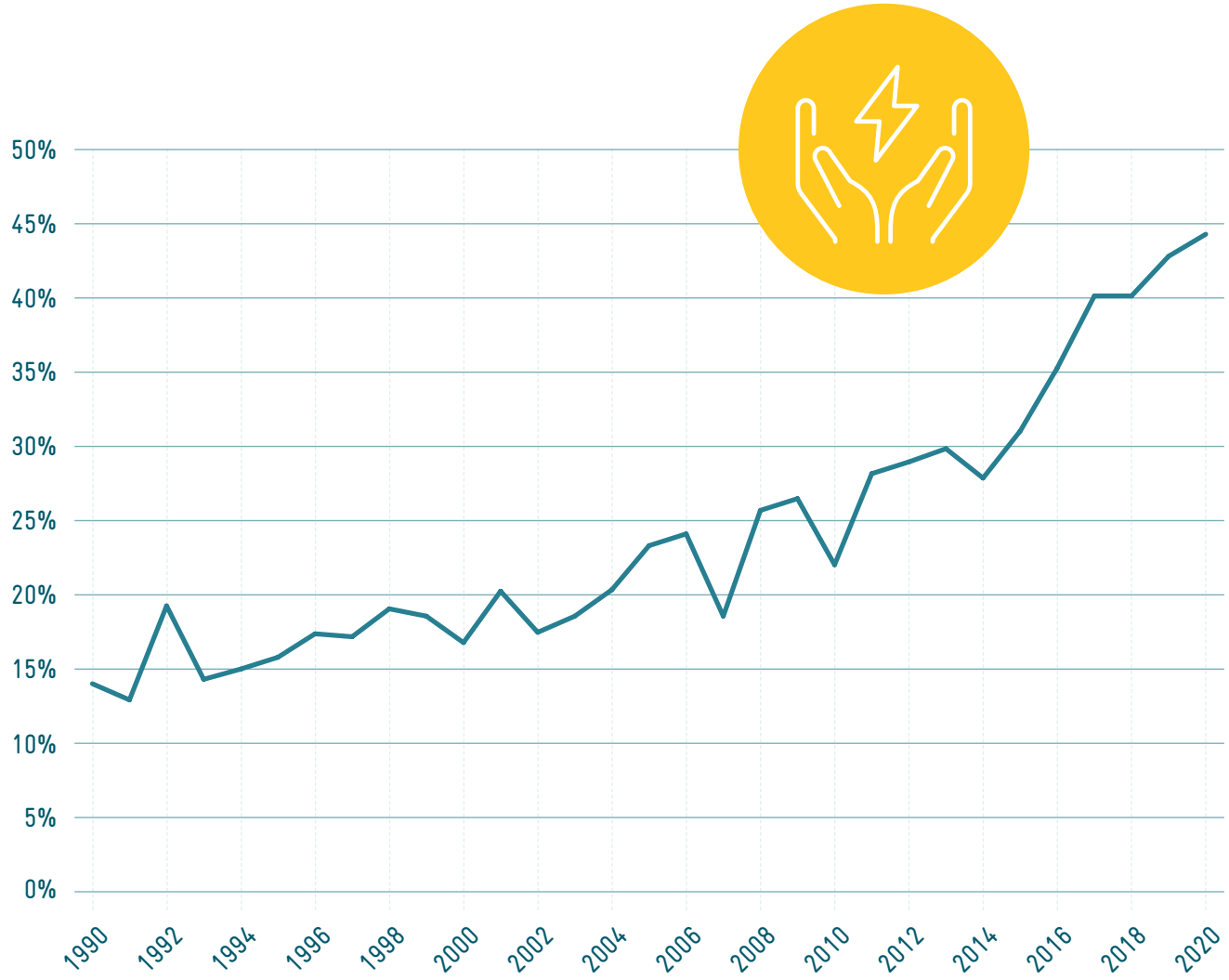
Source: (Energy Regulation Board, 2021)

3.3 Electricity networks

The transmission system in Zambia is operated almost exclusively by ZESCO. The transmission grid is operated at 330 kV, 220 kV, 132 kV, 88 kV and 66 kV, and the voltage is then transformed down to 33 kV and 11 kV at distribution level. The 330 kV backbone connects Lusaka to the Copperbelt Province and also includes an interconnection to Zimbabwe in the south. Zambia is interconnected to the Democratic Republic of Congo and Namibia via a 220 kV line, and to Tanzania via a 66 kV line. A map of the Zambian electricity grid is available in Annex 3.

Zambia has an electrification rate of 44.5% in 2020 (Macrotrends LCC, 2022), which shows the positive trend in electrification in the country but is still low even compared to neighbouring African countries. It is important to note the difference between urban and rural areas: in 2015, the urban access rate was 62% compared to only 4.5% for rural electrification, which is the area where Zambia is lagging behind when compared to other countries. The goal of the Zambian government is to achieve an urban electrification rate of 90% and a rural electrification rate of 51% by 2030, corresponding to a total electrification rate of 66% (USAID, 2018). The low electrification rate, especially in the rural areas, constitutes an appealing market for mini-grid development in the country.

FIGURE 8. Zambia electricity access 1990-2020



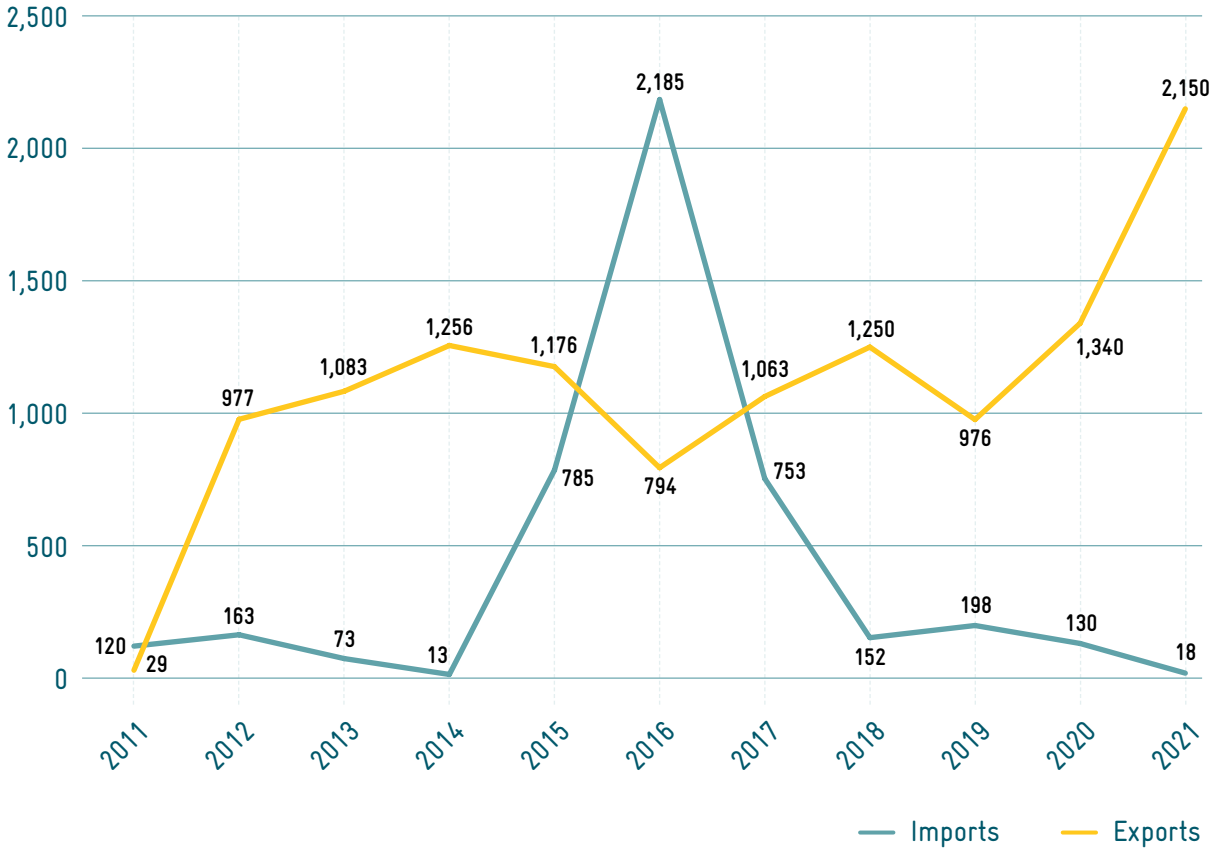
Source: (Macrotrends LCC, 2022)

For consumers connected to the grid, the electricity supply situation has improved in recent years, going from 4 hours of load shedding on average in 2015 to very little – if any – load shedding in 2022, although power cuts are still frequent in some regions due to grid planned and unplanned outages (SAIDI index at 30 hours for June 2022 – source ERB interview 2022). The country has also progressively become a net exporter of electricity in recent years.

However, despite the reduction in load shedding seen over the past few years, the low water levels in Lake Kariba, the main source of hydropower generation for both Zambia and Zimbabwe, resulted in increased load shedding for the first few months of 2023. According to a speech issued by the Minister of Energy in Parliament on 2 December 2022, the water levels in Lake Kariba had slowly decreased due to low inflows from the Zambezi River and its tributaries. The Minister indicated that water in Lake Kariba would be rationed for the succeeding four months to avoid a complete shutdown of electricity generation. Accordingly, Zambezi River Authority stated that with immediate effect, generation on the Zambian side be reduced to a maximum of 800 MW and to a maximum of 600 MW on the Zimbabwean side until further review of the substantive hydrological outlook at Lake Kariba. As a result, a load-shedding plan was published by ZESCO for implementation starting on 15 December 2022. Load shedding came to an end in February 2023 following improved water levels in Lake Kariba.

It is likely that climate change increases the risk of drought events and of lower hydropower generation in the coming years; with a combination of higher temperatures and evaporation and a decline in rainfall, (Byman H. Hamududu, 2016) projects a reduction in hydropower production potential of 18% and 28% in 2050 and 2080, respectively.

FIGURE 9. Electricity imports and exports in GWh (2011-2020)



Source: (Energy Regulation Board, 2021)

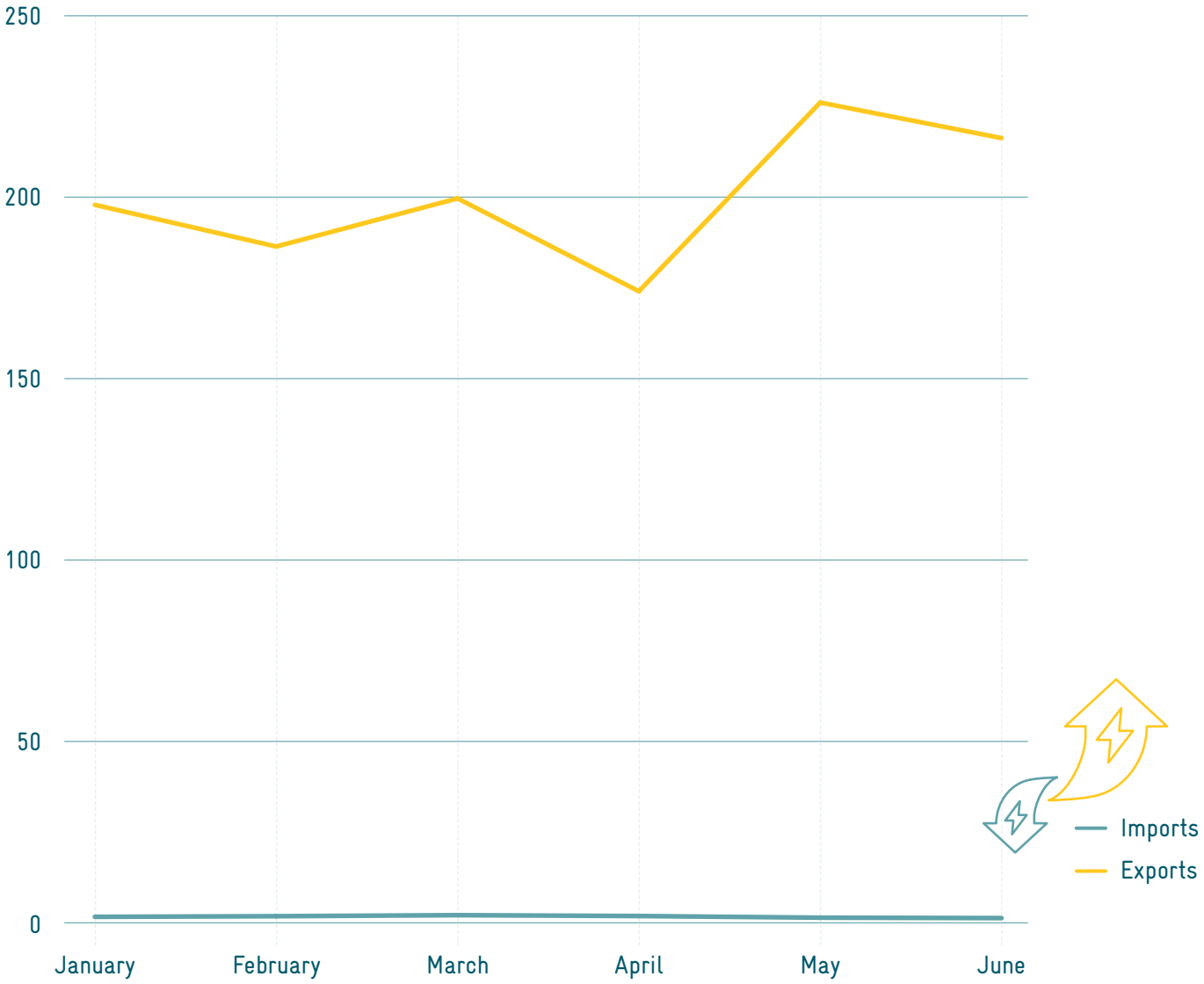
3.4 Interconnections and international electricity exchanges

As mentioned in the previous chapter, Zambia has developed into an export powerhouse in recent years. This is also demonstrated by the data from the first half of 2022. According to the figures from the "Statistical Bulletin" of ERB for the months January to June for the year 2022, in the first half of 2022 Zambia saw total exports of 1,199 GWh and imports of 9.6 GWh (ERB, 2022).

Exports are distributed among the following markets: Nampower Nambia with 543 GWh, SNEL DR Congo with 421 GWh, BPC Botswana with 125 GWh, ESCOM Malawi with 7 GWh, LV Exports with 60 GWh and the rest via SAPP Market with 43 GWh. For imports, the first half of 2022 results in 7 GWh from LV Imports and 2 GWh via SAPP Market.

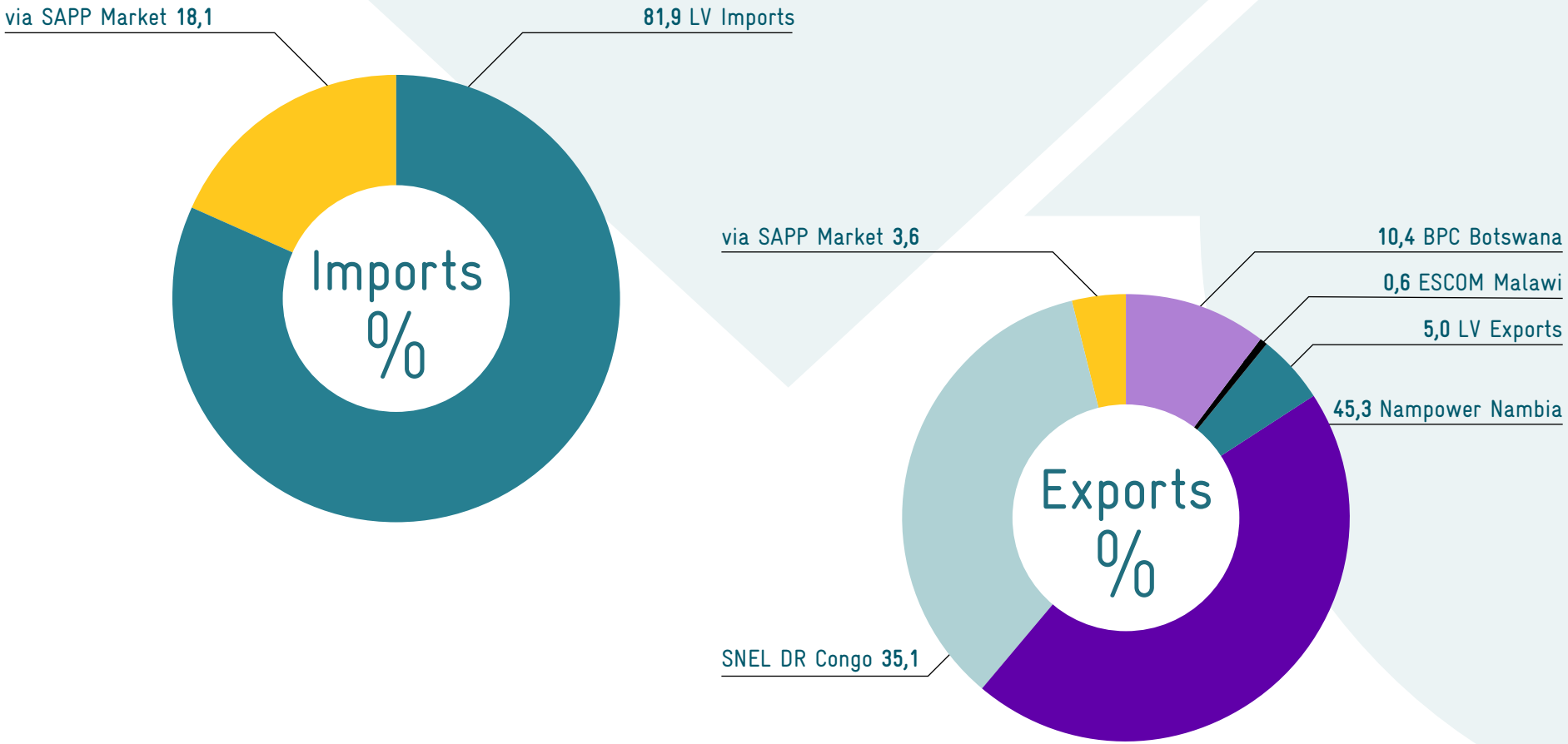
Southern African Power Pool (SAPP) is the name given to the common electricity market established by the countries of Southern Africa. The SAPP was agreed in August 1995 at a summit meeting of the Southern African Development Community (SADC) and includes a set of rules for cooperation between the respective countries and their electricity suppliers (SAPP, sd). The current members are presented in Annex 4.

FIGURE 10. Electricity imports and exports in GWh (first half of 2022)



Source: (ERB, 2022)

FIGURE 11. Imports and exports by country



Source: (ERB, 2022)

3.5 Current electricity tariffs and expected evolution

The Electricity Act regulates the generation, transmission, distribution and supply of electricity to enhance the security and reliability of electricity supply in Zambia. It codifies the rules on tariff setting and introduces the concept of intermediary power trading, a concept that was missing from the previous regulatory framework. The Energy Regulation Act establishes the Energy Regulation Board and provides for its regulatory functions. One of its key functions is the issuance of licenses and monitoring compliance with applicable legislation.

All tariffs, be they for retail consumers or non-retail consumers, are set or varied by power producers, subject to approval by the Energy Regulation Board (ERB). The Electricity Act sets out the following as the principles to be followed when setting and approving (retail) tariffs (Section 30 of the Electricity Act):

1. tariffs must be fair and reasonable, reflecting the cost of efficient business operations;
2. tariffs must ensure quality of service, predictability of adjustment and a reasonable rate of return on capital investment;
3. tariffs should encourage competition, economic use of electricity, good performance and optimum investment;
4. tariffs should reward efficiency in performance; and
5. tariffs should reflect enforceable standards for the quality and cost of the supply of electricity to both retail and non-retail consumers.

The Electricity Act has introduced the concept of a multi-year tariff framework where ERB may approve retail tariffs for a period of up to five years, considering the previous tariffs and any previous adjustments (Section 24 of the Electricity Act). This framework, once implemented, will ensure predictability of retail tariffs.

In the case of non-retail consumers, the ERB determines and sets a minimum bilateral tariff to be paid by a non-retail consumer to achieve cost reflectivity.

The official ZESCO tariffs are presented in Annex 5.

The time-of-use tariffs are applied according to the following periods: standard tariff from 6 am until 6 pm; peak tariff from 6 pm until 10 pm; and off-peak tariff from 10 pm until 6 am (ZESCO, sd). Energy charges are applied to the total energy (in kWh) consumed for each of the periods and the maximum demand charges are applied to the monthly maximum meter reading (in kVA) for each period. The granularity of meter readings in Zambia is 30 minutes.

For customers connected to CEC, the tariffs are negotiated bilaterally, and CEC does not publish any official tariff list.

ERB is currently considering an application by ZESCO for an upward adjustment of tariffs having received public comments on ZESCO's application.

3.6 Policy and tariff evolution

3.6.1 Tariff evolution

One of the factors leading to the government's financial problems was ZESCO's increasing debt, with it being unable to fully cover its costs from revenues. For this reason, Zambia undertook a Cost-of-Service Study (COSS) that was completed in 2021, and which aimed at proposing new, cost-reflective tariffs. The study was undertaken by the EMRC Group with financing from AfDB. The objective of the COSS was to:

provide a basis for setting consumer electricity tariffs for all customer categories to promote efficiency of electricity supply and consumption, and to ensure financial viability of the electricity sector, while taking into account social and equity considerations in the pricing of electricity for poor households (ERB, 2016).

The COSS proposes increasing tariffs for residential consumers and subsequently reducing tariffs for maximum demand consumers (C&I consumers) and those with Power Purchase Agreements (PPA's) with ZESCO. The government, however, has taken the position that there is the need to strike a balance between social and economic considerations in the tariff-cost allocation while ensuring that this does not affect ZESCO and other utilities' financial sustainability (Government of Zambia, 2022). Annex 6 shows the proposed tariff modification in the COSS.

3.6.2 Future demand forecast

The COSS projects that by the year 2040, Zambia's peak demand will increase by 95% from 2,143 MW in 2020 to 4,169 MW in 2040 with the demand largely driven by residential customers, with a projected growth rate of 1.3% annually. While the Zambian government accepts that the demand for power will continue to rise in Zambia, it has taken the view that the demand will be much higher than the 95% projected under the COSS.

According to the government, the desire to attain universal access to electricity; stimulation of agricultural production; support for industrial development; increase in copper production from the current annual 800,000 metric tons to 3 million tons by 2030; and the establishment of Zambia as a hub for electricity trading and a net exporter of electricity will push the demand to levels much higher than those forecast in the COSS. The government anticipates that peak demand will be at 8,000 MW by 2030 and 10,000 MW by 2040 (from around 3,000 MW in 2022). It also projects that the demand will be largely driven by mining and agricultural consumers and not residential consumers as projected in the COSS (Government of Zambia, 2022).

4

Zambia's renewable energy landscape

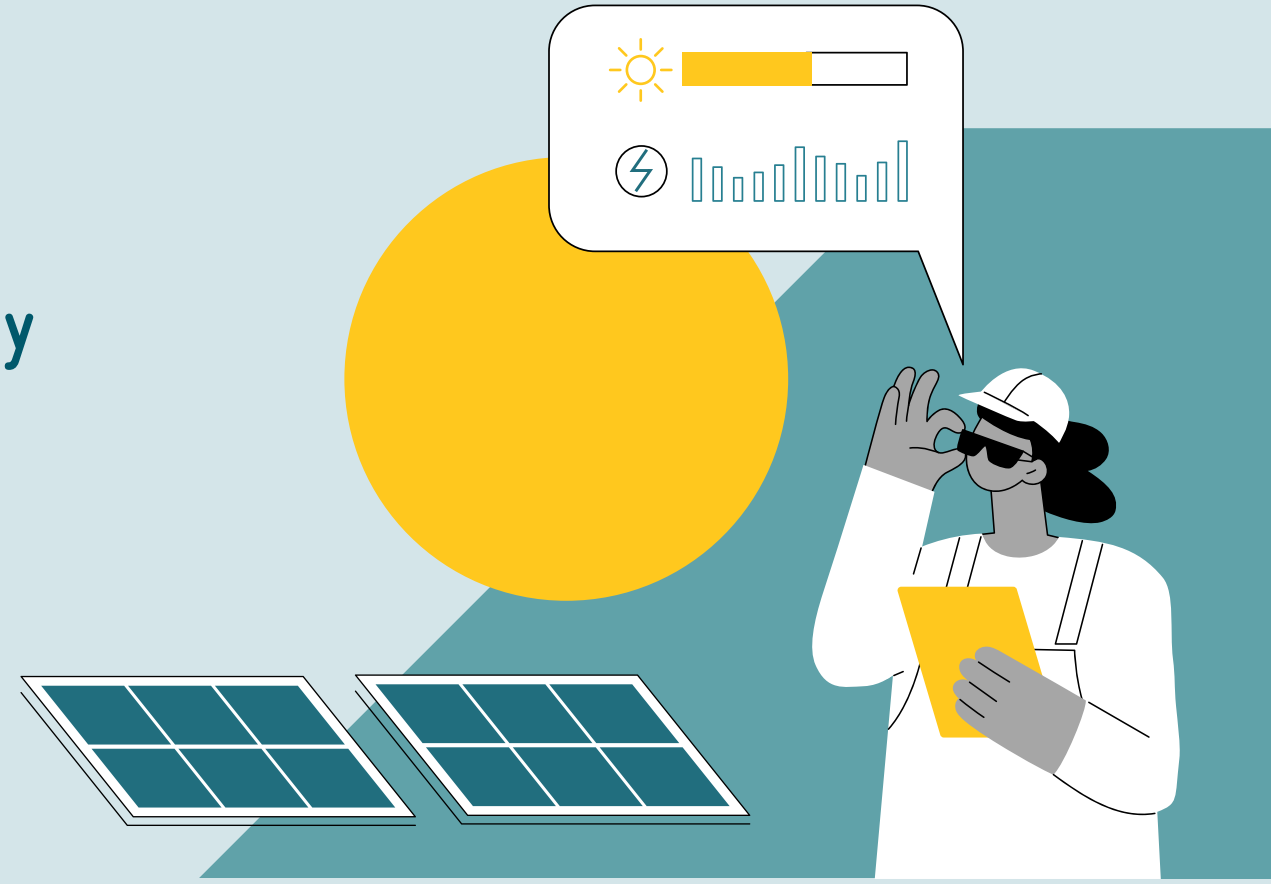
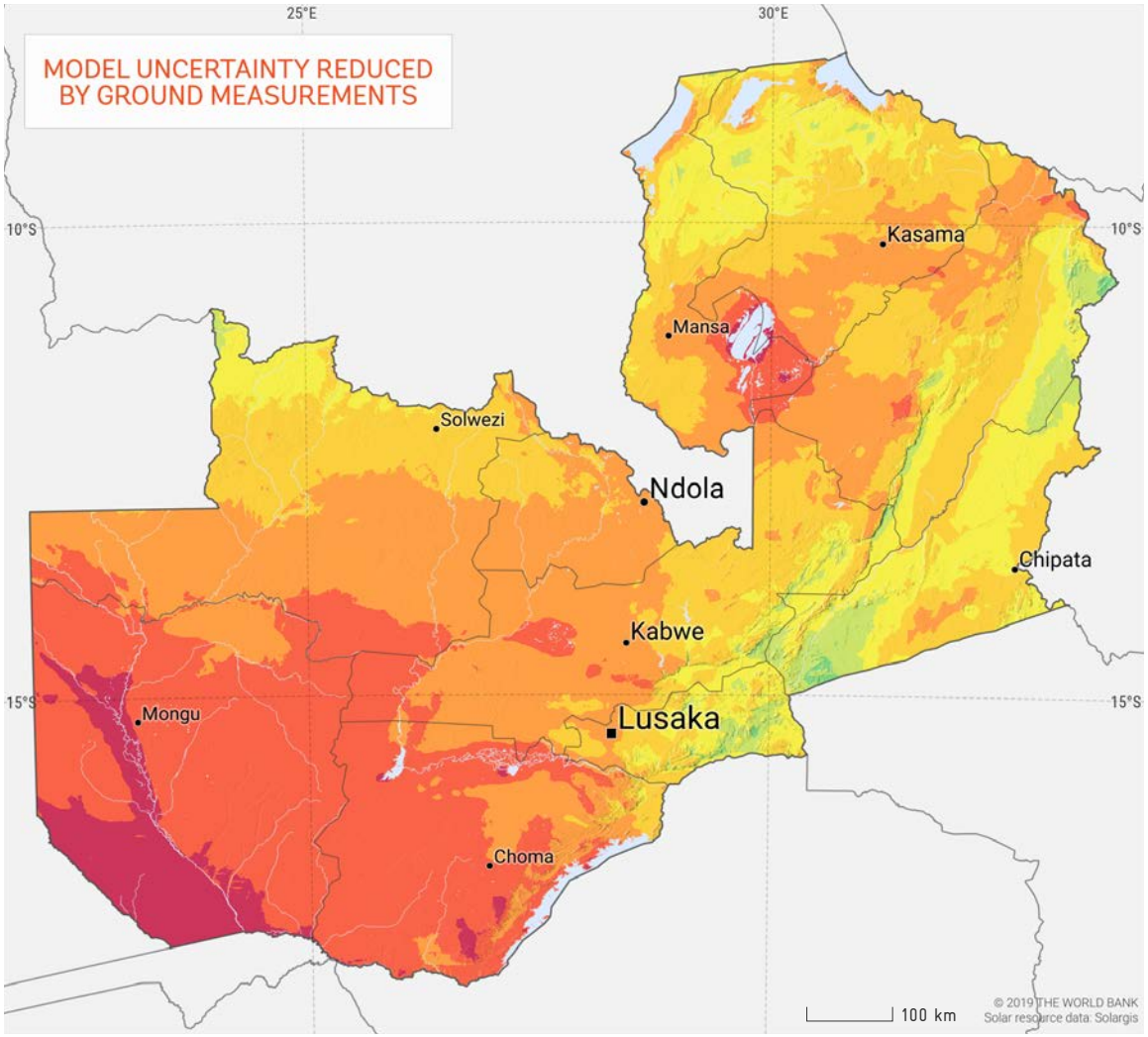


FIGURE 12. Photovoltaic power potential in Zambia



Source: (Solargis, sd)

4.1 Relevant renewable energy and storage technologies in Zambia

Zambia has great potential for the production and storage of renewable energy resources. This section reviews the different technologies available and evaluates whether or not they are suitable for commercial and industrial (C&I) companies.

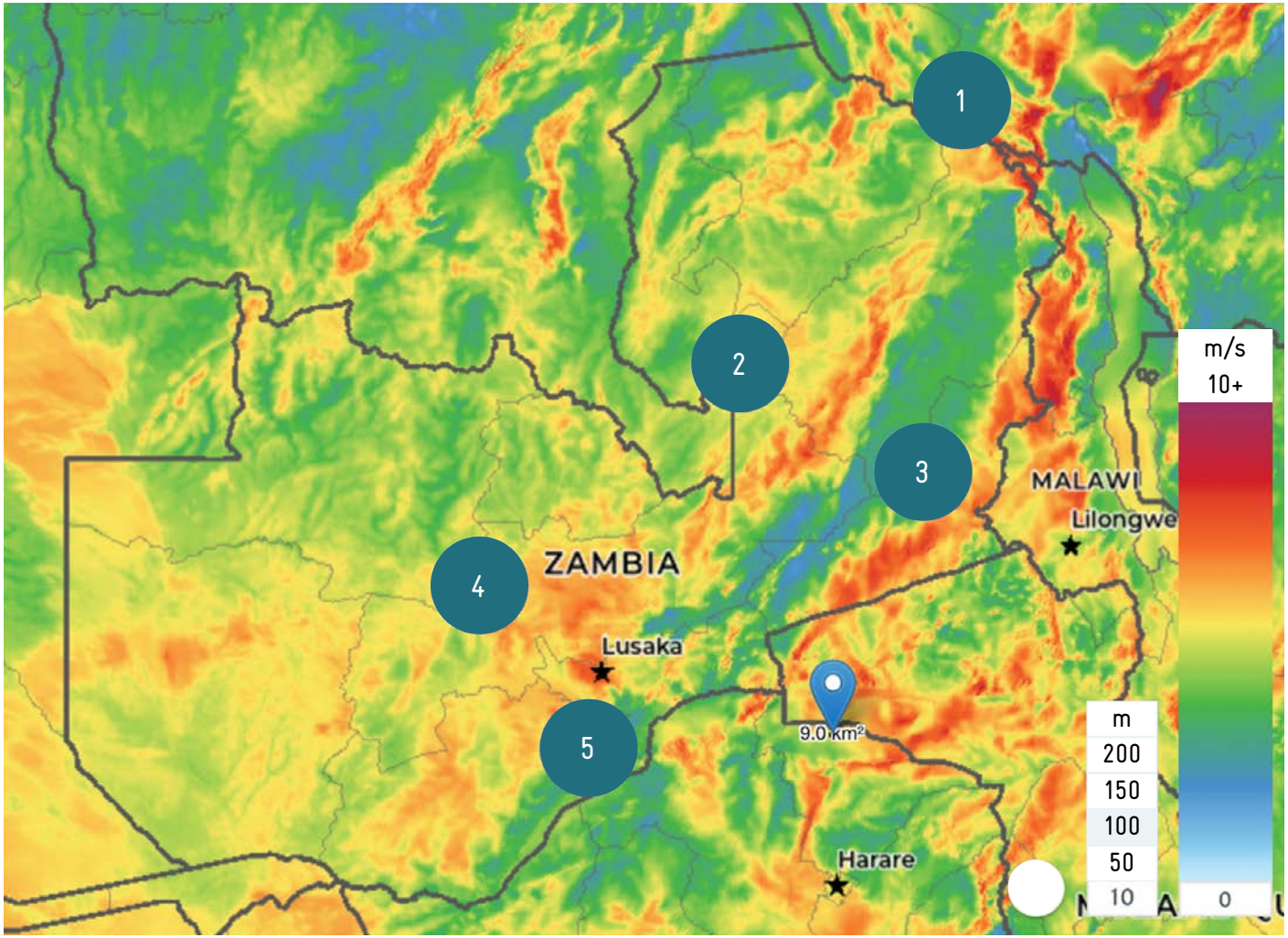
4.1.1 Solar photovoltaics (PV)

Zambia benefits from excellent solar resources, with a specific production output between 1,600 and 1,800 kWh/kWp per year. The regions with the best resources are the south-west part of the country as well as the region around Lake Bangweulu, east of Mansa.

The monthly distribution of solar PV production is also quite favourable, with very little seasonal variation. The period from November to February, corresponding to the rainy season, delivers only 25% less output compared to the best months, August to October (see Annex 7).

Zambia's excellent solar irradiation across the country and the low seasonal variability makes it a technology with relatively constant availability throughout the whole year. Solar photovoltaics is particularly suited to C&I companies due to its scalability since it is possible to develops projects of just several kilowatts to those of multi-megawatts.

FIGURE 13. Wind energy potential in Zambia



Source: (Global Wind Atlas, sd)

Solar photovoltaic modules are installed either on the roof or are mounted on the ground, and the availability of space can be a limiting factor. Production is relatively concentrated in time, around midday, which means that storage is naturally complementary to solar photovoltaics, allowing excess production to be stored during the daytime for use at night.

A list of existing PV plants is available in Annex 2. It is also worth mentioning the partnership between First Quantum Mineral, one of Zambia's largest mining operators, and Total Eren and Chariot Transitional Power for the construction of a 430 MW wind and solar project (Power-technology.com, 2022).

4.1.2 Wind energy

Zambia has a few regions with good wind speeds. These include the Viphya Mountains (1), the Muchinga Escarpment (2), the Eastern Province (3), the Central Province (4) and the Lusaka Province. (5)

A wind atlas can give a good idea of the attractive regions but, unlike PV, potential is very site-specific. In order to confirm the potential of a given site, it is necessary to install a measurement station that will record the wind speeds of that site for a duration of at least one year.

Wind energy is also relatively scalable and, thus, also well suited to application at C&I companies. However, small-scale wind turbines (<1 MW) are usually less economically promising, especially when compared to solar photovoltaics.

4.1.3 Hydroelectric energy

Hydroelectric energy is very relevant in the case of Zambia as it represents the majority of the installed capacity. For C&I customers, however, potential is also very site-specific and the need for electrical storage to enhance hydropower generation is more limited in comparison to the need for complementary photovoltaic or wind energy with suitable storage technologies.

4.1.4 Biomass

There is potential to generate electricity using biomass in the C&I sector, especially in the agricultural and food processing sectors where organic waste is available. However, biomass-based production units are usually dispatchable and the complementarity with electricity storage is not obvious.

4.1.5 Concentrated solar power

Concentrated solar power (CSP) involves large projects that are more relevant in the context of a utility than in the context of a C&I company. It is relevant in combination with thermal storage, which is out of the scope of this sector analysis.

4.1.6 Geothermal energy

Geothermal energy is being explored in Zambia, which has initial promising results (REPP, sd). Like wind energy, it is site-specific and requires further study before its potential can be confirmed.

4.1.7 Battery storage

Lithium-ion is the technology of choice for electricity storage in the context of a C&I company because of the scalability and the good round-trip efficiency. This is the storage technology that will be the focus in the rest of this sector analysis.

Other types of batteries include redox flow batteries, which can be competitive in the context of long-term storage, or sodium sulphur batteries that are well suited to very hot environments due to their high operating temperatures. It is unlikely that either of these technologies will find a large market in Zambia in the short term.

4.1.8 Pumped hydro storage

Mini-pumped hydro storage could be an appealing market in Zambia, but a niche market since this technology is also constrained by the site conditions.

4.1.9 Hydrogen

It is unlikely that power-to-power applications of hydrogen show high potential in Zambia, as these applications still fail to provide a positive business case in the rest of the world. The main issue is the low round-trip efficiency of 30-40%, which results in numerous losses.

4.2 Energy storage value chain

Entry ways for German solution providers along the storage project value chain:

Project Developer

customer-facing actor who performs the initial assessment of project feasibility and coordinates the financial and technical aspects of the project;

Investor/Lender

an entity who serves as third-party investor. It can also be a bank or another type of financial entity providing a loan, also in case of self-financed projects;

Engineering Consultant

executes the preliminary and detailed design of the technical solution. It can be an independent consultant or the engineering department of an EPC contractor (Engineering, Procurement, Construction);

Equipment Manufacturer

provides hardware and software for the project. In battery energy storage projects, we can list the following suppliers:

- battery cell manufacturer (usually includes the integration of cells in modules and racks, as well as the Battery Management System (or BMS))
- AC/DC converter manufacturer
- energy management system (EMS) supplier
- balance of system (cables, circuit breakers, etc.) and ancillaries (HVAC, fire prevention system, etc.)
- battery storage integrator (combines the above components, sometimes in containerised solutions)

Installer

the company that will organise transport and delivery on site and execute the installation work (civil works, electrical connection, etc.);

O&M Service Provider

will ensure monitoring of the systems' operation throughout their entire lifetime, as well as preventive and corrective maintenance;

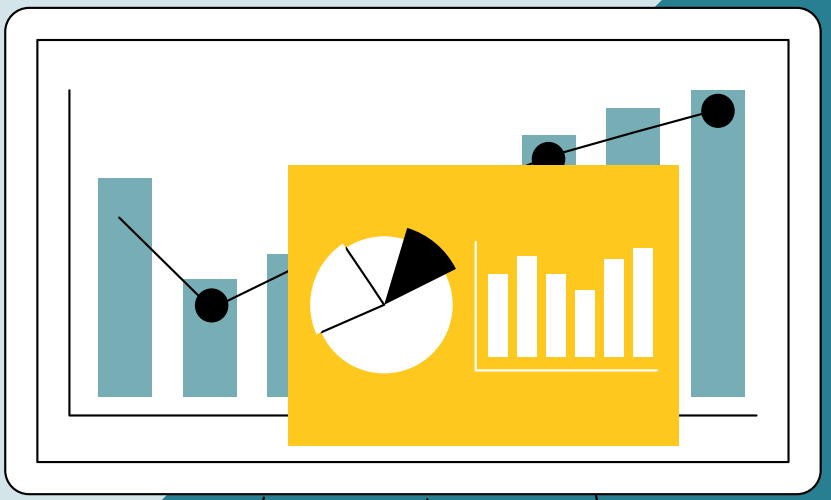
Decommissioning contractor

takes care of deconstruction, disposal and recycling of equipment at the end of their lifetime.

i Of course, one company can combine several roles. Often a single company takes care of engineering, procurement and construction and is referred to as the EPC contractor.

5

Market opportunities for renewable energy and storage



5.1 Renewable energy deployment objectives and government incentives

5.1.1 National Energy Policy

The Nation Energy Policy of 2019 ("NEP 2019") is the guiding document on government policy for the power sector in Zambia and builds on the previous policies of 1994 and 2008. It aims to guide the energy sector in the development of electricity generation, transmission and distribution capacity. The NEP 2019 also facilitates the development and deployment of renewable energy and aims to promote security of energy supply through the diversification of energy sources at cost-reflective prices and increased access to energy in both rural and urban areas (Ministry of Energy, 2019).

The NEP 2019 proposes several measures aiming to enable the deployment of renewable energy systems, for example, by "strengthening the mandate of the Energy Regulator", "establishing the regulatory frameworks for off-grid systems" or "promoting wider usage of renewable energy technologies." The document does not state any target figures in MW or in percentages for the deployment of renewable energy in Zambia but the government has a target to install 600 MW of solar and wind by 2030 (source: interview with MoE 2022).

5.1.2 Mini-grid regulation

The draft mini-grid regulations aim to encourage investment in the electricity subsector by applying light-handed regulations to mini-grid operators. Following the enactment of the Electricity Act and Energy Regulation Act in 2019, the draft mini-grid regulations require alignment with the two principal pieces of legislation (being the Electricity Act and the Energy Regulation Act) and are currently under review by the Ministry of Energy and the ERB (Energy Regulation Board, 2021). It is expected that provisions will also be made for C&I developers.

5.1.3 Net-Metering Regulations

On 15 August 2022, the ERB published the draft Net-Metering Regulations. The draft Net-Metering Regulations define net metering as an arrangement where electricity is generated and primarily consumed on site, and the excess is exported to the grid by the prosumer and compensates offtakes occurring at moments of low production (e.g. at night in the case of solar energy). The draft Net-Metering Regulations provide for the reciprocal obligations between licensed enterprises (distribution and transmission network service providers) that facilitate net metering and prosumers involved in net metering. The parties must enter into a net-metering-generation agreement to provide for technical requirements, operation obligations, sanctions for breach, payment terms or guarantees for supply, tariffs and tariff structure and duration.

All renewable energy technologies are eligible for net-metering generation. These include: solar PV, wind, hydro, geothermal, biomass, biogas, biofuel or fuel cell resources (when the fuel for the fuel cell was produced with net carbon free energy). Both new and existing installations are eligible to apply for net metering provided they meet the prescribed requirements, with renewable energy technology being a prerequisite.

According to the draft Net-Metering Regulations, generation is not and should not be a commercial activity as construed under the Electricity Act. Neither the Electricity Act nor the draft Net-Metering Regulations define what amount of energy generated is given to "commercial users". This will need to be clarified in the updated draft Net-Metering Regulations. However, the intention of the generation should be for self-use, with any surplus being exported to the grid.

The draft Net-Metering Regulations provide different tariff structures for imports and exports from the grid, and for this reason it is closer to a Feed-In Tariff mechanism than a net-metering mechanism. For imports, the draft Net-Metering Regulations provide that rates will be identical to retail tariff structures, with monthly charges for the prosumer being what

would be charged if the prosumer was an ordinary consumer of electricity from the grid.

For exports to the grid, the draft Net-Metering Regulations provide that the exports will be valued at a regulated and non-discriminatory value for all forms of renewable energy technologies. The tariffs will be published by the ERB and will depend on the annual percentage of exports to the grid as follows:

TABLE 2. Conditions for net metering

	REGULATED VALUE FOR NET-METERING EXPORTS	CONDITION
1.	100%	Annual exports less than or equal to 50% of annual generation
2.	75%	Annual exports more than 50% and less than or equal to 75% of annual generation
3.	50%	Annual exports more than 75% of annual generation

Source: (ERB, 2022)

Prosumers whose consumption percentage is higher, relative to their exports, will get a higher value for their exports.

5.1.4 Tax incentives

Electricity generation is a priority sector activity as amended under the Zambia Development Agency Act, No. 6 of 2006 (the "**ZDA Act**"). This means that licensed investors in the energy sector are entitled to incentives under the Income Tax Act, Chapter 323 of the Laws of Zambia (the "**Income Tax Act**") and the Customs and Excise Act, Chapter 322 of the Laws of Zambia (the "**Customs Act**"). To benefit from these incentives, an investor is required to obtain an investment licence from the ZDA and invest a minimum of USD 50,000 in the case of local investors and USD 500,000 in the case of foreign investors.

Incentives are currently provided in the Income Tax Act, which states that improvement allowances may be deducted from the profits of a person or company when determining the taxable income if they are operating in a priority sector in a multi-facility economic zone (special economic zone) or industrial park, at a rate of 100%.

5.2 RE/ESS project development process and procedures

Renewable energy projects are regulated by the Energy Regulation Act and the Electricity Act. Current legislation does not differentiate between IPP projects and C&I projects. All regulated projects are generally subject to the same regulations and licensing requirements of the ERB. In addition, IPP projects have to obtain approval of their feasibility studies from the MoE prior to applying for licences from the ERB (Energy, 2022).

Whether or not a project is regulated is determined by the installed capacity and whether the generated electricity is for own use or for the use of another person or entity. The Electricity Act provides that a project with an installed capacity of 250 kilowatts or more must comply with the provisions of the Energy Regulation Act and be licensed by the ERB. A licence must also be obtained from the ERB where generated electricity is for the use of another person other than the one producing it, even though the capacity is below 250 kilowatts.

In either of the above scenarios, the technology used does not matter (solar, wind, hydro, thermal or biomass), nor does the fact of whether the project is on- or off-grid.

5.2.1 Licence application procedures and timelines for RE

Approval for a project by the ERB involves two stages:

1. application for a construction permit and
2. application for a generation licence.

Upon being granted a construction permit, a developer can commence construction works on the project site. On completion of construction and installation, a developer must apply for a generation licence before it can begin operations.

CONSTRUCTION PERMIT APPLICATION PROCESS

The request for a construction permit involves the following steps:

1. payment of an application fee of ZMW 1,000.20 to the ERB for issuance of a construction permit;
2. submission of an application to the ERB after completing a feasibility study and obtaining a decision letter or approval from the Zambia Environmental Management Agency;
3. consideration of the application by the ERB within 21 days; and
4. granting of the construction permit or rejection of the application by the ERB.

GENERATION LICENCE APPLICATION PROCESS

The request for a generation licence involves the following steps:

1. payment of an application fee of ZMW 1,000.20 and submission of the prescribed application form to the ERB;
2. technical and financial assessment of the application by the ERB;
3. applicant invoiced for licence processing fee of 0.1% of the cost of the project. Minimum payable amount is ZMW 2,500;
4. issuance of provisional licence issued within 3 weeks of payment of licensing processing fee;
5. waiting for 14 days after the ERB's publication of intention to issue licence to allow for public objection;
6. approval of application by the ERB;
7. issuance of the generation licence within 60 days from date of application if all information has been provided to the ERB.

ESS PROJECTS

ESS are also regulated by the ERB. For the installation of solar batteries, a licence to manufacture, supply, install and maintain RE-generating equipment is required if the ESS is not for the use of the project owner. If the ESS is to be used for own consumption, an application for approval of "excluded activity" must still be made to the ERB.

An application for installation of a battery involves the submission of a prescribed application form with the following supporting documents:

1. proof of payment of the application fee of ZMW 1,000.20;
2. certificate of incorporation;
3. prescribed declaration of availability of funds form;
4. five-year business plan (a template is provided by the ERB);
5. latest stamped company printout from the Patents and Companies Registration Agency "PACRA");
6. tax clearance certificate issued by the Zambia Revenue Authority;
7. PACRA annual return status; and
8. a standard checklist of information required by the ERB. This includes confirmation of qualified technical staff and supervising engineers registered with the Engineering Institution of Zambia, fire certificate, insurance cover, confirmation of project costs, etc.

CHALLENGES

The current legislation does not distinguish between commercial projects and generally applies the same rules to all project sizes. It is currently under review to provide light-handed regulatory requirements or exemptions for smaller projects below a capacity threshold yet to be determined.

5.3 Transport and logistics

Transport and logistics can be a challenging aspect of renewable energy and storage projects. One of the particularities of Zambia, as mentioned earlier, is that the country does not have direct access to the sea.

5.3.1 Shipping

The best port for the shipment of a container of goods or products from Germany or any part of Europe to Zambia is through the port of Walvis Bay, Namibia, because of its shorter distance to Europe. Transportation of the same container of goods or products via Dar es Salaam in Tanzania would be more expensive as the ship has to pass through the Suez Canal (which attracts charges from Egyptian maritime authorities) or the Horn of Africa (which has security challenges, hence additional costs or charges). However, Dar Es Salaam is the port of choice for goods coming from Asia.

Some of the ports that are used for shipping goods destined for Zambia are Durban, East London and Port Elizabeth (South Africa) and Beira and Nacala (Mozambique). However, the most commonly used ports are Durban (South Africa), Dar es Salaam (Tanzania) and Walvis Bay (Namibia).

Transit from the seaport to Lusaka takes 4 to 6 days depending on the port, including loading/offloading and customs procedures.

5.3.2 Road transportation

Zambia has a total road network of 67,671 km, of which 40,454 km is classified as the Core Road Network (CRN), which should be maintained regularly in order to keep the economy running. According to the 2015 Road Conditions Survey, 87% of the paved Trunk, Main and District (TMD) road network in Zambia is in good condition, while 8% is in fair condition and 5% in poor condition.

All major cities and towns in the country are easily accessible by road, which includes the vast majority of factories and mining sites. Annex 8 shows the travel time between major Zambian cities.

5.4 Customs duty

The Zambian regulation foresees customs duty and VAT exemptions for most equipment used in renewable energy or battery storage projects. Detailed information is provided in Annex 9.

5.5 Business case and business model

5.5.1 Business case

In this section, we discuss the opportunity of battery storage in combination with solar photovoltaics from a financial point of view. The base hypotheses are the result of interviews with commercial and industrial companies in Zambia (2022).

5.5.1.1 PHOTOVOLTAICS ONLY

As a baseline, we first consider the business case for solar photovoltaics without storage. We assume that the photovoltaic system is sized so that 100% of the production can be self-consumed by the owner or that net metering is applicable. In that case, the PV production is used to reduce the electricity bill and/or the diesel fuel bill.

The hypotheses used for solar production are a CAPEX of USD 1,000/kWp (turnkey system – own estimate) and a yearly production of 1,700 kWh/kWp (see 4.1.1).

As of 2022, the cost of diesel in Zambia was around USD 1.5/litre (Global Petrol Prices, sd) and the efficiency of a generator varies between 25% and 35% if operated at at least 30% of its capacity (Skyllas-Kazacos, 2012). If we assume an average efficiency of 30% and considering the fact that one litre contains

approximately 10 kWh (thermal), the cost per kWh (electrical) generated is USD 0.50.

The current price of electricity for the commercial or industrial consumer depends on the ZESCO tariff and on whether the consumer has to make use of a diesel generator as a back-up in case of grid outages. For our comparison, we assume three different (blended) electricity prices: USD 0.03/kWh, which corresponds to the energy charge during the day for a customer with a grid connection between 301 kVA and 2,000 kVA; USD 0.13/kWh[1], which corresponds to a customer operating 5 hours per day on genset and the rest on-grid; and USD 0.50/kWh, which corresponds to a customer operating off-grid, i.e. 100% on diesel.

The financial analysis provides the following results for these three cases:

TABLE 3. Results of the business case for PV self-consumption

Use case	CURRENT ELECTRICITY PRICE	PV PAYBACK TIME (SIMPLE)	PV INTERNAL RATE OF RETURN (25 Y)
Grid electricity (100% on-grid)	USD 0.03/kWh	20 years	2%
19 hrs/day on-grid; 5 hrs/day on diesel	USD 0.13/kWh	5 years	22%
100% off-grid (diesel)	USD 0.50/kWh	1 year	85%

Source: Authors' own illustration, Integration (2022)

We can conclude that PV is not attractive to customers with an uninterrupted supply from ZESCO at 2022 tariffs, but installing a PV system becomes attractive to customers who operate off-grid, partially or totally.

With the expected tariff increase for grid electricity, the business case is expected to improve for on-grid customers. However, it is difficult to estimate the size of this tariff increase since the government's position differs from the conclusion of the COSS (see Section 3.6).

1 Detailed computation: (19/24)*0.03+(5/24)*0.50 = 0.13.

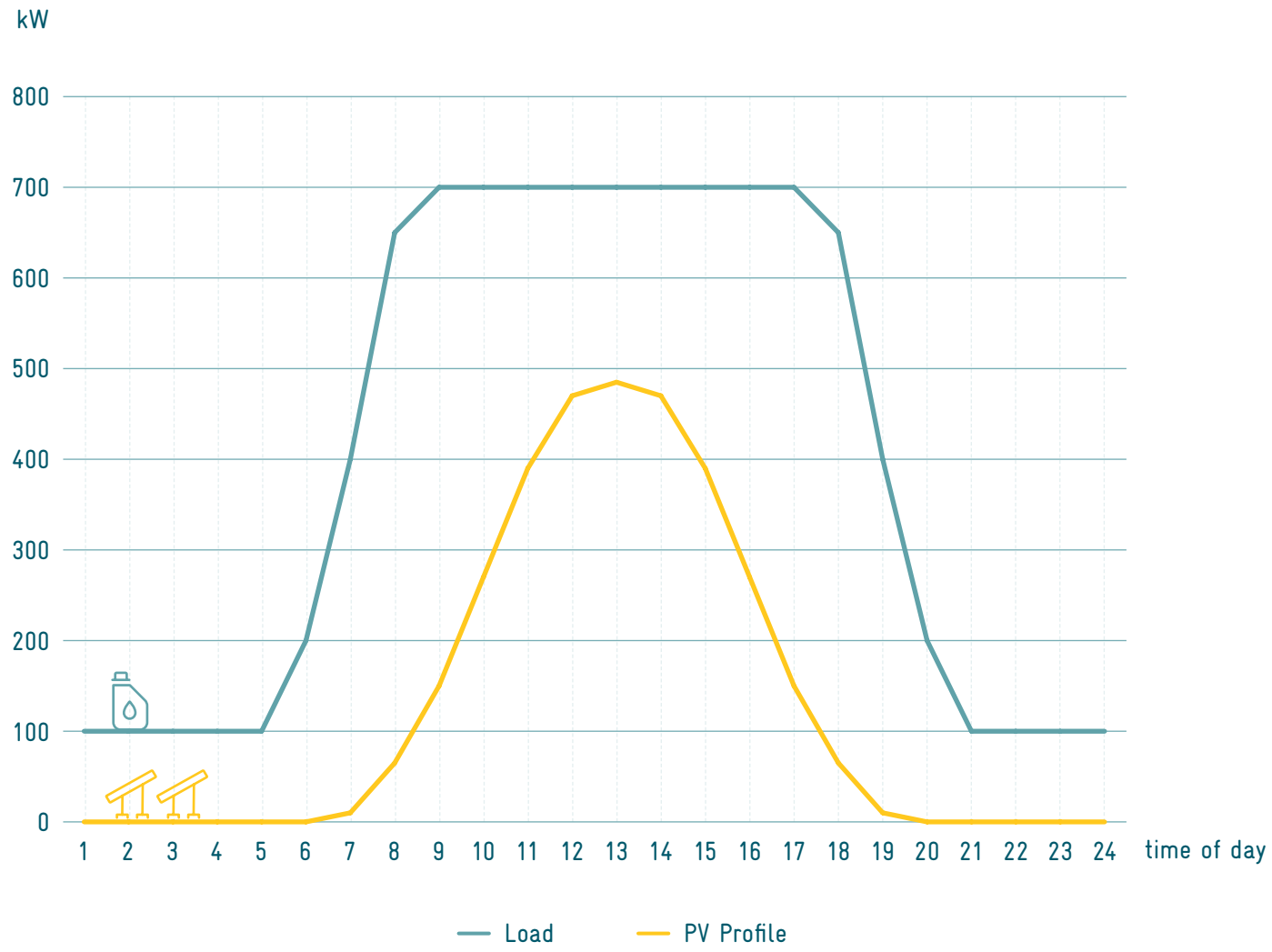
5.5.1.2 PHOTOVOLTAICS WITH STORAGE

An important assumption used in the previous section is that 100% of the solar production can be consumed or that full net metering is applicable. In the case of operation with a diesel generator, this, however, greatly limits the potential size of the PV system because safe operation of the diesel generator usually implies maintaining a minimum load of typically 30% on this generator. This means that the peak production of the PV system, at midday, can only correspond to maximum 70% of the load.

As such, including battery storage in the system will increase the total cost, but will allow the size of the PV system to be increased since PV surplus during the day can be used in the evening or at night.

If we assume that the battery energy storage system (BESS) will cycle once per day for 10 years, we can consider that each kWh of storage capacity will be able to store 3,650 kWh. The unit CAPEX for battery storage can vary quite a lot depending on several factors: system size, features of the converter, chemistry of batteries, country of the manufacturer, maturity of the market, etc. Battery costs increased for the first time in 2022 (Bloomberg New Energy Finance, 2022), but should decrease again in the coming years. With these uncertainties, and based on interviews with BESS suppliers and installers, we assume a relatively wide range of prices for BESS in

FIGURE 15. Maximum PV penetration for operation with diesel generator



Source: Authors' own illustration, Integration (2022)

Zambia, between USD 500/kWh and USD 1,000/kWh. With 3,650 kWh stored during the lifetime of the system, we can compute a cost of storage of USD 0.14/kWh and USD 0.27/kWh. This simple computation, which does not consider a discount rate nor cycling losses, shows that battery storage is only appealing to customers with a high electricity cost, mostly those operating totally off-grid.

5.5.1.3 PEAK SHAVING

Commercial and industrial customers in Zambia are also subject to peak charges, which are called maximum demand charges, in USD/kVA. For these customers, automated meter reading is performed with 30-minute values, and the highest value of the month is used to compute the maximum demand charge (for three time-of-use periods, see Section 3.5).

For the purpose of this analysis, we consider three maximum demand tariffs:

- USD 3/kVA per month (corresponding to a customer with a grid connection between 16 kVA and 300 kVA),
- USD 6/kVA per month (corresponding to a customer with a grid connection between 7.5 MVA and 25 MVA), and
- USD 15/kVA per month. The last value corresponds to the tariff value that would provide an acceptable payback time for battery storage (at USD 1,000/kWh) of ~5 years.

It is possible that some Zambian customers have a bilateral contract with ZESCO or CEC that is not based on the official tariffs and includes a higher maximum demand charge. It is also possible that the official tariffs will increase in the future.

TABLE 4. Results of the business case for peak shaving

CURRENT ELECTRICITY PRICE	BESS PAYBACK TIME (SIMPLE)
USD 3/kVA per month	27 years
USD 6/kVA per month	14 years
USD 15/kVA per month	5 years

Source: Authors' own illustration, Integration (2022)

In this case, we assume that a 1-hour battery will be able to shave peaks of 30 minutes to 1 hour, at the same turnkey cost of USD 1,000/kWh. The validity of this assumption is highly dependent on the customer's load profile since longer peaks would require larger batteries with higher CAPEX. This business model also bears a high risk: the BESS has to be highly efficient at peak shaving, with very high availability, because one peak per month is enough to greatly impact the electricity bill.

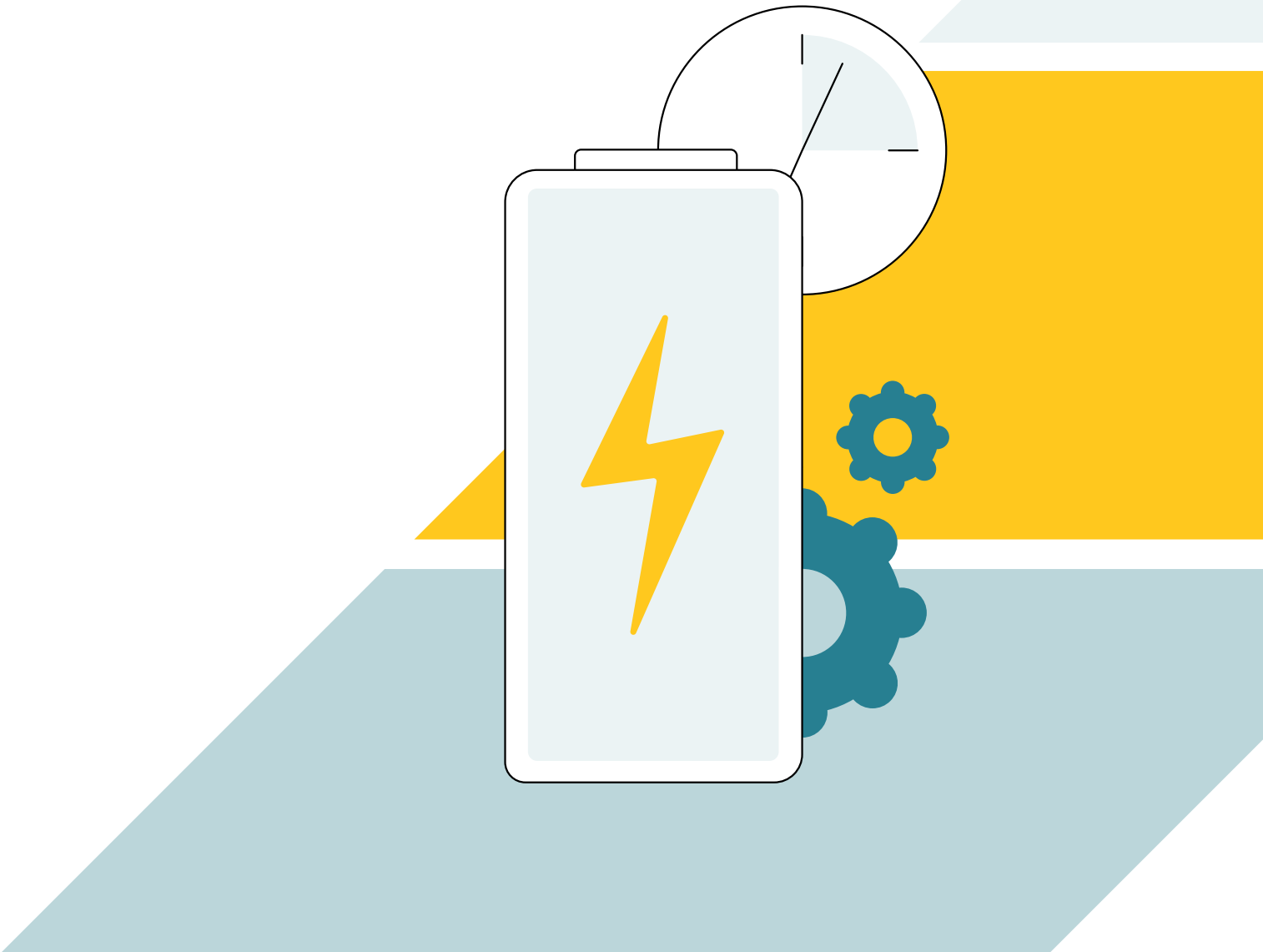
For these reasons, it is likely that the application of peak shaving will be unreasonable in Zambia as a standalone business model, but, as a bonus, could be combined with another BESS application.

5.5.1.4 CRITICAL BACK-UP AND POWER QUALITY

Other applications of BESS include critical back-up (e.g. UPS) and power quality applications. Even though load shedding has been reduced in Zambia in recent years, it does not mean that the quality of the available power is sufficient, especially for sensitive applications or equipment. It is difficult to quantify the economic benefit of these applications, as they will vary considerably from customer to customer or depend on the sensitivity of equipment to power quality. Customers looking for power reliability solutions are also more likely to favour European or German solutions, even if they may be more expensive than alternatives.

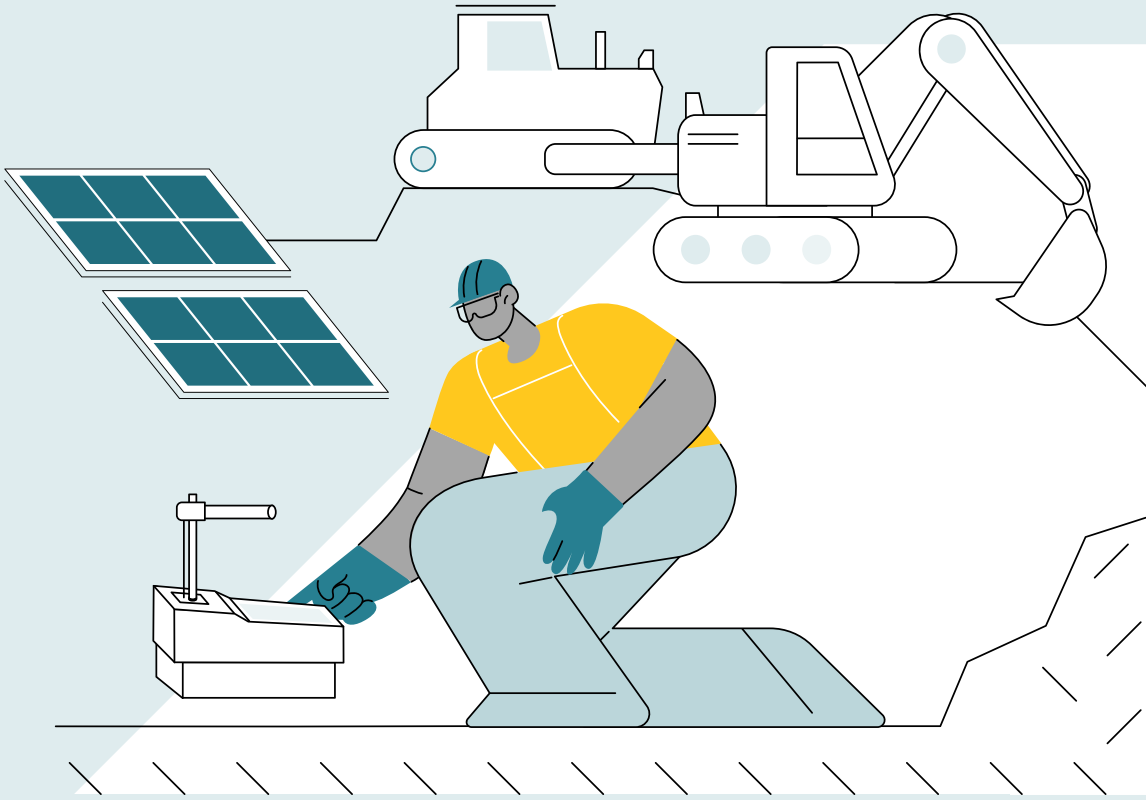
5.5.2 Business models

The main requirement for installing a RE/ESS system is to apply and obtain licences from the ERB (construction and generation licences). According to this regulation, there is no restriction on the ownership model, therefore it is possible for the customer to be the owner of the system or to call upon a third party for financing, be this in a lease or electricity sale agreement.



6

Market entry strategies and risks in selected sectors



6.1 Sector 1 – Mining

6.1.1 Overview of the sector

Mining has been the main driver of Zambia's economy, contributing about 12% to the Gross Domestic Product (GDP) (ZamStats, 2022) and generating at least 70% of foreign exchange earnings, which accounts for a large share of foreign direct investments (FDIs) as well as a considerable amount of government revenue through mineral royalty tax (MRT) and VAT. It also accounts for 8% of formal employment (Mr Paul Kabuswe, Minister of Mines and Minerals Development).

The main copper mining region in Zambia is the Copperbelt Province, whose main cities are Kitwe and Ndola (which are Zambia's second and third largest cities, respectively). There are also mining activities extending into the North-Western Province. The largest copper mines in the country are Kansanshi, Konkola, Lumwana, Sentinel and Mufulira. Konkola and Mufulira mines are located in the Copperbelt Province while Kansanshi, Lumwana and Sentinel mines are located in the North-Western Province. Whilst copper mining is the most dominant, there are other mining activities: cobalt, manganese, gold and a variety of gemstones (including emeralds). Mining activities are anchored by downstream activities such as concentrating, smelting and refining.

6.1.2 Specific RE/ESS applications

A typical application for energy storage in the mining sector is the displacement of diesel for mines operating off-grid. This is even more true for remote mines, where transportation costs can cause a significant increase in the cost of diesel delivered on site. In this case, solar photovoltaics can provide substantial savings but requires storage to achieve high solar penetration (see Section 5.5.1.2).

Most mines in Zambia are connected to the grid and use diesel generation as back-up, but only occasionally. The large mines hold bilateral power purchase contracts with ZESCO or CEC for which the applied tariffs are confidential, but there are several indications that some of these consumers might be subject to higher tariffs than the official ZESCO tariffs.

Lastly, the mining sector is Zambia's biggest electricity consumer, with several mines having a peak load above 100 MW. This makes mining the sector of choice for large-scale C&I projects.

6.2 Sector 2 – Telecom

6.2.1 Overview of the sector

The telecommunications sector was liberalised in 1994 and comprises the public switched telephone network (PSTN), international voice, local loop, national voice, mobile, private data networks and internet service providers (ISPs). Whilst the others are competitive subsectors, international voice and the PSTN are monopolistic, and while the telecom market revenue accounts for an average of 2% of GDP, the sector's tax and fee payments account for around 5% of total government fiscal revenue (ZICTA, 2022). This implies that the sector's overall tax and non-tax revenue contribution is more than double its relative size in the Zambian economy.

Following regulatory changes to the licensing framework, there has been an increase in operators: as of November 2022, there were a total of 82 valid licences in the telecom sector. Currently, there are three (3) mobile network operators (MNOs). The fourth and newly-licensed operator was launched in January 2023 and is scheduled to commence operations in July 2023. Furthermore, there are two (2) operators in the telecom infrastructure space (towers), IHS Towers and Infratel Zambia Limited, at least 23 ISPs and, according to the regulator, there were 11,903 operational telecommunication sites and 3,417 telecommunication towers across the country as of November 2022.

6.2.2 Specific RE/ESS applications

The telecom sector has been implementing projects combining photovoltaics and battery storage in recent years, and there are several tenders ongoing in the sector to further develop these kinds of projects.

The typical project includes small systems, in the order of 5 kVA, but on tens of sites. The main application is the power supply to base transceiver stations (BTS), the main component of mobile networks. The BTS can either be connected to the ZESCO grid (in which case the solar system with storage provides back-up), or located off-grid in remote areas. These projects usually use DC systems.

6.3 Sector 3 – Agriculture

6.3.1 Overview of the sector

Agriculture contributes about 19% to Zambia's GDP and employs at least 75% of the population (ZamStats, 2022). Domestic production comprises crops such as maize, sorghum, millet and cassava, while exports are largely driven by sugar, soya beans, coffee, groundnut, rice and cotton as well as floriculture and horticulture. Agriculture in Zambia is mostly rainfed with a few irrigation facilities in commercial establishments. Livestock production is mainly effected in the Central, Southern and Western Provinces. While agro-processing facilities are mostly located in the Lusaka and Copperbelt Provinces, there are a few in the Central, Eastern, Luapula, Northern and Southern Provinces. This includes peanut butter processing, cashew nut processing, animal and stockfeed production, cassava production, grain milling (such as maize, wheat, rice, etc.), edible oil production, fruit canning and juice production, meat, dairy and leather processing, fish canning and fish meal production, cotton spinning and textiles, bio-diesel and ethanol production and honey and beeswax processing.

Region 2 of the country includes much of central Zambia (most of the Central, Eastern, Lusaka and Southern Provinces). It contains the most fertile soils and most of the country's commercial farms. Annual rainfall in Region 2 averages 800-1,000 mm and the growing season is 100-140 days long.

6.3.2 Specific RE/ESS applications

Power-consuming applications include water pumping and food processing. Water pumping can be efficiently combined with solar energy, but it is often more cost efficient to store the pumped water rather than to store electricity. If the activities also include food processing, then energy consumption can become quite high, with high energy-consuming appliances such as mills or boilers. These sites can often provide large spaces for ground-mounted photovoltaics, although this reduces the land available for agriculture. For battery storage, the focus should be on companies operating off-grid in remote areas, or in a weak grid environment.

It is also important to mention that many companies can also benefit from processing waste that can be burned in biomass systems to produce electricity and heat.

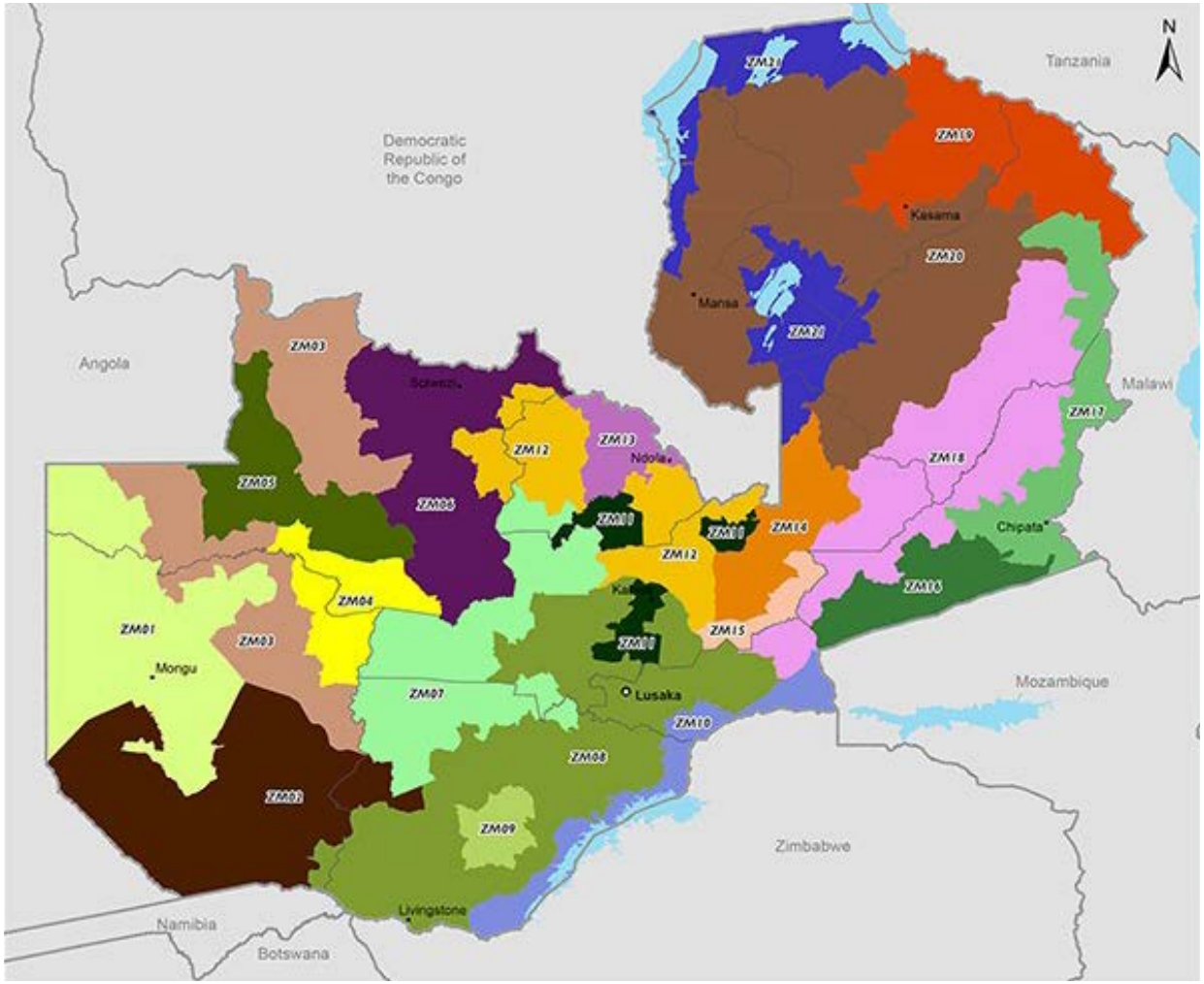
6.4 Sector 4 – Manufacturing

6.4.1 Overview of the sector

The manufacturing sector accounts for nearly 8% of the GDP. It has been consistently growing due to sustained investments in the sector and a general improvement in the business environment. The 2020 Labour Force Survey states that the manufacturing sector accounts for 27% of formal employment in Zambia.

Manufacturing industries (including agro-processing industries discussed above) are mainly located in the Lusaka and Copperbelt Provinces. Scattered operations are located in the Central, Eastern, Luapula, Northern and Southern Provinces. The main contributors to the manufacturing sector are: engineering, textiles and garments, wood and wood products, building materials, processed foods, chemicals and pharmaceuticals, leather and leather products, rubber, plastic, paper and paper products, tobacco, basic metal and non-metallic mineral products and handicrafts.

FIGURE 16. Map of agricultural areas



ZM01 – Zambezi Plain Rice, Livestock, and Fishing
ZM02 – Southwestern Cereal, Livestock, and Timber
ZM03 – Western and Northwestern Cassava, Maize, and Cattle
ZM04 – Kaoma Smallholder Food Crop and Tobacco
ZM05 – Northwestern Timber and Honey
ZM06 – Solwezi and Kasempa Mining Labor and Agriculture
ZM07 – Kalue Plain Maize, Cattle, and Fishing
ZM08 – Commercial Rail Line Maize, Livestock, and Cotton
ZM09 – Southern Plateau Cattle, Maize, and Tobacco
ZM10 – Zambezi Valley Agro-Fisheries
ZM11 – Mkushi, Chisamba, and Mpongwe Commercial Farming Block
ZM12 – Central Copperbelt Maize, Cassava, and Sweet Potato
ZM13 – Copperbelt Labor and Trade
ZM14 – Mkushi and Serenje Maize, Sweet Potato, and Horticulture
ZM15 – Luangwa Valley Informal Mining, Fishing, and Hunting
ZM16 – Eastern Plateau Maize, Cotton, and Groundnut
ZM17 – Eastern Plateau Maize, Groundnut, Tobacco, and Trade
ZM18 – Luangwa Valley Subsistence Farming, Hunting, and Tourism
ZM19 – Northern Border Maize, Beans, Livestock, and Trade
ZM20 – Muchinga, Northern, and Luapula Cassava, Groundnut, and Millet
ZM21 – Mweru, Bangweulu, and Tanganyika, Fisheries

Source: (FEWS, 2014)

6.4.2 Specific RE/ESS applications

With manufacturing activities mostly located in the Lusaka and Copperbelt Provinces, this means that most factories are connected to the public grid and benefit from a relatively reliable power supply. However, many of these processes involve the use of sensitive machinery that may get damaged during power outages and for which diesel back-up is required together with short-term battery storage (uninterruptible power supply – UPS). In some cases, hybrid projects can be considered where the battery storage is used to both store excess renewable energy production and to provide UPS services.

6.5 Sector 5 – Tourism

6.5.1 Overview of the sector

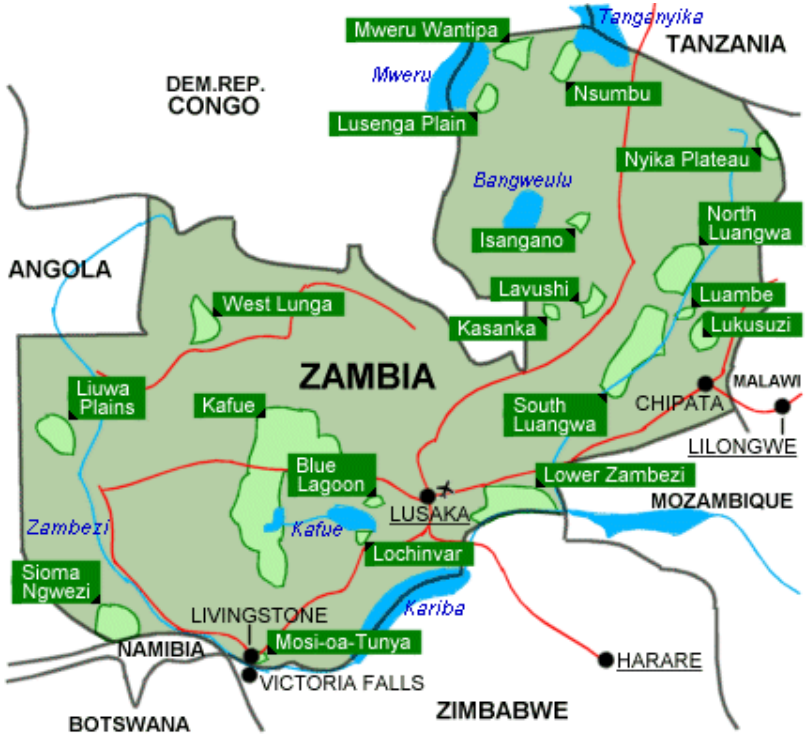
The tourism sector contributes about 7% to Zambia's GDP, approximately 10% of total exports, 7% of government revenue and at least 7% of formal sector employment (ZamStats, 2022). The tourism sector is largely based on foreign tourists coming into Zambia (domestic tourism is yet to take off, develop and grow). Tourism enterprises include hotels, lodges and guesthouses, tour operators, restaurants, night clubs, travel agents and transport providers.

The bulk of tourism activities relates to nature-based tourism and these include Victoria Falls, various national parks around the country (such as the Lower Zambezi National Park (LZNP), Kafue National Park (KNP), South Luangwa National Park (SLNP), North Luangwa National Park (NLNP) and Lochinvar National Park (LNP)), etc. The various tourism sites are located in different parts of the country: including the Southern, Eastern and Northern Provinces.

6.5.2 Specific RE/ESS applications

Since most tourist activities are nature-based, it means that many hotels and lodges are located in remote areas, often operating off-grid. When facilities provide simple energy services, such as lighting or refrigeration, they can be equipped with a small solar system (~10 kVA). Larger or more premium facilities will have higher energy needs, such as air-conditioning, pool heaters or spas, and may be good candidates for large-scale renewable energy and/or storage projects.

FIGURE 17. Map of tourist areas



Source: (High Commission of the Republic of Zambia – Pretoria, 2022)

7

Conclusion

This sector analysis has given an overview of the Zambian context with key information on geography, politics, economy and energy. It illustrates the potential and business cases for RE and ESS but also the risks that should be taken into account before implementing a RE and ESS project.

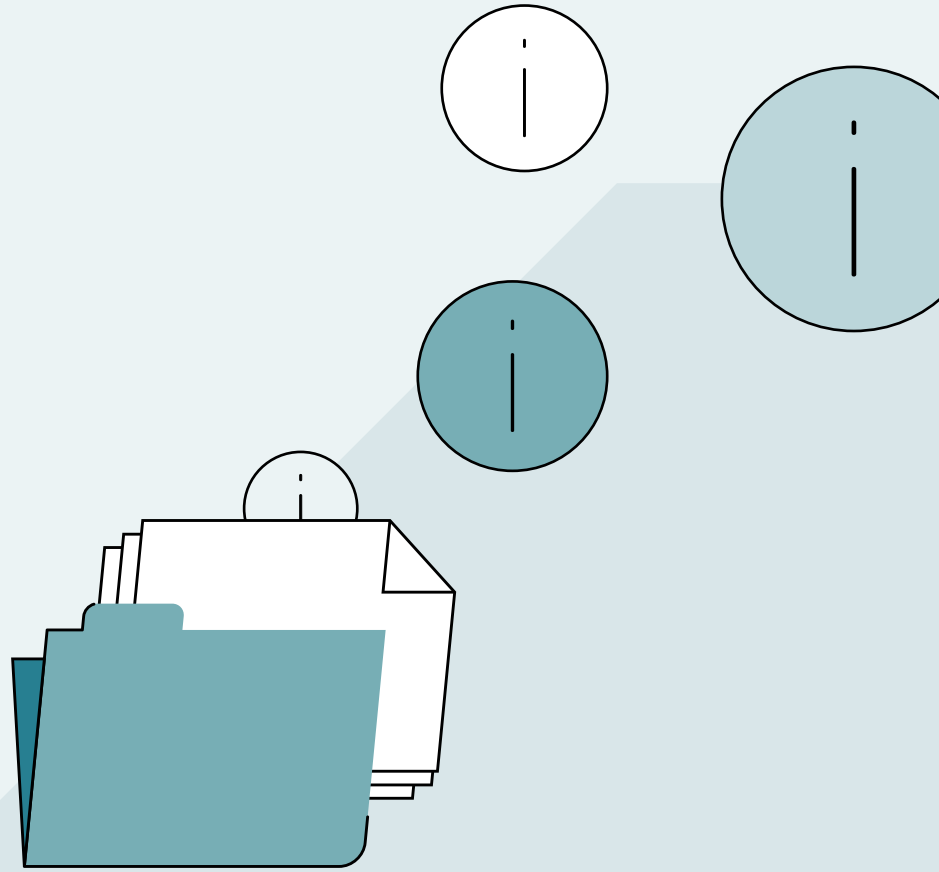
The electricity sector is undergoing a lot of changes, with an improvement in energy supply in recent years, but still a lot of work ahead in securing sufficient production (especially in the face of climate change and the risk of drought, given the high dependency on hydropower) and in improving the electrification rate, where Zambia is still lagging behind. Some regulatory developments like the new draft Net-Metering Regulations or the prospect of new, cost-reflective electricity tariffs were presented but their conclusion is not expected until several months from now.

With only about 90 MWp of installed capacity in solar photovoltaics, and even with the government target of 600 MW by 2030 (for solar and wind), Zambia's excellent solar potential is still greatly underutilised. If solar energy follows the same exponential growth in Zambia as in other countries, the need for energy storage will soon materialise on a large scale.

At present, the best business cases for energy storage are complementary to the electricity grid, as a back-up or to improve power quality, or for off-grid energy uses, for example, in remote areas.

Specific applications are relevant to the different Zambian industrial sectors. Mining is the sector with the biggest customers able to implement large multi-megawatt projects. At the other end of the spectrum, remote tourism and telecom towers mostly exhibit small-scale applications (kW-scale), with many projects already commissioned. And finally, the remaining industrial sector, with manufacturing or food processing, among others, is in-between with 100 kW to 1 MW projects.

Annexes



Annex 1 List of German companies registered and operating in Zambia

TABLE 5. List of German companies registered and operating in Zambia

NAME OF COMPANY	SECTOR OR ACTIVITY
AB Bank Zambia Limited	Banking and finance
Achelis & Sohne (Achelis Zambia Limited)	Public procurement
Action Auto Zambia	Authorised dealer and retailer of Opel, Isuzu and Chevrolet motor vehicles in Zambia
Amatheon Agri Zambia Limited	Agriculture
BASF Zambia Limited	Agriculture, construction and mining
Bayer (Proprietary) Limited	Agriculture
BHBW Zambia Limited	Agriculture equipment, parts and service
CC Systems	Sales and service of digital multi-functional photocopy machines, printers, copiers, communication systems and equipment, VSAT systems and solar power systems
Debbefeld Meat Merchants	Meat processing and outdoor catering services
Drake & Gorham (Zambia) Limited	Air conditioning, refrigeration, ventilation, lifts and escalators
Doneka	Renewable energy
Ger.d	German dentist providing services in Lusaka
Handwerkskammer Frankfurt-Rhein-Main	Skills development project with the Chamber of Commerce – ZACCI
BG Gauff Ingenieure (Gauff Consultants)	Engineering services
KfW Development Bank	Development finance
Liebherr Zambia Limited	Mining
Majoru Investments Limited	Supply of fresh and processed meat: slaughter, processing and distribution of beef, pork and lamb products
MiBa Solutions Limited	Aerial pictures, IT consultancy services, 3D design and printing
Munich Advisors Group	Consultancy services: strategic planning, project management, emerging technologies in renewable energy, etc.
Sandy Beach Safari Lodge	Accommodation, food and beverage services
Shazula Cultural Forum	Art, intercultural education and creative tourism
Southern African-German Chamber of Commerce and Industry (AHK)	Chamber of Commerce, various business services, market entry consultations, networking. The AHK has an energy competence centre and is part of the German Energy Solutions Initiative.
Southern BioPower Limited	Renewable energy, biogas-based waste management, consultancy
Thyssenkrupp Industrial Solutions (Africa) (Proprietary) Limited	Mineral processing, power and energy, cement processing, process technologies, capacity-building services
Tukumuka Consulting Limited	Management consulting services to Zambian SMEs
World Wide Help Africa	Retreat and conference facilities, food and beverage services
Zambian-German Agricultural Knowledge & Training Centre	Agriculture

Source: (German Business Circle in Zambia, sd)

Annex 2 List of licensed generation units

TABLE 6. List of licensed generation units

ORGANISATION	NAME OF FACILITY OR PROJECT	SOURCE OF ENERGY	INSTALLED CAPACITY
ZESCO Limited	Kafue Gorge Upper	Hydro	990.0
	Kariba North Bank	Hydro	720.0
	Kariba North Bank Extension	Hydro	360.0
	Victoria Falls	Hydro	108.0
	Lunzua River	Hydro	14.8
	Lusiwasi Lower	Hydro	12.0
	Chishimba Falls	Hydro	6.0
	Musonda Falls	Hydro	10.0
	Shiwang'andu	Hydro	1.0
	Lusiwasi upper	Hydro	6.0
	Kafue Gorge Lower	Hydro	300.0
Itezhi Tezhi Power Corporation	Itezhi-Tezhi	Hydro	120.0
Zengamina Power Limited	Zengamina – Ikelengi	Hydro	0.75
Lunsemfwa Hydro Power Company	Mulungushi	Hydro	30.8
	Lunsemfwa	Hydro	23.2
		Total	2,702.50

ORGANISATION	NAME OF FACILITY OR PROJECT	SOURCE OF ENERGY	INSTALLED CAPACITY
Maamba Collieries Limited	Maamba Power Plant	Coal	300.00
Dangote Cement Zambia Limited	Dangote Thermal Power Plant	Coal	30.00
		Total	330.00

ORGANISATION	NAME OF FACILITY OR PROJECT	SOURCE OF ENERGY	INSTALLED CAPACITY
Copperbelt Energy Corporation Generation Plants	Luano	Diesel	40.00
	Bancroft	Diesel	20.00
	Kankoyo	Diesel	10.00
	Maclaren	Diesel	10.00
ZESCO Limited Diesel Generation Plants	Shang'ombo	Diesel	1.60
	Lundazi	Diesel	1.75
	Chama	Diesel	1.45
		Total	84.80

ORGANISATION	NAME OF FACILITY OR PROJECT	SOURCE OF ENERGY	INSTALLED CAPACITY
Ndola Energy Generation Plants	Ndola	Heavy Fuel Oil	110.00
		Total	110.00

ORGANISATION	NAME OF FACILITY OR PROJECT	SOURCE OF ENERGY	INSTALLED CAPACITY
Copperbelt Energy Corporation	Kitwe	Solar	1.00
Muhanya Solar Limited	Sinda Village	Solar	0.03
Ngonye Power Company Limited	LSMFEZ	Solar	34.00
Bangweulu Power Company Ltd	LSMFEZ	Solar	54.30
Solera Power Vending Machine	Luangwa bridge	Solar	0.0125
	Taferansoni (Chadiza)	Solar	0.025
	Kacholola (Nyimba)	Solar	0.015
	Ken (Katete)	Solar	0.025
	Kapasa (Chipangali)	Solar	0.025
	Chanyalubwe (Lundazi)	Solar	0.025
	Chikomeni (Lumezi)	Solar	0.015
	Madzi a Tuwa (Lumezi)	Solar	0.025
Chibwika Chiefdom Development Trust	Chibwika (Mwinilunga)	Solar	0.0324
Katamanda	Katamanda (Chipangali	Solar	0.06
Standard Micro-grid	Sioma	Solar	0.01
	Kafue	Solar	0.02
Mugurameno	Chirundu	Solar	0.014
Engie Power	Chitandika	Solar	0.02835
		Total	90.32
		Grand Total	3,319.62

Source: Authors' own compilation, Integration (2022), based on (ERB, 2022)

Annex 3 Map of the Zambian electricity grid

FIGURE 18. Map of the Zambian electricity grid

Source: (Sisla, 2008)

Annex 4 List of SAPP members

TABLE 7. List of SAPP members

Botswana Power Corporation	BPC	Botswana
Electricidade de Mozambique	EDM	Mozambique
Electricity Supply Corporation of Malawi	ESCOM	Malawi
Rede Nacional de Transporte de Electricidade	RNT	Angola
Eskom	Eskom	South Africa
Hidroelectrica de Cahora Bassa	HCB	Mozambique
Lesotho Electricity Corporation	LEC	Lesotho
Mozambique Transmission Company	MOTRACO	Mozambique
Nam Power	Nam Power	Namibia
Societe Nationale d'Electricite	SNEL	DRC
Eswatini Electricity Company	EEC	Swaziland
Tanzania Electricity Supply Company Ltd	TANESCO	Tanzania
ZESCO Limited	ZESCO	Zambia
Copperbelt Energy Cooperation	CEC	Zambia
Lunsemfwa Hydro Power Company	LHPC	Zambia
Zimbabwe Electricity Supply Authority	ZESA	Zimbabwe
Ndola Energy Corporation Limited	Ndola	Zambia
Africa GreenCo Power Services Limited*	Africa GreenCo	Zambia

*Africa GreenCo is a recent member of SAPP but not yet listed on the SAPP website (source: interview with Africa GreenCo, 2022).

Source: (SAPP, sd)

Annex 5 Official ZESCO tariffs

TABLE 8. Official ZESCO tariffs

CUSTOMER CATEGORY	TARIFF COMPONENTS	CURRENT TARIFF	APPROVED TARIFFS EFFECTIVE 1ST JANUARY 2020
1. METERED RESIDENTIAL (Prepaid) (capacity 15 kVA)			
R1 – Consumption from 1 - 100 kWh in a month	Energy charge/kWh	0.15	0.47
R2 – Consumption between 101kWh - 300 kWh in a month	Energy charge/kWh	0.89	0.85
R3 – Consumption above 300kWh	Energy charge/kWh	Nil	1.94
	Fixed Monthly Charge	18.23	Abolished
2. Commercial Tariffs (capacity 15kVA)			
C1 – Consumption up to 200kWh	Energy charge/kWh	0.54	1.07
C2 – Consumption above 200kWh	Energy charge/kWh	Nil	1.85
	Fixed Monthly Charge	96.41	Abolished
3. Social Services			
Schools, Hospital, Orphanages, churches, water pumping & street lighting	Energy charge K/kWh	0.49	1.19
	Fixed Monthly Charge	83.84	203.73
4. Maximum Demand Tariffs			
MD1- Capacity between 16 - 300 kVA	MD Charge (K/kVA/Month)	24.45	42.79
	Energy Charge (K/kWh)	0.35	0.61
	Fixed Monthly Charge (K/Month)	239.44	419.02
	Off Peak MD Charge (K/KVA/Month)	12.22	21.39
	Off Peak Energy Charge (K/kWh)	0.26	0.46
	Peak MD Charge (K/KVA/Month)	30.56	53.48
	Peak Energy Charge (K/kWh)	0.44	0.77
MD2- Capacity 301 to 2,000 kVA	MD Charge (K/kVA/Month)	45.73	80.03
	Energy Charge (K/kWh)	0.3	0.53
	Fixed Monthly Charge (K/Month)	478.84	837.97
	Off Peak MD Charge (K/KVA/Month)	22.87	40.01
	Off Peak Energy Charge (K/kWh)	0.23	0.39
	Peak MD Charge (K/KVAMonth)	57.17	100.03
	Peak Energy Charge (K/kWh)	0.37	0.66

Source: (Energy Regulation Board, 2021)

CUSTOMER CATEGORY	TARIFF COMPONENTS	CURRENT TARIFF	APPROVED TARIFFS EFFECTIVE 1ST JANUARY 2020
MD3- Capacity 2,001 to 7,500kVA	MD Charge (K/kVA/Month)	73.06	126.39
	Energy Charge (K/kWh)	0.25	0.43
	Fixed Monthly Charge (K/Month)	1,014.55	1,755.17
	Off Peak MD Charge (K/KVA/Month)	36.52	63.2
	Off Peak Energy Charge (K/kWh)	0.18	0.32
	Peak MD Charge (K/KVA/Month)	91.33	157.99
	Peak Energy Charge (K/kWh)	0.3	0.54
MD4-Capacity 7500kVA to 25,000 kVA	MD Charge (K/kVA/Month)	73.47	127.39
	Energy Charge (K/kWh)	0.21	0.36
	Fixed Monthly Charge (K/Month)	2,029.13	3,510.39
	Off Peak MD Charge (K/KVA/Month)	36.73	63.55
	Off Peak Energy Charge (K/kWh)	0.16	0.27
	Peak MD Charge (K/KVA/Month)	91.84	158.88
	Peak Energy Charge (K/kWh)	0.25	0.45
Bulk Distributors tariff (Purchasers of Power for distribution)	Maximum Demand customers - MD Charge/KVA/month	Nil	58.6
	Retail customers – Energy charge / kWh	Nil	0.49

NOTE:
The above tariffs are:
1. Exclusive of 3% Government excise duty
2. Exclusive of 16% Value Added Tax (VAT)

Source: (Energy Regulation Board, 2021)

Annex 6 Tariffs proposed in the COSS

TABLE 9. Tariffs proposed in the COSS

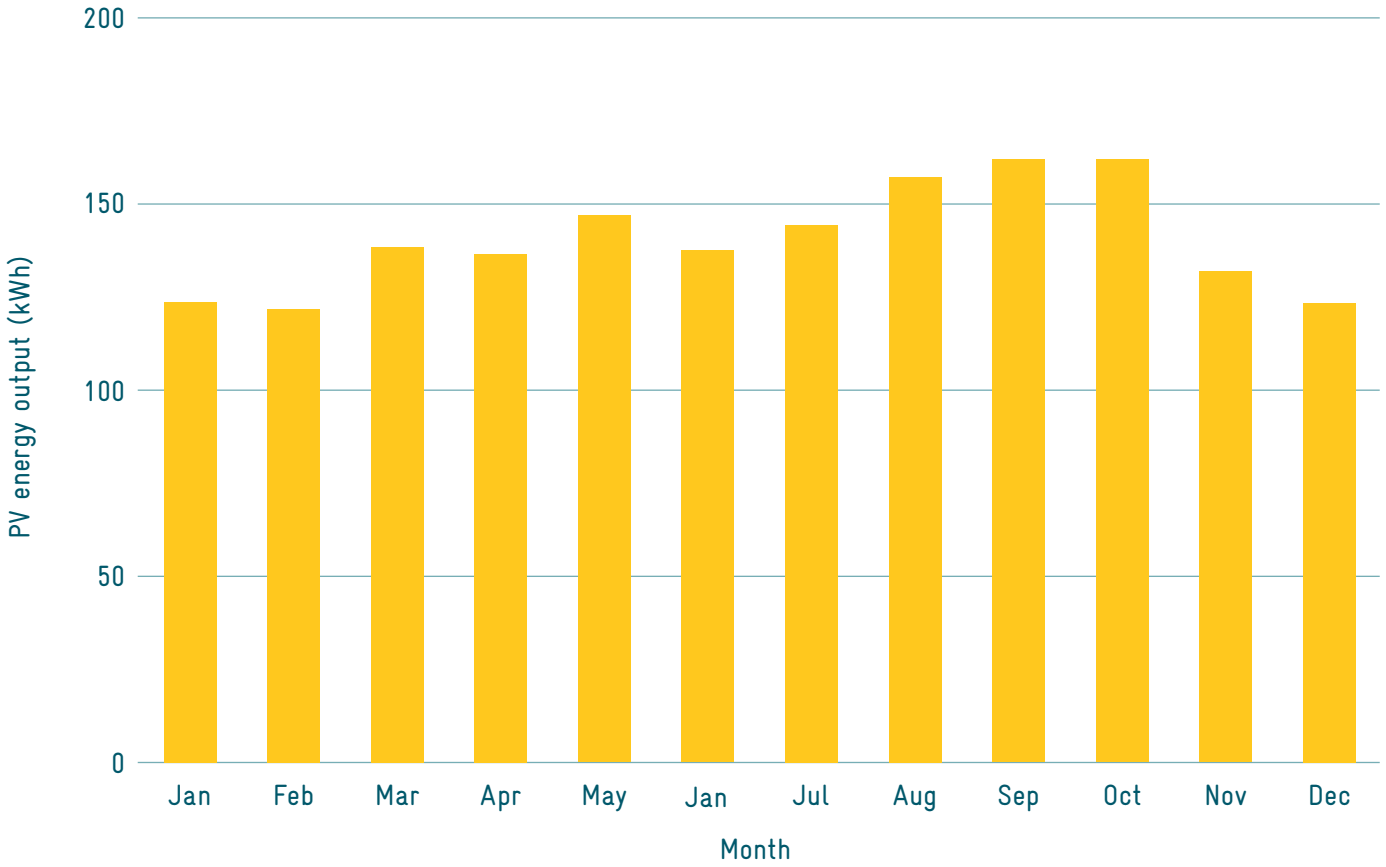
CUSTOMER CATEGORY	TARIFF COMPONENTS	CURRENT TARIFF	AVERAGE LEVELIZED COST REFLECTIVE TARIFFS	DIFF	DIFF (%)
1. METERED RESIDENTIAL (Prepaid)					
R1 – Consumption from 1 - 100 kWh in a month	Energy charge/kWh	0.47	1.15	0.68	144%
R2 – Consumption between 101kWh - 300 kWh in a month	Energy charge/kWh	0.85	2.05	1.20	141%
R3 – Consumption above 300kWh	Energy charge/kWh	1.94	4.37	2.43	125%
2. Commercial Tariffs (capacity 15kVA)					
C1 – Consumption up to 200kWh	Energy charge/kWh	1.07	1.75	0.68	63%
C2 – Consumption above 200kWh	Energy charge/kWh	1.85	3.00	1.15	62%
3. Social Services					
Schools, Hospital, Orphanages, churches, water pumping & street lighting	Energy charge K/kWh	1.19	2.13	0.94	79%
	Fixed Monthly Charge	203.73	197.66	(6.07)	-3%
4. Maximum Demand Tariffs					
MD1- Capacity between 16 - 300 kVA	MD Charge (K/kVA/Month)	42.79	65.05	22.26	52%
	Energy Charge (K/kWh)	0.61	0.12	(0.49)	-80%
	Fixed Monthly Charge (K/Month)	419.02	406.89	(12.13)	-3%
	Off Peak MD Charge (K/KVA/Month)	21.39	21.13	(0.26)	-1%
	Off Peak Energy Charge (K/kWh)	0.46	0.12	(0.34)	-74%
	Peak MD Charge (K/KVA/Month)	53.48	222.40	168.92	316%
	Peak Energy Charge (K/kWh)	0.77	0.12	(0.65)	-84%

CUSTOMER CATEGORY	TARIFF COMPONENTS	CURRENT TARIFF	AVERAGE LEVELIZED COST REFLECTIVE TARIFFS	DIFF	DIFF (%)
MD2- Capacity 301 to 2,000 kVA	MD Charge (K/kVA/Month)	80.03	80.77	0.74	1%
	Energy Charge (K/kWh)	0.53	0.12	(0.41)	-78%
	Fixed Monthly Charge (K/Month)	837.97	813.39	(24.58)	-3%
	Off Peak MD Charge (K/KVA/Month)	40.01	22.02	(17.99)	-45%
	Off Peak Energy Charge (K/kWh)	0.39	0.12	(0.27)	-70%
	Peak MD Charge (K/KVAMonth)	100.03	249.13	149.10	149%
	Peak Energy Charge (K/kWh)	0.66	0.12	(0.54)	-82%
MD3- Capacity 2,001 to 7,500kVA	MD Charge (K/kVA/Month)	126.39	89.62	(36.77)	-29%
	Energy Charge (K/kWh)	0.43	0.12	(0.31)	-72%
	Fixed Monthly Charge (K/Month)	1,755.17	1,703.73	(51.44)	-3%
	Off Peak MD Charge (K/KVA/Month)	63.20	29.95	(33.25)	-53%
	Off Peak Energy Charge (K/kWh)	0.32	0.12	(0.20)	-63%
	Peak MD Charge (K/KVA/Month)	157.99	301.42	143.43	91%
	Peak Energy Charge (K/kWh)	0.54	0.12	(0.42)	-78%
MD4-Capacity 7500kVA to 25,000 kVA	MD Charge (K/kVA/Month)	127.39	88.97	(38.42)	-30%
	Energy Charge (K/kWh)	0.36	0.12	(0.24)	-67%
	Fixed Monthly Charge (K/Month)	3,510.39	3,407.51	(102.88)	-3%
	Off Peak MD Charge (K/KVA/Month)	63.55	31.41	(32.14)	-51%
	Off Peak Energy Charge (K/kWh)	0.27	0.12	(0.15)	-56%
	Peak MD Charge (K/KVA/Month)	158.88	317.79	158.91	100%
	Peak Energy Charge (K/kWh)	0.45	0.12	(0.33)	-74%
Distributors tariffs	Demand charge (k/kW/Month)	58.60	394.56	335.96	573%
	Energy (k/kWh)	0.49	0.12	(0.37)	-76%

Source: (Energy Market and Regulatory Consultants Limited, 2021)

Annex 7 Monthly distribution of PV production in Zambia

FIGURE 19. Monthly distribution of PV production in Zambia



Source: (PV GIS, European Comission, sd)

Annex 8 Travel time between major Zambian cities

TABLE 10. Travel time between major Zambian cities in hours

	LUSAKA	NDOLA	SOLWESI	CHIRUNDU	CHIPATA	LIVINGSTONE	MBALA	MWINILUNGA
LUSAKA		4	8	1.5	6	5	10	15
NDOLA	4		4	6	10	9	14	9
SOLWESI	8	4		9.5	14	13	18	5
CHIRUNDU	1.5	6	9.5		7.5	5	11.5	14.5
CHIPATA	6	10	14	7.5		11	15	19
LIVINGSTONE	5	9	13	5	11		15	18
MBALA	10	14	18	11.5	15	15		23
MWINILUNGA	15	9	5	14.5	19	18	23	

Source: (Logistics Capacity Assessment, sd)

Annex 9 List of customs duty and VAT exemptions

TABLE 11. List of customs duty and VAT exemptions

ENERGY-RELATED EQUIPMENT/SOLAR PRODUCT	COMPONENT	CUSTOMS DUTY (%)	VAT (%)
Solar lantern (integrated kit)	Solar panels	–	–
	LED lighting	–	–
	Lithium-ion battery	–	–
	Solar charge control units	–	–
Solar home systems (integrated kits)	Solar panels	–	–
	LED lighting	–	–
	Lithium-ion battery	–	16%
	Lead-acid batteries	–	–
	Static converters	–	–
	Hybrid inverters	–	16%
	Solar charge control units	–	–
	Solar cables	25%	16%
	Solar switches	15%	16%
	Solar breakers	15%	16%
Fluorescent lamps and bulbs		–	–
Solar geysers		–	–
Solar street lights		–	–
BOS electrical components		15%	16%
Solar mini-grids (also applicable to C&I projects)	Solar panels	–	–
	LED lighting	–	–
	Lead-acid battery for piston engine	–	–
	Other lead-acid accumulator	–	–
	Nickel-cadmium batteries	–	–
	Nickel-iron batteries	–	–
	Nickel-metal hydrid battery	–	16%
	Lithium-ion battery	–	16%
	Static converters	–	–
	Hybrid inverters	–	16%
	Solar charge control units	–	–
	Solar cable	25%	16%
	Solar breakers	15%	16%
	Solar switches	15%	16%
	DC irrigation pump	–	–
	Standard 20-foot shipping container	5%	16%
	Integrated Nodal Distributed Grid Management	–	16%
	PV Module Support Structure (with SADC Certificate)	15%	16%

Source: (Africa Clean Energy Technical Assistance Facility, 2022)

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As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

Published by
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

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Design/Layout
DITHO Design GmbH, Cologne

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On behalf of
German Energy Solutions Initiative of the
German Federal Ministry for Economic Affairs and Climate Action (BMWK)
Berlin
Martina Habibes
Berlin

Berlin, 2023

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

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