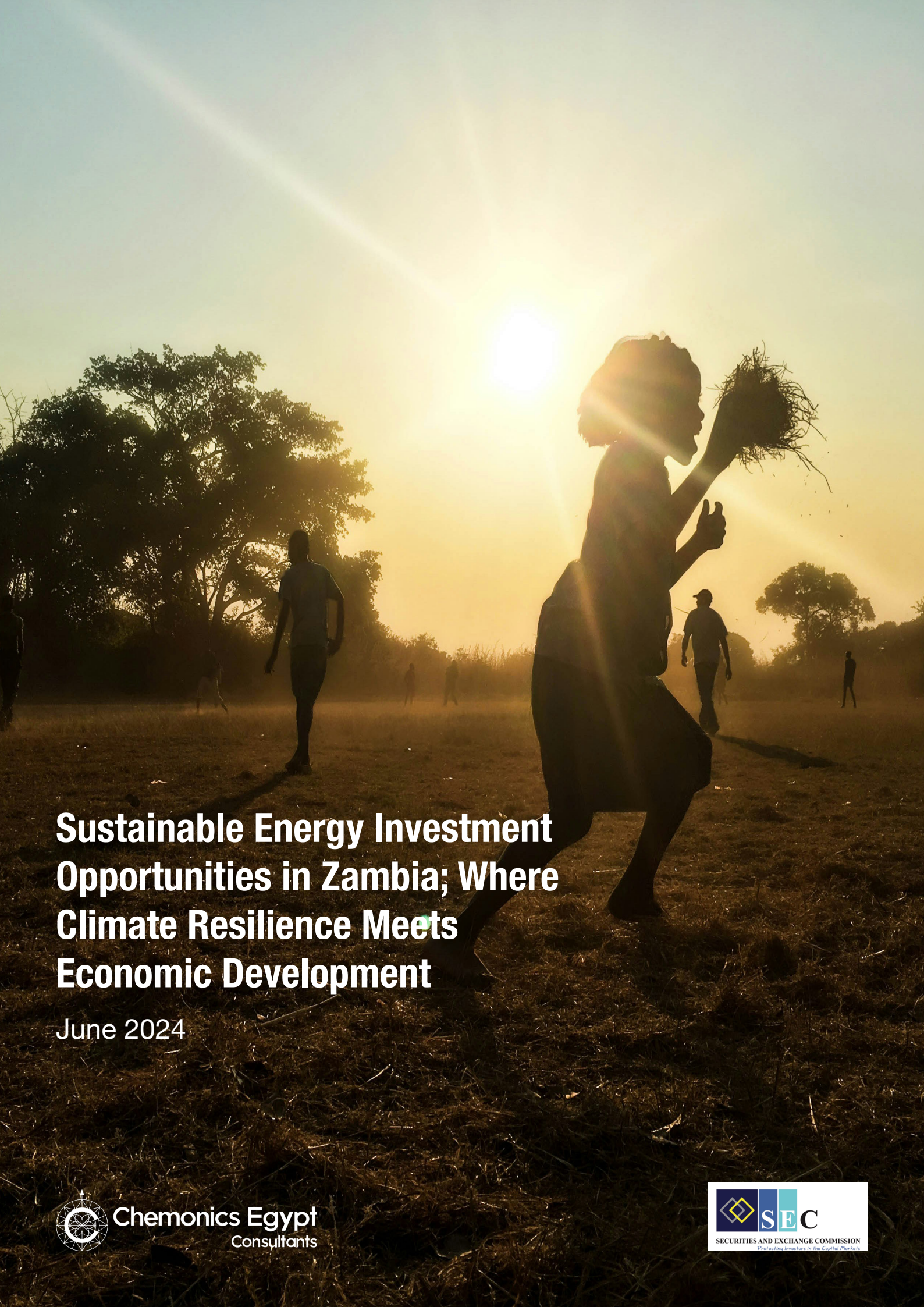

Sustainable Energy Investment Opportunities in Zambia; Where Climate Resilience Meets Economic Development

June 2024

Chemonics Egypt
Consultants

SEC
SECURITIES AND EXCHANGE COMMISSION
Protecting Investors in the Capital Markets

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Acknowledgments

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List of Abbreviations and Acronyms

BO	Business Opportunity
BOM	Business Opportunity Mapping
B2B	Business-to-Business
CO^2	Carbon Dioxide
CE	Chemonics Egypt Consultants
CAGR	Compound Annual Growth Rate
CSP	Concentrated Solar Power
CC	Creative Commons
EV	Electric Vehicle
EESAP	Energy Efficiency
EESAP	Energy Efficiency Strategy and Action Plan
ESCO	Energy Services Company
EUR	EURO
FiT	Feed-in-Tariff
FAO	Food and Agriculture Organization of the United Nations
GET	Green Energy Technology
GHG	Greenhouse Gases
GDP	Gross Domestic Product
IPP	Independent Power Producer
ICT	Information and Communication Technology
IRP	Integrated Resource Plan
IFC	International Finance Corporation
IRENA	International Renewable Energy Agency
KFW	Kreditanstalt für Wiederaufbau
MW	Mega-Watt
MNDP	Ministry of National Development Planning
MSW	Municipal Solid Waste
NEP	National Energy Policy
NPCC	National Policy on Climate Change
NDC	Nationally Determined Contribution
PV	Photovoltaics
RDF	Refuse-Derived Fuel
RE	Renewable Energy
RESAP	Renewable Energy Strategy and Action Plan

List of Abbreviations and Acronyms

REMP	Rural Electrification Master Plan
SEC	Securities and Exchange Commission
SME	Small and Medium Enterprise
SWH	Solar Water Heating/Heaters
8NDP	The Eighth National Development Plan
MGEE	The Ministry of Green Economy and Environment
NAP	The National Adaptation Plan for Zambia
ZDA	The Zambia Development Agency
TPES	Total Primary Energy Supply
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
USD	United States Dollars
UCO	Used Cooking Oil
WFP	World Food Programme

Photo by ChanMuk - Freeimages

Executive Summary

Zambia is positioned for a significant transformation in its energy landscape, making it a promising destination for investments in renewable energy and energy efficiency investments.

The country's population growth, rising electricity tariffs, industrialization, and urbanization have generated strong potential for sustainable energy and energy efficiency solutions. On the supply side, Zambia's energy mix, which is heavily reliant on hydropower, accounting for 85% of the installed capacity in 2023, has shown vulnerability to climate change, particularly during recent power shortages caused by water scarcity. Additionally, 12% of the energy supply depends on thermal sources like coal, which are subject to significant price volatility. The increasing demand for reliable and cost-effective energy, combined with Zambia's abundant natural resources, including solar irradiation, wind potential, and biomass, underscores the country's potential as a hub for renewable energy development and innovation in energy efficiency solutions.

The Zambian government has taken significant steps to enable a sustainable and green energy transition.

Key initiatives include the Rural Electrification Master Plan (REMP 2008), which aims to expand access to electricity in rural areas, and the National Policy on Climate Change (NPCC 2016), which provides a framework for addressing climate-related challenges.

The Energy Efficiency Strategy and Action Plan (EESAP 2022) and the Renewable Energy Strategy and Action Plan (RESAP 2022) further reinforce the country's commitment to enhancing energy efficiency and expanding renewable energy adoption. Additionally, the amended Environmental Management Act – Act No. 12 of 2011 strengthens the regulatory framework for environmental protection, ensuring that the green economy's development aligns with sustainable practices. To support these efforts, the Securities and Exchange Commission (SEC) of Zambia established green bond issuance guidelines in 2020, facilitating financing for green and sustainability-linked investments. Zambia's inaugural green bond issuance in 2023 has paved the way for innovative financing opportunities in the sector. These strategic initiatives lay a strong foundation for Zambia's transition to a sustainable and resilient energy future. As the country continues to build on these efforts, it is well-positioned to attract further investments, drive economic growth, and solidify its role as a leader in green energy within the region.

The lack of accessible and reliable market information poses a significant challenge to the development of Zambia's green economy.

This information asymmetry hinders decision-makers, investors, and SMEs from effectively identifying and capitalizing on investment opportunities, leading to

higher perceived risks and increased costs of capital. Consequently, this results in a reduction of bankable projects, inadequate project evaluation, and limited access to green finance opportunities. Moreover, the misalignment of non-financial support further exacerbates these issues, ultimately delaying market development. This study was conducted to address these challenges and to facilitate the flow of investments into Zambia's renewable energy and energy efficiency sectors by bridging the critical information gap.

The Securities and Exchange Commission (SEC) in Zambia and Chemonics Egypt Consultants have partnered to explore renewable energy and energy efficiency business opportunities for SMEs and investors in Zambia.

The study aims to bridge the information gap by providing critical market insights to foster an environment conducive to investment. Aligned with the Capital Markets Master Plan[1], the study seeks to create an inviting investment landscape, promote innovation through green financing instruments like green bonds and carbon credits, and raise awareness among key stakeholders. The Commission has actively promoted sustainability by raising awareness about green bonds and their role in financing green projects. Furthermore, it has engaged with policymakers, potential issuers, and industry practitioners to enhance stakeholder participation and develop sustainable financing mechanisms, solidifying Zambia's vision of becoming a preferred Global Green Investment Hub. The study is part of meeting the aspirations under strategic objective one (1) of the Commission's strategic implementation plan on increasing stakeholder participation in the Capital markets with specific strategies speaking to the development of guidelines for new innovative products, development of the market for Green Bonds and other sustainable financing mechanisms and products.

Leveraging an established methodology with a decade-long track record, the opportunities were identified and prioritized using criteria that not only consider market viability but also emphasize environmental and social impact.

Using the «Business Opportunity Mapping» (BOM) methodology developed by Chemonics Egypt Consultants with the United Nations Industrial Development Organization (UNIDO) in 2014, thirty-seven business opportunities were initially identified through secondary research and expert input. After conducting interviews and further analysis, these were consolidated into twenty opportunities, which were then prioritized based on multi-dimensional criteria to identify the ten most promising renewable energy and energy efficiency opportunities in Zambia. The selection criteria included market viability, social impact, environmental sustainability, supply and demand dynamics, market saturation, operational ease, and growth potential.

Fact sheets were also created for the top ten opportunities, highlighting key market, economic, social, and environmental features.

The top ten business opportunities are:

1. Stand-alone solar PV-powered irrigation systems and solar PV-powered farming equipment (such as pesticide sprayers) for agriculture applications;
2. Solar food drying for local consumption and export;
3. Decentralized solar PV systems for mining, residential, street lighting, food packaging, food storage centres;
4. Small biogas units for on-farm usage (including for crop, poultry and livestock farms)
5. Solar water heating (SWH) residential and industrial applications (including for steam generation in food and dairy industrial facilities);
6. Shredded Refuse-Derived Fuel (RDF) from municipal solid waste for energy intensive industries;
7. Efficient (renewable energy-powered) cold chain for fruits, vegetables, dairy, and fish storage and distribution (including reefer trucks and refrigerators);
8. Efficient motors, pumps, and Variable Speed Drives (V.S.D.s) in industrial and commercial application (including for the mining and textile industries and in telecommunication data centres);
9. Biodiesel from Used Cooking Oil (U.C.O.) for export and pyrolysis oil from tires waste, and
10. Utility scale wind and solar.

The remaining structure of the report is as follows:

- Section 1 provides the introduction and background to the study.
- Section 2 provides an overview of key market drivers generating the demand for renewable energy and energy efficiency solutions in Zambia.
- Section 3 provides the methodology used and presents the identified and subsequently prioritised business opportunities.
- Section 4 presents aspects of the governing and enabling landscape in Zambia.
- Section 5 concludes the report and presents a way forward.

We aspire for this study to serve as a catalyst for broader market studies, comprehensive feasibility assessments, enhanced SME support, and more vigorous investment promotion activities, ultimately positioning Zambia as a prominent regional green investment hub.

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[1] The «Capital Markets Master Plan» (CMMP) is a five-year strategic framework focused on enhancing market infrastructure, regulatory reforms, and capacity building to attract investments and foster economic growth. Source: Capital Markets Master Plan – Securities & Exchange Commission, Zambia (seczambia.org.zm)

About The Securities and Exchange Commission in Zambia:
The Securities and Exchange Commission (SEC or "the Commission") is the regulator of the capital markets in Zambia. The Commission was established through an Act of Parliament, the Securities Act, Chapter 354 of the Laws of Zambia which was repealed and replaced by the Securities Act No. 41 of 2016 as amended by the Securities Amendment Act No. 21 of 2022. The Commission has continued its existence under the Securities Act of 2016.

Mandate
- Protection of investors
- Ensuring markets are fair, transparent, efficient
- Market development and Education (awareness)

The Securities and Exchange Commission (SEC) of Zambia is actively pushing the sustainability agenda in the countrys capital markets. Recognizing the importance of Environmental, Social, and Governance (ESG) factors, the SEC has established a Green Finance Unit to coordinate green and sustainable finance activities after the issuance of green bond guidelines in 2020. These efforts aim to incentivize companies to integrate ESG practices, attract green investments, and channel capital towards environmentally friendly projects. While Zambia's green bond market is still nascent, the SEC's ongoing collaboration with stakeholders like the Sustainable Banking and Finance Network (SBFN) and its engagement in capacity-building initiatives suggest a concerted effort to position the country as a regional hub for green finance.

About Chemonics Egypt Consultants:
Chemonics Egypt Consultants (CE), an Egyptian Engineering and Management Consulting firm based in Cairo, was founded in 1992 as a franchise to Chemonics International (CI), a Washington D.C. based international development consulting firm. The firm has +450 projects in +15 countries in the Middle East and Africa (MEA) with the public and private sectors as well as Non-Governmental Organizations (NGOs), international development agencies and donors. With a focus on developing green and circular economies, Chemonics Egypt's key sectors of focus are: water and wastewater; waste management and recycling; sustainable agriculture and food production, and sustainable energy and energy efficiency. Services include direct advisory to start-ups and MSMEs, green credit facility design, financial and economic studies, and investment promotion.

SECTION 1

INTRODUCTION & BACKGROUND

Introduction and Background

Zambia possesses strong potential for renewable energy and energy efficiency solutions, fuelled by several key factors.

Zambia is poised for a significant transformation in its energy landscape, driven by a combination of rising population, GDP growth, and rapid urbanization and industrialization. These factors create a strong and dynamic market for renewable energy and energy efficiency solutions across diverse sectors, including mining, agriculture, commercial and residential buildings, and transportation. The country's abundant natural resources, such as solar irradiation, wind potential, and biomass, further strengthen its prospects for developing renewable energy. Additionally, the volatility of fossil fuel costs and the growing vulnerability of hydropower, which currently accounts for 85% of Zambia's energy mix, underscore the need for diversified, sustainable energy sources. While hydropower remains the dominant energy source, and will continue to be until 2050 according to the Integrated Resource Plan (IRP)[1], its generation is vulnerable to droughts and fluctuations in the Kafue and Zambezi Rivers[2], leading to concerns about grid stability. In response to these opportunities and challenges, the Zambian government has undertaken significant initiatives to promote renewable energy and green investments, laying the groundwork for a sustainable and resilient energy future.

Zambia has made significant strides in advancing renewable energy and energy efficiency through a series of progressive actions. Key initiatives include the National Energy Policy 2019[3], which incentivizes private sector participation, and the Renewable Energy Strategy and Action Plan (RESAP 2022)[4], which provides a comprehensive roadmap for the adoption of renewable energy technologies. The Energy Efficiency Strategy and Action Plan (EESAP 2022)[5] aims to optimize energy use across economic, financial, social, and environmental dimensions, positioning Zambia as a potential net energy exporter. In 2024, the launch of the Integrated Resource Plan (IRP) for the electricity sector, emphasizing sustainable and climate-resilient growth, and the recent open access policy to attract Independent Power Producers (IPPs)[6] in addition to the Renewable Energy Financing Framework[7] supporting the Renewable Energy

[1] Integrated Resource Plan for the Power Sector in Zambia, 2023. Available online: 00_IRP_Summary Report (1).pdf. Accessed on: 26 January 2024

[2] Future Hydropower Operations in the Zambezi River Basin: Climate Impacts and Adaptation Capacity, 2022. Available online: https://www.researchgate.net/publication/358959564_Future_hydropower_operations_in_the_Zambezi_River_basin_Climate_impacts_and_adaptation_capacity. Accessed on 1 December 2023.

[3] National Energy Policy, 2019. Available online: The National Energy Policy 2019 - Ministry of Energy Integrated Resource Plan (moe.gov.zm). Accessed on 15 July 2023.

[4] Renewable Energy Strategy and Action Plan, Ministry of Energy, Republic of Zambia, 2022. Available online: https://www.moe.gov.zm/wp-content/uploads/2022/08/Renewable-Energy_final-file_for-web.pdf. Accessed on 15 July 2023.

[5] Zambia Energy Efficiency Strategy and Action Plan, 2022. Available online: Zambia-Energy-Efficiency-Strategy-and-Action-Plan-2022.pdf (moe.gov.zm). Accessed on 15 July 2023.

[6] Zambia adopts an open access regime for the electricity market, 2024.Available online: Polity - Zambia adopts an open access regime for the electricity market. Accessed on 26 August 2024.

[7] Green Climate Fund. «Zambia Renewable Energy Financing Framework (FP080).» Available online: https://www.greenclimate.fund/project/fp080. Accessed: 15 July 2023.

Feed-in Tariff (REFIT) policy further highlight Zambia's commitment to a green and resource-efficient future. These initiatives, along with the Securities and Exchange Commission (SEC) of Zambia introduction of the green bond issuance guidelines in 2020[8], are critical in driving Zambia's transition to a sustainable energy landscape and attracting green investments. The successful issuance and listing of Zambia's first green bond in 2023[9] for the Copperbelt Energy Corporation Plc (CEC) has opened new avenues for innovative financing, facilitating financing for green and sustainability-linked investments.

For Micro, Small, and Medium Enterprises (MSMEs), investors, and market enablers, having detailed information on demand, supply, and available technologies is crucial for capitalizing on opportunities.

Chemonics Egypt's (CE) experience in managing enterprise support programs, green facilities, and investment facilitation with over 50 investors, financial institutions, and more than 500 SMEs in the green and circular economies has revealed that inadequate access to market information, such as insights on national demand, supply, and technology availability, poses a significant barrier to establishing and validating business models and cases for customers and financiers. This also limits access to finance and investments. CE's extensive research indicates that limited access to market information leads to distorted risk assessments and unreliable valuation methods by private investors, ultimately hindering the deployment of essential funding in these critical sectors. As a result of this information asymmetry, private sector entities, such as SMEs and investors, face higher perceived risks and increased capital costs, making it more difficult to secure necessary funding. This situation reduces the number of bankable projects and hampers effective project evaluation. Additionally, limited access to green finance opportunities and mismatched non-financial support together further constrain the growth potential of private sector entities. Consequently, these challenges collectively delay market development, hindering the overall progress and sustainability of these emerging businesses.

Despite the recognized potential of renewable energy and energy efficiency solutions in Zambia, significant challenges in accessing market information and sector-specific knowledge continue to hinder the full realization of these opportunities. The lack of readily available data exacerbates the risks and uncertainties for those attempting to innovate or invest in these vital markets, ultimately slowing the pace of progress and adoption.

An efficient methodology developed and piloted by United Nations Industrial Development Organization (UNIDO) and Chemonics Egypt in 2014, known as Business Opportunity Mapping or «BOM», aims to address this barrier.

The main objective of the BOM is to specify opportunities in a certain geographical setting which offers start-ups a higher chance of success and also ensure that such success implicitly improves social conditions; for instance, preservation of natural resources and job creation for youth and women. The BOM's neutral identification of opportunities, backed by technical and market expertise, has encouraged entrepreneurs and investors at varying stages to invest in sectors with which they may not be familiar. It provides essential information to decision makers, mitigating the lack of access to crucial market data necessary for shaping their business strategies. The BOM also aids in identifying and disqualifying opportunities entailing high legal and regulatory barriers, knowledge that is often unavailable to enterprises, investors, and other decision makers. The BOM also provides foundational knowledge related to business opportunities, serving as a starting point for enterprise and investment promotion programs. For instance, MSMEs supported in pre-mapped business opportunities since 2014 have exhibited significantly higher business success rates, with 50% of idea-stage businesses supported now successfully operating, and over 30% continuing to grow. Furthermore, these enterprises have realized the predetermined social and environmental impact.

The objectives of the study encompass a multifaceted and strategic approach aimed at positioning Zambia as a prominent regional green investment hub.

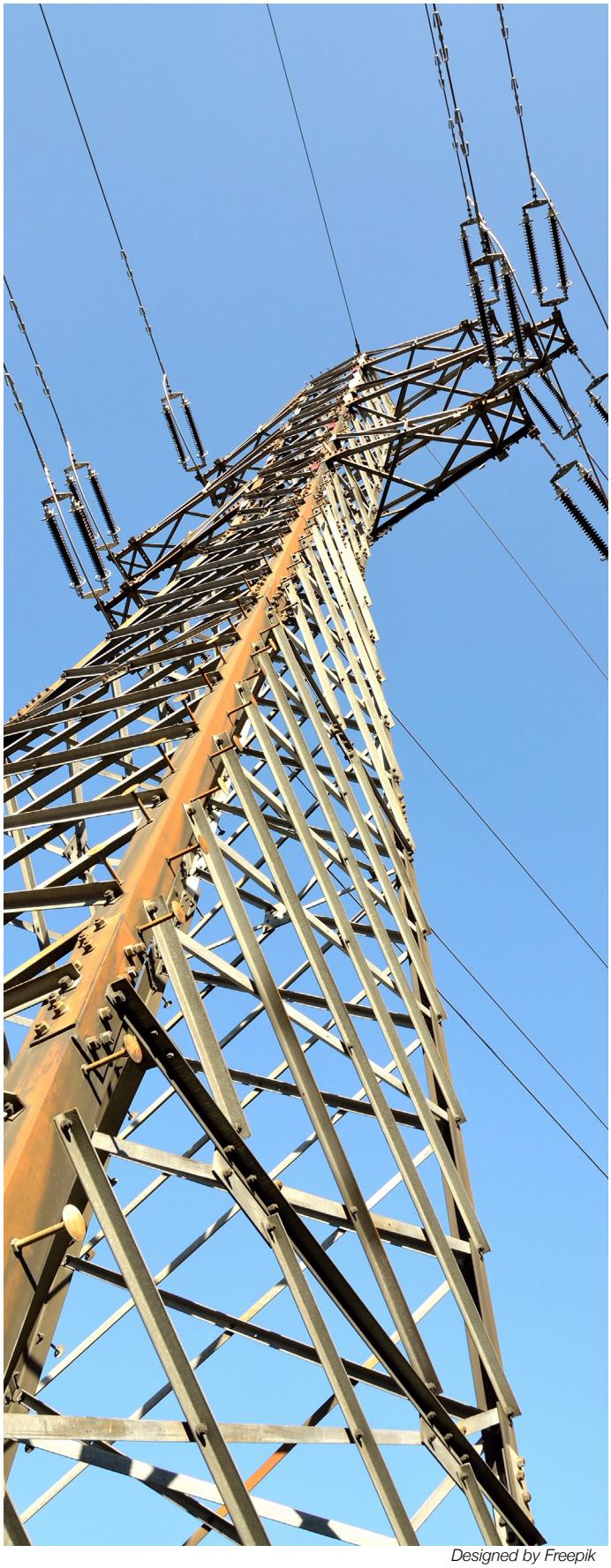
The study intends to mitigate the barriers and risks related to difficulties in accessing sector-specific knowledge and market information. It seeks to enhance the likelihood of success and growth for enterprises and investors operating and investing in renewable energy and energy efficiency solutions in Zambia. The study also aims to channel innovation towards economically profitable and environmentally and socially impactful opportunities, while attracting more support from the enterprise support and investment promotion ecosystem, as well as increased capital investment and financing. Additionally, the study aims to align with the «Capital Markets Master Plan», with the overarching goal of fostering sustainable investment practices in Zambia. It strives to create an attractive investment landscape for international partners, promote innovation by encouraging the development of new green financing instruments such as green bonds and carbon credits, and raise awareness among key stakeholders and

[8] The Securities (Green Bonds) Guidelines, 2019. Available online: Guidelines – Securities & Exchange Commission, Zambia (seczambia.org.zm). Accessed on 15 July 2023.

[9] CEC Investor. «Successful Listing of Zambia's First Green Bond on the LUSE.» Available online: https://cecinvestor.com/successful-listing-of-zambias-first-green-bond-on-the-luse. Accessed on 15 January 2024.

partners to create an enabling environment for bankable green investments in Zambia.

In conclusion, the study endeavours to encourage meaningful dialogue and concrete actions aimed at fostering the growth and expansion of renewable energy and energy efficiency business opportunities in Zambia, catering to SMEs, investors, and market enablers. It does so by facilitating access to crucial market information pertaining to investment opportunities with significant potential for success.



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SECTION 2

KEY MARKET DRIVERS FOR RENEWABLE ENERGY AND ENERGY EFFICIENCY

Key Market Drivers For Renewable Energy And Energy Efficiency Solutions In Zambia

This section delves into the key demand drivers for renewable energy and energy efficiency solutions across Zambia's most critical sectors, highlighting the factors that are propelling their adoption. These insights reveal significant opportunities for businesses, investors, and market enablers to play a pivotal role in Zambia's transition to a green economy, while also enhancing the competitiveness and sustainability of these sectors.

Key Demand Aspects in Various Sectors

There is significant growth potential and demand for energy solutions across key sectors in Zambia. The agriculture, commercial (including tourism), industrial (including agro-processing and mining), residential, public and transportation sectors all present opportunities for adopting renewable energy and energy efficiency solutions to enhance competitiveness, sustainability, and operational efficiency.

The rapid growth and modernization of Zambia's agriculture sector, particularly the increasing need for irrigation and mechanization, are driving a significant surge in energy demand.

While 75 percent of Zambians work in agriculture, the sector comprised only 3.9 percent of GDP in 2022. The agriculture sector's contribution to GDP has declined by about 4-fold since 2000 to largely due to variable rainfall, adverse weather conditions, and limited access to necessary inputs and infrastructure. Zambia currently utilizes less than 14 percent of its 40 million hectares of arable land, with only 5.7 percent of this land being irrigated, highlighting significant potential for water-efficient irrigation and mechanization improvements[1]. Despite this, Zambia's mixed crop yield performance and the small fraction of irrigated land indicate significant potential for improvement, particularly through irrigation solutions. With significant water resources, diverse agro-ecological zones, and the need and political drive to mitigate climate impacts, Zambia has the capacity to enhance agricultural productivity and food security through improved irrigation and mechanization. The government's commitment to water-efficient irrigation development and foreign investment could help reduce reliance on rain-fed agriculture. Additionally, the demand for agricultural mechanization is rising due to economic growth, population expansion, and increasing labour costs. This demand encompasses a variety of machinery, including tractors, harvesters, and irrigation systems, tailored to different farm sizes and types. Accordingly, demand for power in agriculture is anticipated to surge from 48 MW in 2020 to 3,625 MW by 2050 according to Zambia's Integrated Resource Plan (IRP). Key drivers

[1] U.S. Department of Commerce, International Trade Administration. «Zambia - Agriculture.» Available online: www.trade.gov/country-commercial-guides/zambia-agriculture. Accessed 6 June 2024.

include an 85-fold increase in wheat production, increased maize and soya production, and significant irrigation and agro-processing activities to support the increase in farm production. The agricultural sector's modernization and expansion are major contributors to this demand[2].

> Energy demand in agriculture is anticipated to surge by 75X and the largest expected increase among all sectors. Although it currently accounts for a minor share of demand, it is expected to exceed that of the mining sector by 2050.

Agro-processing and food manufacturing activities in Zambia present significant opportunities for clean energy and energy efficiency solutions to bolster growth and competitiveness, with the added potential to mitigate food waste and enhance the trade balance. These sectors are experiencing substantial growth, driven by rising domestic demand and expanding export opportunities.

Processed and refined foods, such as maize meal, wheat flour, sugar, cooking oil, and stockfeed, constitute a substantial portion of Zambia's non-traditional exports. However, despite growth in export earnings, future increases in demand for processed goods could strain the country's import bills if national production does not keep pace. For instance, Zambia's edible oil market is projected to grow annually by 9.59% (CAGR 2024-2029)[3], yet the country currently faces an increasing edible oil deficit, resulting in imports worth more than $200 million per year[4]. Zambia's dependency on food imports, particularly for staples like maize, wheat, and edible oil, as well as foodstuffs like sugar, sauces, and processed vegetables, highlights the urgent need to expand local agro-processing capabilities to reduce reliance on imports and improve the trade balance. In 2022 alone, Zambia spent over $300 million on vegetable products and foodstuffs, excluding processed edible oil, tobacco, and beverages, representing 3% of the total import value. This underscores the necessity of developing the domestic processing industry to ensure a stable supply of reliable and cost-effective energy sources, which are critical for supporting industrialization and improving the trade balance. Additionally, to enhance export competitiveness and meet growing international demand for lower-carbon footprint products, Zambia has the opportunity to deploy cleaner energy and energy efficiency measures.

Zambia aims to more than double its agricultural export earnings to $2 billion by 2026. The country is focusing on adding value to traditional products, diversifying its economy beyond copper mining, and boosting growth in various sectors[5]. However, like many African countries, Zambia faces significant challenges with post-harvest losses and food waste, estimated at 30-40% of the food produced[6]. These losses further emphasize the risks of relying on food imports, as inadequate infrastructure, including limited access to storage facilities, appropriate transportation, and processing equipment, leads to spoilage and damage of perishable products. Financial constraints exacerbate this issue, as farmers often lack the resources to invest in improved storage, processing, or transportation facilities, resulting in substantial economic losses and missed opportunities to enhance food security. The increasing local and regional demand for food, coupled with export opportunities, is expected to fuel interest in cold chain solutions. Although international partners, SMEs, and start-ups are expanding cold chain solutions, demand continues to outpace supply.

Providing reliable, cost-effective, and clean energy supply sources, along with energy-efficient value-added production in the agriculture and food production sectors, is crucial not only for enabling producers to access export markets and achieve significant cost savings but also for driving multiple benefits such as emissions reduction, enhanced food security, and broader economic development.

The commercial and industrial sectors in Zambia show significant potential for increased energy demand for various energy use applications and opportunities for energy efficiency improvements, driven by the need for reliable power supplies, cost savings, access to markets, and alignment with national strategies.

The commercial and industrial sectors' energy demand is set to increase from 257 MW in 2020 to 984 MW by 2050, a 283% rise according to the IRP. This growth is fuelled by the industrialization of the economy, including the establishment of an electric vehicle battery manufacturing facility in Ndola[7]. With increasing industrialization, Zambia's commercial and industrial sectors are experiencing a growing demand for electrical and heating solutions. As economic activities expand and new businesses emerge, the need for stable and reliable power supplies has become increasingly crucial, particularly in light of the volatile prices of natural gas and coal. Any disruptions in electricity supply can severely impact both productivity and profitability. In industries such as food processing, wood manufacturing, and textile production, efficient and cost-effective water heating solutions are also essential. These sectors are placing a greater emphasis

[2] Ministry of Energy, Zambia. "Integrated Resource Plan (IRP)." Available online: https://www.moe.gov.zm/irp/. Accessed: February 20, 2024.

[3] Statista Market Forecast. «Market Insights: Edible Oils - Zambia» Available online: https://www.statista.com/outlook/cmo/food-beverages/edible-oils/zambia. Accessed: 1 February 2024.

[4] Daily Nation. «Upscaling Local Content in the Edible Oils Sector.» Available online: https://newsite3.dailynationzambia.com/2021/05/upscaling-local-content-in-the-edible-oils-sector/. Accessed: 1 July 2023.

[5] EEP Africa. «Cold Chain Storage Market Assessment 2023.» Available online: Cold-chain-storage-market-assessment-2023.pdf (eepafrica.org). Accessed on 5 July 2023.

[6] United Nations Zambia. «From Food Loss to Food Gain.» Available online: https://zambia.un.org/en/211433-food-loss-food-gain. Accessed on 6 January 2024.

[7] «Integrated Resource Plan (IRP),» Ministry of Energy, Zambia, accessed February 20, 2024, https://www.moe.gov.zm/irp/.

on energy efficiency to manage rising energy costs and reduce GHG emissions to respond to heightened environmental awareness among consumers and emissions reduction regulations, both domestically and in export markets. The implementation of high-efficiency motors, appliances, and other advanced technologies can significantly reduce energy consumption and ease the burden on the power grid.

> The commercial and industrial sector's energy demand is set to increase by about 4X in the next three decades driven by industrialization of the economy. This excludes mining.

As a result, there is a substantial opportunity for solution providers in Zambia's commercial and industrial sectors. The demand for reliable power supply options is rising, along with the need for efficient water heating technologies, such as solar thermal systems or high-efficiency boilers. By understanding and addressing the specific needs and challenges of various industries, providers can capitalize on the increasing demand for reliable, efficient, and sustainable electricity and heating solutions in Zambia's commercial and industrial sectors.

Zambia's residential and public sectors present substantial opportunities for energy demand growth and energy efficiency advancements, driven by the need for stable, cost-effective electricity as well as cooking, heating and cooling solutions.

Over the past decade, Zambia has made notable strides in increasing electricity access, albeit with a significant discrepancy between rural and urban areas. In rural areas, access to electricity has risen from 8.2% in 2012 to 14.5% in 2022. Urban areas have seen an almost similar increase, with access growing from 60.1% in 2012 to 87% by 2022[8]. Energy demand in the residential sector is expected to rise from 769 MW in 2020 to 1,923 MW by 2050 according to the IRP[9]. Continued urbanization and population growth further contribute to this rising demand. This highlights a significant market for grid extension and off-grid solutions such as solar-power mini and micro-grids and stand-alone systems.

Zambia's residential and public sectors present an opportunity for SMEs and investors in the energy sector, driven by rapid urbanization, rising living standards, and ambitious government electrification and sustainable development goals. For example, there is significant potential in deploying biogas units for cookers in rural households as an alternative to charcoal, which also serves as a solution for manure management and provides access to farming inputs from the bio-digestate by-product of the biogas units. These biogas units offer cost savings, energy access, and enhanced energy security for rural households. Additionally, decentralized solar PV systems, including mini- and micro-grids, present opportunities to meet multiple residential and public sector demand aspects such as street lighting, space heating and cooling, water heating, powering appliances, and in the long term, residential and public EV charging stations, providing both cost savings and energy security. Furthermore, utility-scale wind and solar projects have the potential to contribute significantly to the electrical grid as electricity demand rises and the economic viability of these projects improves, thereby enhancing energy mix diversification and supporting Zambia's broader energy goals.

Zambia's tourism sector presents a growing demand for renewable energy and energy-efficient solutions, driven by the need to improve sustainability, lower operational costs, and access eco-conscious market segments.

In Zambia's tourism sector, the demand for renewable energy and energy efficiency solutions is driven by the need for eco-lodges and tourist facilities to enhance their sustainability, reduce operational costs, and provide a superior guest experience. Energy-efficient building designs, high-efficiency appliances, and renewable energy sources like solar panels offer significant potential for lowering electricity expenses, which can substantially reduce operational costs and contribute to the financial viability of tourist facilities. Additionally, the development of off-grid microgrids powered by renewable sources ensures reliable power supply while minimizing environmental impact, further enhancing cost-effectiveness and operational stability. Transitioning from diesel generators to cleaner energy aligns with eco-tourism principles, attracting environmentally conscious travellers and unlocking cost savings, ultimately benefiting the bottom line of tourist facilities.

Investors serving Zambia's mining sector can seize opportunities by adopting energy-efficient and renewable solutions, ensuring reliable energy access, operational efficiency, cost savings, and environmental sustainability.

Energy demand in the mining sector is projected to grow from 886 MW in 2020 to 2,052 MW by 2050 according to Zambia's IRP. This increase is driven by the projected rise in copper production to 3 million tonnes per annum by 2040. Additional mining activities for minerals such as manganese, tin, gold, and lithium also contribute to the growing demand[10]. Zambia's growing mining sector presents an enticing opportunity for energy-focused investors. The industry faces the crucial challenge of securing reliable power for its operations while also contending with escalating fossil fuel costs and

[8] World Bank. «Access to Electricity (% of Population) - Zambia». Available online: https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS?locations=ZM. Accessed on 5 January 2024.

[9] Ministry of Energy of Zambia. «Integrated Resource Plan (IRP)». Available online: https://www.moe.gov.zm/irp/ . Accessed on 20 February 2024.

[10] Ministry of Energy of Zambia. «Integrated Resource Plan (IRP)». Available online: https://www.moe.gov.zm/irp/ . Accessed on 20 February 2024.

environmental concerns. To leverage these opportunities, investors can implement a multifaceted approach involving energy supply, energy-efficient equipment, process optimizations, and smart control systems aimed at reducing energy consumption across the entire mining value chain, spanning from extraction to processing. The adoption of such solutions can yield concrete advantages, including decreased operational costs, heightened profitability, and improved environmental impact. Additionally, innovative cooling and ventilation technologies can play a pivotal role in optimizing energy use within multiple applications, resulting in substantial energy savings and simultaneously enhancing the safety and comfort of mining personnel.

Energy demand in the mining sector is projected to grow by about 2.5X in the next three decades driven by the projected rise in copper and additional mining activities for minerals.

The demand for energy solutions in Zambia's transportation sector is on the rise.

The transport sector will see an increase from a negligible amount in 2020 to 153 MW by 2050. This demand projection is conservative as it is limited to the development of inter-city and urban electric rail networks and does not include Electric vehicles (EVs). However, the electrification of the transport sector is seen as crucial for reducing reliance on fossil fuels and promoting sustainable transport solutions[11]. Zambia's leading position as the world's eighth-largest copper producer and second in Africa underscores its strong potential for producing value-added, responsibly sourced copper-based materials and for battery manufacturing. This potential is further supported by efforts to develop an integrated value chain for electric vehicle (EV) battery production in the Central and Southern Africa region, enhancing Zambia's role in transportation electrification[12]. The growing middle class is driving an increased demand for passenger cars and electric vehicles (EVs) are gaining popularity due to their decreasing costs and the increasing costs of fuels. Furthermore, the market for two- and three-wheeler EVs is set for significant growth, particularly for urban commutes and last-mile deliveries. Additionally, the emergence of ride-sharing platforms in Zambia offers opportunities to integrate EV fleets into urban transportation, reducing pollution and providing convenient options for urban residents. In the commercial sector, transitioning to electric models, especially heavy-duty trucks in mining and agriculture, offers both long-term cost savings and environmental benefits.

Reflection on the Demand Drivers

As described above, key drivers propelling the adoption of renewable energy and energy efficiency solutions across various sectors in Zambia include energy access, market opportunities, cost savings, and alignment with national policies, each playing a crucial role in shaping the sustainable energy landscape across most sectors in Zambia. The main drivers determined by the study are as follows:

Energy access, reliability, and security involves providing reliable, affordable, and secure modern energy services to all. In the rural household context this includes electricity and clean cooking solutions. In the agriculture sector, it means powering irrigation systems, cold storage, and the mechanization of agriculture. For the industrial and commercial sectors, it ensures consistent energy supply for manufacturing, operations, and business continuity. In the public sector, it supports the functioning of essential services like healthcare and education, while in the transportation sector, it enables the transition to electric vehicles and sustainable transportation infrastructure.

Access to markets, international funding and resources are key drivers for sectors like commercial, industrial, public, and transportation to adopt renewable energy and energy efficiency solutions. Access to export markets and environmentally-conscious segments, along with international funding through concessional capital, carbon credit markets, and technical assistance are some examples of key drivers for entities in these sectors to invest in sustainable practices and technologies.

The potential for significant **cost savings** is a key driver for the adoption of renewable energy and energy efficiency solutions, particularly strong among entities in the agriculture, residential, commercial, and industrial sectors. By diversifying energy sources, reducing energy expenses and improving operational efficiency, these sectors can reduce operational interruptions and overheads thus enhancing profit margins, and maintaining competitive pricing, making sustainability a strategic advantage in increasingly cost-sensitive markets.

Alignment with national strategies and compliance with policies on clean energy, energy diversification, and GHG reduction can drive key sectors in Zambia, including the industrial sector (agro-processing, mining) and the public sector, by ensuring access to incentives, reducing regulatory risks, and enhancing alignment with national and global strategies and mandates.

[11] Ministry of Energy of Zambia. «Integrated Resource Plan (IRP)». Available online: https://www.moe.gov.zm/irp/ . Accessed on 20 February 2024.

[12] Center for Strategic and International Studies. «U.S.-Zambia-DRC Agreement on EV Batteries Production: What Comes Next.» Available online: https://www.csis.org/analysis/us-zambia-drc-agreement-ev-batteries-production-what-comes-next. Accessed 5 January 2024.

Zambia's key sectors offer significant growth potential, reinforced by strong incentives to adopt renewable energy and energy efficiency solutions, positioning the country as a highly promising landscape for sustainable investment. Capitalizing on these opportunities will be crucial for driving Zambia's green economy forward and ensuring long-term socio-economic development. It is important to note that the information presented is not intended to serve as a comprehensive market assessment, but rather as a foundational background to the business opportunity mapping, guiding investors and stakeholders toward identifying and leveraging high-potential opportunities in Zambia's evolving green economy landscape.

Table 1 High level mapping of sectors against key motives. Two ticks indicate that the demand driver is very strong and one tick indicates that the demand driver exists but is moderate.

Sector	Energy access, reliability and security	Access to markets, international funding and resources	Cost savings	Alignment with national strategies and compliance
Agriculture	✓✓	✓	✓✓	
Commercial (including tourism)	✓✓	✓✓	✓✓	✓
Industrial (including agro-processing and mining)	✓✓	✓✓	✓✓	✓✓
Residential	✓✓		✓✓	
Public	✓	✓✓	✓	✓✓
Transportation	✓✓	✓✓	✓	✓

SECTION 3

BUSINESS OPPORTUNITIES

Photo by Copperbelt Energy Corporation ("CEC Renewables")

Business Opportunities - Methodology

This section details the methodology used for mapping the business opportunities, along with a presentation of the results, which includes the identified opportunities, the prioritization matrix, and the top 10 opportunities identified. The findings were derived through a combination of desk research, interviews, and various stakeholder engagement methods, including a consultative workshop.

Methodology

Business Opportunity Mapping (BOM) is a systematic process designed to survey markets and identify promising business opportunities based on specific investment and impact priorities. The methodology effectively identifies and ranks high-potential business opportunities within specific localities, regions, or countries, targeting those that fulfil pre-defined criteria designed to maximize success probabilities for Small and Medium Enterprises (SMEs) and large-scale investments.

Developed by Chemonics Egypt Consultants in collaboration with The United Nations Industrial Development Organization (UNIDO) Egypt in 2014, the BOM methodology has since facilitated the mapping and assessment of over 350 green and circular economy business opportunities.

Over the years, the methodology has effectively reduced investment risks and channelled financing and technical assistance toward opportunities with high economic, social and environmental returns. Given the challenges associated with acquiring market data in many emerging economies, BOM integrates primary and secondary research alongside stakeholder engagement through interviews and consultative workshops to present essential information to guide priority investment opportunities. It also leverages the Delphi method, a systematic and interactive approach to forecasting and decision-making, relying on diverse expert inputs[1]. The approach aims to efficiently map investment opportunities in a manner that is both streamlined and market-centric. The main output of the BOM includes preliminary investment profiles and basic market information which can inform feasibility studies and other enterprise support, financing or policy development.

The BOM plays a crucial role in enhancing market visibility and supporting decision-making by providing essential market information to allocate resources towards high-potential opportunities.

Feedback from over 100 stakeholders across 30 projects in three countries on the BOM underscores its pivotal role in identifying investment opportunities in targeted sectors. The outcomes of the BOM empower

[1] Investopedia. "Delphi method". Available online: https://www.investopedia.com/terms/d/delphi-method.asp. Accessed on 1 February 2023.

organizations across public, private, and non-governmental sectors, including policymakers, business incubators, accelerators, investors, and financial institutions (FIs), to allocate funds, technical assistance, and other private sector development resources toward high-potential investment opportunities. For example, enterprise support programs such as incubation, acceleration, and growth management programs have effectively tailored their interventions using BOM data. Similarly, off-the-shelf financial products in the green economy have been structured according to BOM insights to meet specific sectoral needs. BOM findings have also guided the development of tailored industrial strategies, aligning national economic goals with investment priorities. Furthermore, international partners and public entities have also utilized BOM data in their investment promotion activities to attract targeted investments into opportunities identified as having significant growth potential as well as environmental and social impact, thereby aligning investor interests with strategic national development goals.

Overview

In mapping and prioritizing the business opportunities, the study leveraged desk research, expert consultations and interviews as well as insights from multiple stakeholder workshops involving diverse practitioners and industry leaders across various sectors and technologies. Key sectors targeted by the business opportunities included agriculture, residential, commercial, and industrial, while technologies such as solar, energy efficiency, electric vehicles, and waste-to-energy were also examined. The opportunities were prioritized using multi-dimensional criteria, encompassing market and economic aspects as well as social and environmental considerations. The mapping also focused on projects viable to be implemented within a two-year investment horizon, under current market conditions, and with minimal policy or legislative obstacles.

The multi-tiered methodology comprised of:

Preliminary Mapping: This involved stakeholder interviews, a comprehensive literature review, as well as insights from Chemonics Egypt's technical and market experts, resulting in 37 business opportunities (BOs).

Consolidation: A consultative process with key stakeholders in Zambia added new business opportunities and clustered markets and technologies, leading to a refined short list of 20 BOs.

User-defined Prioritization: Chemonics Egypt and Zambia's SEC collaboratively developed a multi-criterion scoring system to prioritize business opportunities based on balanced market, social, and environmental impacts, promoting sustainable and inclusive growth. The BOM methodology assesses diverse investment time horizons based on stakeholder inputs, emphasizing opportunities for short-, medium-, and long-term investments aligned with Zambia's current infrastructure, market dynamics, and regulatory environment. Reflecting Zambia's national priorities and SEC's mandate, this process resulted in the identification of the top 10 prioritized business opportunities (BOs). Notably, the criteria and their relative importance can be customized to align with the strategic investment priorities of various entities. The criteria used to assess and prioritize business opportunities for the purpose of the study are as follows:

1. Availability of Supply: Existence of raw materials, equipment, or other necessary supplies for a business operating in this opportunity.
2. Existence of Demand: Market demand for the product or service offered.
3. Market Saturation: Level of competition and the presence of similar products or services in the market.
4. Supply Chain Simplicity: Logistics and supply chain complexity required for the business.
5. Growth Potential: Potential for a business operating in the opportunity to expand and scale based on the market potential.
6. Access to Finance: Availability of funding and financial services for a business operating in the opportunity.
7. Clarity and Simplicity of Regulations and Policies: Clarity and straightforwardness of the regulations and policies.
8. Access to Knowledge: Availability of necessary information and expertise to run a business operating in the opportunity.
9. Availability of Skilled Labour: The presence of a workforce with the skills required for a business operating in the opportunity.
10. Simplicity of Technology: Complexity and accessibility of the technology needed for a business operating in the opportunity.
11. Environmental Impact: Evaluating the potential environmental effects of a business operating in the opportunity.
12. Labour Intensity: The intensity of labour required to produce goods or provide services.
13. Absorptive Capacity for Unemployed/Unskilled Labour: The business's capacity to provide employment opportunities, especially for the unemployed or unskilled workers.
14. Favourability to Women: Degree of inclusiveness and support for female participation in the workforce.

Qualitative grades for the above criteria were assigned numerical equivalents from one to three (3=high, 2=medium, 1=low). A group of market and technical experts from Chemonics Egypt conducted the scoring after conducting the desk research and stakeholder interviews as well as two online workshops, during which stakeholders were invited to validate the scores. As a result, rankings of the short-listed opportunities based on specific criteria were generated. The opportunities were finally presented to a group of diverse stakeholders in a consultative workshop. An equal weighting criterion

was used to identify the top 10 business opportunities for SMEs and investors to succeed and grow, while also achieving social impact in terms of job creation, equitable access to jobs for women, and local economic development.

The heatmap developed aims to enable rapid decision-making on which opportunities to prioritize based on user-defined criteria. However, it should not be used to provide definitive comparisons between opportunities. Its application should be limited to shortlisting top-ranking opportunities.

Factsheet Development: Compiling preliminary market information led to the creation of factsheets for the top 10 BOs. Each factsheet provides high-level information about the market, including the final product, required inputs, and the level of competition. It also covers the process/technology, detailing the complexity, type of process, main equipment and materials, and human resources needed. Furthermore, the factsheets outline forward and backward linkages, key financial features such as primary revenue streams and the intensity of capital expenditures (CapEx) and operational expenditures (OpEx), as well as key challenges, advantages, and the environmental and social impact. These factsheets are designed to facilitate initial investment decisions and to inform feasibility studies.

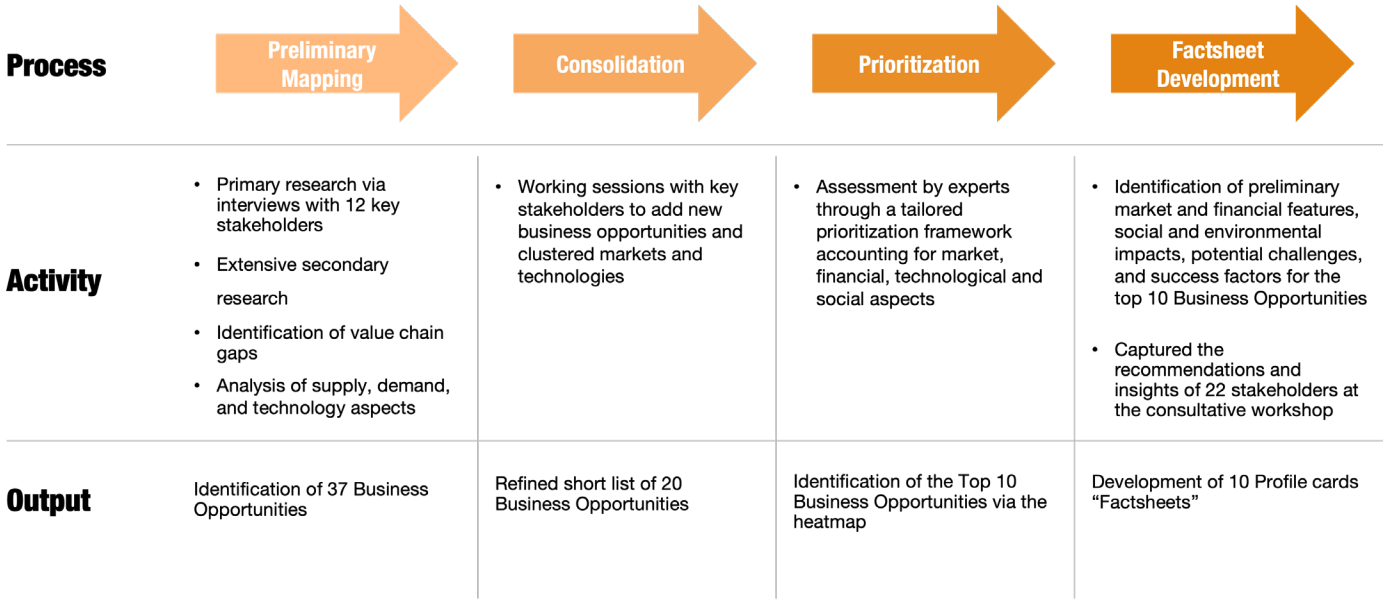

Figure 1: Overview of the methodology

The objective of the BOM methodology is to identify and prioritize near-term, high-potential business opportunities based on multi-dimensional criteria that consider market, social, and environmental impacts.

Based on the BOM, business opportunities were evaluated across diverse sectors including agriculture, residential, commercial, and industrial, and diverse technologies were explored such as solar, energy efficiency, and waste-to-energy.

Results

The analysis of mapped business opportunities in Zambia highlights a diverse array of opportunities along different technological categories and sectors, offering significant potential for both SMEs and large investors to capitalize on emerging trends while also reflecting varying investment timelines that cater to different strategic objectives. Table 2 presents an overview of the 20 BOs.

Mapping

The analysis reveals a broad spectrum of business opportunities across various technology categories, showcasing significant potential in solar energy, waste-to-energy solutions, energy efficiency improvements, and diverse technological innovations. Figure 2 presents the distribution of 20 business opportunities across various technology categories. Waste-to-Energy technologies, both biomass valorisation and municipal waste valorisation, together representing the largest

share, 40%, underscoring the opportunities in converting waste materials into energy. Business opportunities (BOs) leveraging solar technologies (Solar PV and solar thermal) account for the second largest share at 30%, indicating significant potential for solar energy utilization. Energy efficiency follows at 10%, highlighting opportunities in increased efficiency and reducing energy consumption. The remaining 20% cover a range of technologies that add diversity to the overall portfolio such as electric vehicles and their infrastructure.

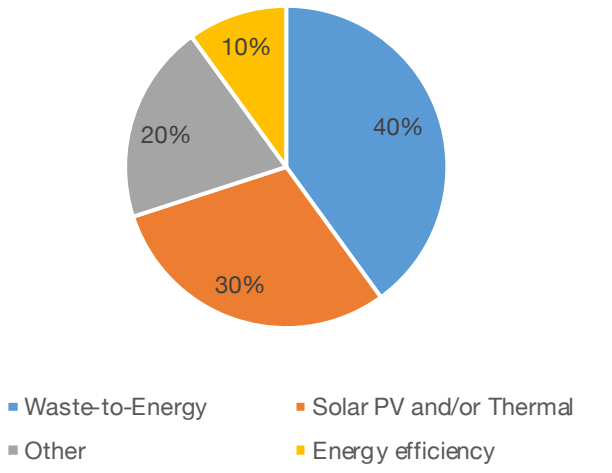

Figure 2 Distribution of main technologies among the 20 BOs

Key demand drivers in Zambia's commercial and industrial sectors, alongside prominent roles of residential and agriculture sectors, underscore **the breadth of business opportunities across varied sectors**, complemented by other sectors contributing to the diverse economic landscape. Figure 3 highlights the diversity of sectors addressed by the mapped BOs in Zambia. Most opportunities serve key sectors, with many targeting multiple segments, while a few are limited to specific customer types. The concentration of opportunities in the commercial and industrial sectors, particularly agro-food processing and mining, underscores the significance of these markets in driving demand for energy efficiency and alternative energy sources in Zambia.

Figure 3 Main sectors served by the 20 BOs (by frequency of occurrence)

The distribution of business opportunities across short-term, medium-term, and long-term investment categories provides strategic insights for investors, highlighting varying timelines suited to different investment objectives in Zambia. Though the go-to-market and implementation timeline greatly depend on the business model and operational expertise of the investor, the BOM also considered investment time horizons based on stakeholders' inputs regarding the potential for assessed businesses to begin implementation and achieve high success rates within Zambia's current state of infrastructure, market dynamics, and policy, legislative, and regulatory framework. A majority, 50%, of the business opportunities are classified as short-term investments, suggesting prospects ready for rapid execution, appealing to investors or businesses seeking immediate action within two years. Next, 30% of the opportunities are categorized as long-term, reflecting opportunities which may take more than five years to mature given the current infrastructure and macro environment in Zambia. Medium-term investments make up 20%, indicating a smaller subset of opportunities expected to reach maturation within two to five years (Figure 4).

According to the methodology discussed above, a consolidated list of 20 business opportunities pertinent to Zambia was developed, as shown in the table below. This table presents a diverse range of opportunities, ranked by their potential success, which ties demand and supply through technologies accessible to the local community. The factsheets for the top 10 opportunities are provided in the Annex. Regardless of their varying degrees of success, these opportunities represent viable businesses that could drive local economic development while leveraging appropriate technologies. Moreover, while the mapped opportunities are not exhaustive, this study is intended to serve as a launch pad for further exploration and development.

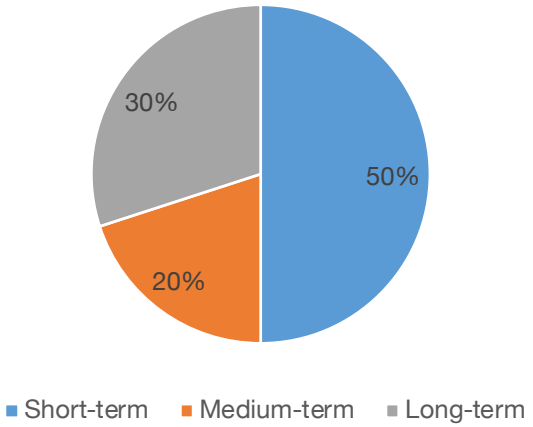

Figure 4 Distribution of the 20 BOs by possible implementation timelines

Table 2 Overview of the 20 mapped business opportunities

Rank	Business Opportunity Title	Supply	Technology	Sectors driving the demand	Investment Horizon
1	Stand-alone Solar PV-powered irrigation systems and Solar PV-powered farming equipment (such as pesticide sprayers) for agriculture applications	PV panels, electric pumps, inverters, cables	Solar PV	Agriculture	Short-term
2	Solar food drying for local consumption and export	Solar collector, solar chimney, drying bin	Solar Thermal	Agriculture; Commercial and Industrial; Export	Short-term
3	Decentralized Solar PV systems for mining, residential, street lighting, food packaging, food storage centres	Solar PV panels, batteries, inverters, cables	Solar PV	Commercial and Industrial, Residential, Public	Short-term
4	Small biogas units for on-farm usage (including for crop, poultry and livestock farms)	Digester, inlet system, storage unit, outlet system, mixed agricultural waste	Waste-to-Energy (Biomass valorisation)	Agriculture	Short-term
5	Solar water heating residential and industrial applications (including for steam generation in food and dairy industrial facilities)	Solar collector, insulated tank, piping	Solar Thermal	Commercial and Industrial	Short-term

Rank	Business Opportunity Title	Supply	Technology	Sectors driving the demand	Investment Horizon
6	Shredded Refuse-Derived Fuel (RDF) from municipal solid waste for energy intensive industries	Municipal solid waste	Waste-to-Energy (Municipal waste valorisation)	Commercial and Industrial	Short-term
7	Efficient (renewable energy powered) cold chain for fruits, vegetables, dairy, and fish storage and distribution (including reefer trucks and refrigerators)	PV panels, vapour compression systems, insulation, batteries	Solar PV and/or Thermal	Agriculture, Commercial and Industrial	Short-term
8	Efficient motors, pumps, and VSDs in industrial and commercial application (including for the mining and textile industries and in telecommunication data centres)	Energy-efficient components	Energy efficiency	Commercial and Industrial	Short-term
9	Biodiesel from used cooking oil (UCO) for export and Pyrolysis oil from plastic and tires waste for industrial boilers	Waste vegetable oil and tires	Waste-to-Energy (Municipal waste valorisation)	Export; Commercial and Industrial	Medium-term
10	Utility scale wind and solar	PV panels, batteries, inverters, cables, wind turbines, wind towers, blades	Solar PV and/or Thermal	Public; Commercial and Industrial	Short-term

Rank	Business Opportunity Title	Supply	Technology	Sectors driving the demand	Investment Horizon
11	Refuse-Derived Fuel (RDF) from municipal solid waste for energy intensive industries	Municipal solid waste	Waste-to-Energy (Municipal waste valorisation)	Commercial and Industrial	Long-term
12	Biogas units for food factories	Digester, inlet system, storage unit, outlet system, mixed agricultural waste	Waste-to-Energy (Biomass valorisation)	Commercial and Industrial	Medium-term
13	Biomass pellets for export	Mixed agricultural waste	Waste-to-Energy (Biomass valorisation)	Export	Medium-term
14	Electric buses for commercial and industrial fleets	Electric buses	Other	Commercial and Industrial	Long-term
15	Biogas for cookers in rural households	Food and animal waste	Waste-to-Energy (Biomass valorisation)	Residential	Medium-term

Rank	Business Opportunity Title	Supply	Technology	Sectors driving the demand	Investment Horizon
16	Smart energy monitoring and metering systems for industrial facilities	Data, sensors, meters, software	Energy efficiency	Commercial and Industrial	Short-term
17	Electric vehicle systems for gas vehicle owners	Assembly lines, electric batteries, electric motors, controllers	Other	Residential	Long-term
18	Electric vehicle charging stations for electric vehicles	Power supply, charging cables, connectors, end-user interface	Other	Residential; Commercial and Industrial	Long-term
19	Combined Heat and Power (CHP) generation from Sewage Sludge (SS) from wastewater treatment plants and factories	Sewage sludge	Waste-to-Energy (Biomass valorisation)	Public; Commercial and Industrial	Long-term
20	Assembled electric batteries for EV automakers	Lithium-ion cells, casing, wires, assembly and packaging lines	Other	Transport	Long-term

Assessment and Prioritization

To prioritize the business opportunities, a multi-criterion scoring system was developed collaboratively by Chemonics Egypt and Zambia's SEC, focusing on balancing market viability with social and environmental impacts. This method evaluated opportunities across 14 criteria, such as market demand, environmental impact, access to finance, and favourability to women. Each criterion was assigned a qualitative grade, converted into numerical scores (from 1 to 3, 3=high, 2=medium, 1=low, and vice versa where applicable).

As demonstrated in Table 3, these scores, indicated by a color-coded heatmap where dark green represents the highest score, yellow represents an average score, and red the lowest, were determined by Chemonics Egypt's experts based on desk research and the stakeholder interviews conducted. The scores were then validated through stakeholder engagement, including two online workshops and a face to face consultative workshop. The heatmap serves as a decision-making tool to help prioritize the top 10 business opportunities. The mapped Business Opportunities (BOs) highlight robust market demand and growth potential across diverse sectors, indicating a balanced competitive landscape with minimal variance in their rankings. Table 3 presents the assessment results of the 20 opportunities.

Solar PV opportunities stand out as the most mature and established. The presence of a variety of solution providers, trained personnel, and a clear governing framework contributes to higher access to finance for solar PV projects compared to other opportunities. This makes solar PV an investment with lower perceived risk, supported by its demonstrated scalability and reliability. This maturity is evidenced by the availability of financing options and the presence of green financing initiatives. In contrast, waste management opportunities, while offering strong social and environmental impacts, including significant employment opportunities, face more complex supply chains and technologies. These complexities lead to limited access to finance, as investors often perceive these projects as higher risk due to the operational challenges and logistical hurdles involved in waste collection and processing. However, the high potential for meeting strong market demand, social impact, particularly in creating jobs for both skilled and unskilled labour, underscores the long-term value of these investments, provided that supply chain and technological challenges can be effectively managed. Investors should also note the significant potential in the biogas sector, particularly for small biogas units for on-farm usage and biogas units in food factories. These opportunities are bolstered by Zambia's abundant agricultural and livestock waste, which can be converted into valuable energy resources. However, similar to waste management, the biogas sector faces challenges related to supply chain complexity and the need for specialized knowledge and infrastructure. Despite these hurdles, the biogas market presents a promising avenue for sustainable energy production with strong environmental and social benefits, especially in rural areas where energy access remains limited.

The market for energy efficiency solutions in Zambia is still in its nascent stage, resulting in limited realized demand. This emerging sector requires increased awareness among potential adopters and a more robust framework to support the adoption of energy-efficient technologies. Despite the current challenges, the potential for energy efficiency solutions to reduce operational costs and improve sustainability makes it an area worth monitoring for future investment opportunities.

Regarding electric vehicles (EVs), this market is viewed as a medium to long-term opportunity in Zambia. The sector requires substantial investment in infrastructure, including charging stations and maintenance centres, to support the adoption of EVs. Additionally, there is a need to develop a strong business case for end-users to drive demand. The growth of this market will depend on the gradual build-up of necessary infrastructure and the continued evolution of the EV ecosystem, making it a longer-term play for patient investors willing to support foundational development.

Overall, while the solar PV market offers immediate investment opportunities due to its maturity, other sectors like waste management and energy efficiency present potential high-impact opportunities that require strategic investment to overcome initial barriers. The development of the EV market, though further off, could also present lucrative opportunities as Zambia's infrastructure and market readiness improve over time.

Table 3 Scoring of the 20 BOs against the 14 criteria

Business Opportunity Title	Availability of Supply	Existence of Demand	Market Saturation	Supply Chain Simplicity	Growth Potential	Access to Finance	Clarity and Simplicity of Regulations, Legislations and Policies	Access to Knowledge	Availability of skilled labour	Simplicity of Technology	Environmental Impact	Labour Intensity	Absorptive capacity for unemployed/unskilled labour	Favourability to Women	Overall
1. Standalone Solar PV powered irrigation systems and Solar PV powered farming equipment (such as pesticide sprayers) for agriculture applications															
2. Solar food drying for local consumption and export															
3. Decentralized Solar PV systems for mining, residential, street lighting, food packaging, food storage centres															
4. Small biogas units for on-farm usage (including for crop, poultry and livestock farms)															

Business Opportunity Title	Availability of Supply	Existence of Demand	Market Saturation	Supply Chain Simplicity	Growth Potential	Access to Finance	Clarity and Simplicity of Regulations, Legislations and Policies	Access to Knowledge	Availability of skilled labour	Simplicity of Technology	Environmental Impact	Labour Intensity	Absorptive capacity for unemployed/unskilled labour	Favourability to Women	Overall
5. Solar water heating residential and industrial applications (including for steam generation in food and dairy industrial facilities)															
6. Shredded refuse-Derived Fuel (RDF) from municipal solid waste for energy intensive industries															
7. Efficient (renewable energy powered) cold chain for fruits, vegetables, dairy, and fish storage and distribution (including reefer trucks and refrigerators)															
8. Efficient motors, pumps, and VSDs in industrial and commercial application (including for the mining and textile industries and in telecommunication data centres)															
9. Biodiesel from waste vegetable oil for export and pyrolysis oil from plastic and tires waste for industrial boilers															

Business Opportunity Title	Availability of Supply	Existence of Demand	Market Saturation	Supply Chain Simplicity	Growth Potential	Access to Finance	Clarity and Simplicity of Regulations, Legislations and Policies	Access to Knowledge	Availability of skilled labour	Simplicity of Technology	Environmental Impact	Labour Intensity	Absorptive capacity for unemployed/unskilled labour	Favourability to Women	Overall
10. Utility scale wind and solar															
11. Refuse-Derived Fuel (RDF) from municipal solid waste for energy intensive industries															
12. Biogas units for food factories															
13. Biomass pellets for export															
14. Electric buses for commercial and industrial fleets															

Business Opportunity Title	Availability of Supply	Existence of Demand	Market Saturation	Supply Chain Simplicity	Growth Potential	Access to Finance	Clarity and Simplicity of Regulations, Legislations and Policies	Access to Knowledge	Availability of skilled labour	Simplicity of Technology	Environmental Impact	Labour Intensity	Absorptive capacity for unemployed/unskilled labour	Favourability to Women	Overall
15. Biogas for cookers in rural households															
16. Smart energy monitoring and metering systems for industrial facilities															
17. Electric vehicle systems for gas vehicle owners															
18. Electric vehicle charging stations for electric vehicles															
19. Combined Heat and Power (CHP) generation from Sewage Sludge (SS) from waste water treatment plants and factories															

Business Opportunity Title	Availability of Supply	Existence of Demand	Market Saturation	Supply Chain Simplicity	Growth Potential	Access to Finance	Clarity and Simplicity of Regulations, Legislations and Policies	Access to Knowledge	Availability of skilled labour	Simplicity of Technology	Environmental Impact	Labour Intensity	Absorptive capacity for unemployed/unskilled labour	Favourability to Women	Overall
20. Assembled electric batteries for EV automakers															

The Top 10 Business Opportunities

The study introduces Table 4, which showcases the top ten Business Opportunities (BOs) ranked in descending order of total score according to selected criteria. As discussed earlier, it is essential to note that BOs not included or ranked lower do not necessarily indicate unviability, highlighting the nuanced factors influencing their prioritization. Decision-makers should conduct comprehensive market analysis, due diligence, and feasibility assessments for more advanced investment decisions tailored to specific technologies, project scales, and Zambia's diverse geographic and economic contexts. Innovative business models, financing strategies, and a focus on practical business model innovation and operational excellence are crucial for ensuring successful implementation, scalability and sustainability of these opportunities' prospects.

Table 4 Top 10 BOs

Business Opportunity Title	Availability of Supply	Existence of Demand	Market Saturation	Supply Chain Simplicity	Growth Potential	Access to Finance	Clarity and Simplicity of Regulations, Legislations and Policies	Access to Knowledge	Availability of skilled labour	Simplicity of Technology	Environmental Impact	Labour Intensity	Absorptive capacity for unemployed/unskilled labour	Favourability to Women	Overall
1. Standalone Solar PV powered irrigation systems and Solar PV powered farming equipment (such as pesticide sprayers) for agriculture applications															
2. Solar food drying for local consumption and export															
3. Decentralized Solar PV systems for mining, residential, street lighting, food packaging, food storage centres															
4. Small biogas units for on-farm usage (including for crop, poultry and livestock farms)															

Business Opportunity Title	Availability of Supply	Existence of Demand	Market Saturation	Supply Chain Simplicity	Growth Potential	Access to Finance	Clarity and Simplicity of Regulations, Legislations and Policies	Access to Knowledge	Availability of skilled labour	Simplicity of Technology	Environmental Impact	Labour Intensity	Absorptive capacity for unemployed/unskilled labour	Favourability to Women	Overall
5. Solar water heating residential and industrial applications (including for steam generation in food and dairy industrial facilities)															
6. Shredded refuse-Derived Fuel (RDF) from municipal solid waste for energy intensive industries															
7. Efficient (renewable energy powered) cold chain for fruits, vegetables, dairy, and fish storage and distribution (including reefer trucks and refrigerators)															
8. Efficient motors, pumps, and VSDs in industrial and commercial application (including for the mining and textile industries and in telecommunication data centres)															
9. Biodiesel from waste vegetable oil for export and pyrolysis oil from plastic and tires waste for industrial boilers															

Business Opportunity Title	Availability of Supply	Existence of Demand	Market Saturation	Supply Chain Simplicity	Growth Potential	Access to Finance	Clarity and Simplicity of Regulations, Legislations and Policies	Access to Knowledge	Availability of skilled labour	Simplicity of Technology	Environmental Impact	Labour Intensity	Absorptive capacity for unemployed/unskilled labour	Favourability to Women	Overall
10. Utility scale wind and solar															

1. Standalone Solar PV-powered irrigation systems and Solar PV-powered farming equipment for agriculture applications.

Off-grid solar photovoltaic (PV) technologies offer promising business opportunities in Zambia's agricultural sector. They provide reliable, clean, cost-effective energy for applications like irrigation systems and solar-powered farming equipment, including pesticide sprayers, greenhouse ventilation, milking machines, etc. Such technologies allow farmers to operate key farm production equipment without relying on fossil fuel-powered equipment, reducing operational costs and Greenhouse Gas (GHG) emissions. The revenue stream primarily comes from the commissioning, sales and maintenance of solar systems and equipment. Other business models could include rental services and subscription-based pay-per-use for portable systems. However, businesses operating in this opportunity could face challenges such as convincing smallholder farmers to adopt the relatively new technologies, dependence on imported components which could affect market demand fulfilment, high initial costs for end-users in the agriculture sector, and a lack of financing options for them. Despite these challenges, the advantages are significant, including reduced operations and maintenance costs compared to traditional fossil fuel-powered systems. A substantial market opportunity is also driven by growing demand for irrigation and expanding agricultural activities in remote or off-grid areas, all contributing to improved farmer livelihoods and sustainable farming practices.

2. Solar-power food drying for farmers and agro-processing factories for local and export markets.

This opportunity offers an alternative to traditional open-air sun drying for farmers and fossil-fuel-based drying equipment for agro-processing facilities, featuring a variety of solar dryers. Solar dryers come in four primary types: passive, indirect, direct, and hybrid, each offering unique benefits suited to different drying needs. Passive solar dryers harness natural air circulation and sunlight without mechanical assistance, making them cost-effective for small-scale operations. Indirect solar dryers employ solar collectors to heat air away from the drying chamber, enhancing control over the drying process and making them ideal for commercial uses where consistent results are necessary. Direct solar dryers expose food directly to sunlight, which can be highly effective but might cause uneven drying. Lastly, hybrid solar dryers integrate solar energy with alternate heating sources like natural gas or electricity, providing flexibility and consistent drying capabilities under varying weather conditions. Applications include on-farm drying, which enables farmers to preserve and enhance the value of their produce, leading to increased income. Solar-powered food dryers also offer commercial food processors an environmentally friendly and cost-effective solution to extend shelf life, reduce spoilage, and produce high-margin value-added products. Revenue streams include selling and maintaining solar dryers as well as providing contract drying services to other farmers or cooperatives. Businesses could also process and export dried herbs, fruits, and vegetables as a revenue stream, adding value to local agricultural products, reducing reliance on imports, and accessing broader markets. Solar drying technology offers multiple benefits, including improving farmer livelihoods by converting harvested produce into storable and tradable goods, suitable for off-season sales or exports. Moreover, the technology is less dependent on external weather conditions than open field drying, producing more consistent output. The controlled drying process ensures improved food quality and safety, increases nutrient retention, and extends shelf life, reducing food waste and increasing market reach. These advantages are significant for both local consumption and exports, enhancing income for farmers and processors and contributing to food security in regions lacking reliable drying methods or stable access to processed food. Challenges for adopting solar power food dryers include persuading farmers to switch from traditional open-air drying methods and the high initial costs for end-users. Food processors often struggle with unfamiliarity with various technologies and identifying reliable service providers. Additionally, farmers and processors may encounter marketing, and sales difficulties.

3. Decentralized Solar Photovoltaic (PV) systems for multiple residential, commercial and industrial applications including mining, residential, street lighting, food packaging, food storage centres.

Decentralized solar photovoltaic (PV) systems offer an alternative, or complement, to traditional grid-based power for applications ranging from residential and street lighting to industrial mining and food storage. These systems utilize solar panels to convert sunlight into electricity directly, reducing dependence on centralized power generation and transmission infrastructure. These systems can function independently (standalone) or connect with neighbouring systems forming a mini-grid (or a microgrid). They can work alongside the main grid (grid-tied) or store excess energy in batteries (with battery storage), adapting to diverse needs and preferences. The revenue stream primarily comes from the commissioning, sales and maintenance of the solar systems and equipment. Other business models could include franchising, where construction firms deploy and sell power through microgrids, and the ESCO Model, which involves energy service companies operating decentralized systems for a fixed fee, reducing upfront costs for customers while limiting their control. Decentralized solar PV systems provide several benefits, including reduced energy costs, improved energy security, and stability. They also have a lower environmental impact than conventional energy sources and increase power access in remote areas. However,

several factors need careful consideration. These challenges include the substantial initial investment costs and at time, the current structure of electricity tariffs. Additionally, large-scale projects may require specialized expertise that exceeds local capacity. Moreover, there is a dependency on imported equipment, which introduces risks of supply chain disruptions and potential gaps in meeting demand.

4. Small-scale biogas units for on-farm usage (including for crop, poultry and livestock farms).

Small-scale biogas units in rural areas utilize anaerobic digestion within sealed digesters to transform organic waste, including manure, into biogas primarily consisting of methane and carbon dioxide. The biogas produced is used for cooking, heating, lighting, or electricity generation, while the by-product, a nutrient-rich digestate, is a beneficial fertilizer that enhances soil health and crop yields. The systems present socio-economic and environmental advantages, such as reducing dependence on firewood and kerosene, decreasing greenhouse gas emissions, and providing effective waste management. For small-scale agricultural applications, using biogas directly for cooking and heating with brick structures is often sufficient. Traditional red clay bricks, known for their affordability and durability, contribute to cost-effective solutions and local job creation. Beyond reducing energy costs and increasing security, small biogas units enhance environmental sustainability and farm productivity by offering an alternative energy source and producing bio-based farming inputs, thus reducing the need for chemical fertilizers and minimizing transportation costs due to the availability of on-farm waste. Revenue streams include the commissioning, sales, and maintenance of the systems and other complimentary home appliances to utilize the energy, such as cooking stoves. Businesses providing small-scale biogas units face several challenges, including unclear policies and regulations for construction and installation and the absence of certification schemes for the systems, which may reduce the barrier to the entry of competitors. The high upfront costs also pose a significant barrier for farming end-users, alongside the need to increase awareness and acceptance to enhance adoption.

The 2018 Livestock and Aquaculture Census in Zambia reported a substantial livestock population, including 3.7 million cattle, 3.5 million goats, and 15 million village chickens, predominantly raised by small-scale farmers. This growing livestock population underscores the increasing need for effective manure management solutions to mitigate environmental harm. The valorisation of this waste presents a significant opportunity for sustainable development, turning a potential environmental burden into a valuable resource.

5. Solar Water Heating (SWH) systems for residential and industrial applications:

Solar Water Heating (SWH) systems present a viable business opportunity in residential and industrial settings, offering reduced energy bills and increased, stable hot water availability. In residential applications, replacing conventional water heating systems with Solar Water Heaters (SWHs) can significantly lower household energy consumption and electricity costs, resulting in substantial long-term savings. These systems provide a reliable and consistent source of hot water, particularly during peak demand periods. In industrial contexts, SWHs can preheat water for various processes, significantly reducing energy consumption and operational expenses in industries like food and beverage as well as textiles. SWHs provide a reliable hot water supply, enhancing industrial production efficiency. Advanced SWH systems can reach high temperatures for steam generation, especially in industries like food processing and dairy, reducing the need for traditional boilers and fossil fuels. The main technologies include flat plate collectors for low to medium temperatures (up to 80°C), commonly used in residential settings, and evacuated tube collectors, which are highly efficient and can achieve temperatures up to 120°C. For industrial steam generation, concentrated solar power (CSP) systems, such as parabolic trough and linear Fresnel collectors, are used. These systems should be paired with storage and backup systems to ensure stable operation. Revenue streams for this business opportunity include the commissioning, sales, and maintenance of solar water heating systems. It could also include energy savings contracts where revenue is generated from the energy costs saved by the customer and service agreements for regular performance monitoring and system optimization. The challenges in implementing solar water heating systems include high initial costs for end-users to purchase the systems, limited financing options, difficulty accessing high-quality suppliers, and dependence on imported components, which may hinder meeting market demand.

6. Shredded Refuse-Derived Fuel (RDF) from municipal solid waste for energy-intensive industries.

Refuse-Derived Fuel (RDF) is a processed fuel from non-recyclable materials found in municipal solid waste (MSW). The creation of RDF involves sorting and processing MSW to extract recyclable and inert materials, leaving a combustible waste fraction. This fraction is then treated further by sorting, shredding, and processing to achieve uniformity in size, moisture content, and calorific value, making it suitable as an alternative to traditional fossil fuels like natural gas and coal in various industrial energy production settings. Once prepared, RDF is transported to energy-intensive industries such as cement plants, steel mills, or power generation facilities where the alternative fuel source is either co-fired with traditional fuels or used as the sole fuel in specific boilers for heat and/or electricity

generation. Revenue streams include the sales of RDF, gate fees for waste intake, sales of recovered materials like metals, and revenues from carbon credit trading. The flexibility of using RDF enables facilities to reduce their dependence on conventional fossil fuels, promoting more sustainable industrial operations. RDF can also provide a cost-effective alternative for industries with high energy demands, potentially lowering operational costs. The macro benefits of RDF encompass improved waste management, which includes diverting waste from landfills to fuel production, enhancing resource recovery, and minimizing landfill impacts. RDF supports material recovery, advances waste management practices, reduces reliance on fossil fuels, and lowers GHG emissions from landfills and industrial facilities using the alternative fuels. It also helps foster social and economic advantages by creating jobs, particularly for marginalized and unskilled labour. Additionally, RDF can act as a hedge against volatile natural gas and coal prices and decrease dependence on imported fuels, thereby enhancing energy security and economic resilience. However, investors in RDF could face several challenges. Complex or unclear regulations for landfill concessions, permitting processes as well as other waste access and processing aspects can create uncertainty potentially causing delays, increased project costs, and restricted access to suitable landfills. A critical success factor for businesses in this industry is achieving supply chain excellence to secure the necessary volumes for serving energy-intensive industrial facilities, coupled with operational and quality excellence to maintain RDF's quality and calorific value. However, these efforts can be compromised by variations in feedstock quality, sorting, processing inefficiencies, and limited access to appropriate working capital financing to finance the cash-intensive operations. Moreover, the availability of MSW for RDF production can be affected by local traders and informal waste collection, coupled with competition for feedstock from other waste valorisation-focused projects. Furthermore, the scarcity of local expertise in operating and maintaining RDF processing plants add to the challenges.

GHG emissions from industry are expected to contribute about 2% of Zambia's GHG emissions by 2030 and that from waste will contribute about 1%.

7. Efficient (renewable energy-powered) cold chain for fruits, vegetables, dairy, and fish storage and distribution (including reefer trucks and refrigerators).

The term «cold chain» refers to controlling the temperature of perishable goods from the point of origin to the point of consumption to ensure quality and safety, avoiding texture degradation, coloration, bruising, and microbiological growth[2]. Cold chain solutions, spanning the entire value chain, offer a significant opportunity for investors in Zambia, particularly in efficient cold storage and distribution for fruits, vegetables, dairy, and fish. In 2021, Zambia produced 1.5 million tonnes of fresh fruit, vegetables, meat, dairy, and fish, requiring an estimated 145,000 to 290,000 cold room units[3]. On-farm cold storage can enable farmers to preserve their harvests for longer, reducing post-harvest losses and increasing income. Technological opportunities include portable forced air mobile coolers for smallholder farmers with limited storage facilities, offering temporary on-site cooling solutions that maintain product quality and enhance marketability. Coolers can also be solar PV-powered to increase reliability and reduce operational expenses. Additional solutions could include biomass, solar PV, solar thermal, or hydro-powered pre-cooling units near production sites for commercial farmers to lower initial product temperatures, thereby reducing energy consumption in subsequent cooling stages and prolonging shelf life. In the mid-stream, cold storage units near consumption centres for wholesalers can maintain product quality close to markets, reduce spoilage during distribution, and facilitate just-in-time inventory management. Refrigerated trucks, «reefers», are vital in delivering perishable goods with sustainable, temperature-controlled transport, minimizing spoilage during distribution. Small-scale reefer trucks offer affordable, fuel-efficient designs, including solar-powered options for remote areas, increasing market access, reducing spoilage, and improving income for small producers. Reefer trucks for large-holder farmers, food processors, and exporters enhance long-distance transport, expand market reach, and maintain product quality. In the downstream, commercial and industrial refrigeration utilizing renewable energy provides a steady and reliable energy source for cooling and freezing. Revenue streams include the sales and maintenance of the units, rental and/or pay-as-you-store of storage space for wholesale markets or smallholder farmers. Investors should consider the high initial investment required for some system types. While initially more expensive than conventional systems, long-term energy savings, reduced food losses, and increased crop quality and profitability can offset these investments. Limited financing options for such systems' often high upfront costs also pose a challenge. Additionally, ensuring proper maintenance and technical support, which may not be readily available in Zambia, is critical for optimal performance.

In 2021, Zambia produced 1.5 million tonnes of fresh fruit, vegetables, meat, dairy, and fish, requiring an estimated 145,000 to 290,000 cold room units.

[2] PManifold and Intellecap. «Assessment of the Cold Chain Market in Kenya.» (2023). Available online: https://sun-connect.org/wpcont/uploads/Assessment-of-the-Cold-Chain-Market-in-Kenya.pdf). Accessed: 23 July 2023.

[3] EEP Africa. «Cold Chain Storage Market Assessment 2023.» Available online: Cold-chain-storage-market-assessment-2023.pdf (eepafrica.org). Accessed on 5 July 2023.

8. Efficient motors, pumps, and Variable Speed Drives (VSDs) in multiple industrial and commercial applications:

Energy-efficient motors, pumps, and Variable Speed Drives (VSDs) enhance industrial and commercial operations by optimizing energy usage; they adjust motor speeds, improve pump performance and flow control, and allow for precise speed adjustments in VSDs to meet varying process demands efficiently. Energy-efficient motors can enhance energy consumption and electricity savings while maintaining or improving performance. Compared to traditional motors, they offer efficiency gains, resulting in substantial savings over time. Efficient pumps can reduce energy consumption by minimizing friction and ensuring efficient operations. Variable Speed Drives (VSDs) enable precise motor speed control, optimizing performance and energy savings. Certain technologies can capture and reuse braking energy, connect to industrial communication networks, and facilitate remote monitoring and control. In telecommunication data centres, VSDs with efficient pumps and fans in cooling systems can significantly reduce energy consumption, a critical factor in data centre operations. In textile manufacturing, VSDs provide precise speed control of spinning and weaving machines, ensuring consistent quality while minimizing energy usage. In mining, optimizing high-power pumps with VSDs and using efficient drives for conveyor belts contribute to substantial energy savings in large-scale operations. Revenue streams in this BO encompass direct commissioning, sales and installations of complete systems for end-users/off-taker and performance-based contracts that guarantee energy savings and share the financial gains with customers. A subscription service can also be offered, providing equipment and ongoing monitoring, maintenance, and performance optimization to ensure continual efficiency improvements. Challenges in adopting energy efficiency solutions include a lack of end-user awareness about potential savings, reliance on imported components, and general unfamiliarity with the various available technologies, business cases, and possible financing models and sources.

9. Biodiesel from Used Cooking Oil (UCO) for export and pyrolysis oil from tires waste for industrial boilers.

The biodiesel process transforms UCO from industrial, commercial, and residential sectors into a clean-burning alternative to traditional diesel fuel. The BO offers export potential to countries with strict GHG emission regulations and environmental benefits like reduced greenhouse gas emissions and air pollution. On the other hand, pyrolysis oil technology breaks down tire waste through thermal decomposition to produce fuel oil for industrial boilers. The BO addresses waste management issues by converting waste into a valuable resource and offers a cost-effective fuel alternative for industrial facilities, contributing to a circular economy. While biodiesel production is relatively established with existing export markets, pyrolysis technology may need further development and market validation. Both technologies create employment in waste management value chains, contribute to landfill diversion, reduce CO^2 emissions, and help end-users hedge against fossil fuel price fluctuations and shortages. Revenue streams include direct sales of biodiesel and pyrolysis oil. Challenges in the BO include managing efficient logistics for collecting and processing UCO or waste tires, maintaining consistent quality of waste feedstock, ensuring reliable transportation for both feedstock and finished products, securing skilled labour to meet export or local quality standards, navigating environmental permitting processes, and adapting technologies to suit local feedstock and operating conditions. Challenges also include limited access to appropriate working capital financing to finance the cash-intensive operations.

10. On-site utility scale wind and solar PV for large-scale agriculture, commercial and industrial applications.

On-site utility-scale wind and solar generation offer significant business opportunities, especially for large-scale agriculture, commercial, and industrial applications. The systems can be installed as hybrid or stand-alone, depending on the site-specific requirements. Based on the off-takers load profiles, they may necessitate backup power sources or energy storage solutions. Revenue streams include the direct commissioning, sale, and installation of complete energy systems. Power Purchase Agreements (PPAs) also enable solar firms to finance, construct, own, and operate systems, selling electricity to clients at a predetermined rate. An ESCO model can also be implemented by financing, installing, and maintaining energy systems, with off-takers repaying the investment through the energy savings achieved. Investors may also develop large solar farms, offering customized subscriptions to multiple customers. Hybrid technology models can also be designed to align with specific customer needs and risk preferences, providing tailored energy solutions. The advantages of this BO include mitigating grid instability and potential blackouts, which are essential for uninterrupted operations in sectors like mining. It offers energy security and stability with potentially lower electricity costs, especially in areas with unreliable grid access, and reduces reliance on expensive, volatile-priced fossil fuels. On-site generation allows for tailored energy production to fit the facility's schedule and needs, can support off-takers in achieving GHG emission reduction goals, and access competitive financing for renewable energy production. However, disadvantages include the high upfront investment required for infrastructure and installation. Technical expertise in operating and maintaining renewable systems can also be challenging to access. Additionally, on-site land use for wind turbines or solar panels and grid connection challenges, which might require additional infrastructure, are significant considerations.

SECTION 4

OVERVIEW OF THE GOVERNING AND ENABLING LANDSCAPE

Overview of the Governing and Enabling Landscape

Zambia has taken important steps toward paving the path for renewable energy (RE) and energy efficiency (EE) business opportunities (BOs). This section is not meant to present a comprehensive assessment of the governing and enabling environment, but rather set the context for the current investment environment and the connection with the business opportunities mapped.

National Strategies and Master Plans

Rural Electrification Master Plan (REMP 2008) formulates a comprehensive strategy for increasing rural electrification in Zambia up to 2030. The plan focuses on expanding the national grid, creating isolated mini-grids using renewable and conventional energy sources, and deploying solar home systems, with the goal of increasing the rural electrification rate from 3% to about 51% by 2030. It also proposes funding mechanisms, including an electrification levy, to support these initiatives. Rural electrification will significantly increase energy demand for lighting, cooking, space heating, cooling, and other essential services, creating substantial opportunities for energy efficiency. Additionally, it will drive the demand for renewable energy sources to meet these growing needs sustainably and could enable, in the medium and long terms, the expansion of electric vehicles. The identified business opportunities align with REMP in presenting solutions such as solar PV-powered irrigation and other post-harvest equipment, solar water heaters, as well as biogas units, which are crucial for meeting the increased energy demand in rural areas[1].

National Policy on Climate Change (NPCC 2016) provides a comprehensive framework to ensure the implementation of current and future initiatives that achieve sustainable development through a coordinated national response to climate change. The policy's goals include climate mitigation and adaptation, particularly in the agriculture, energy, and industrial sectors, which are responsible for 25.5% of Zambia's emissions. It emphasizes the development and transfer of affordable climate adaptation and mitigation technologies, aligning with numerous business opportunities identified in this study. The policy's focus on promoting green investments, including renewable energy and energy efficiency, directly correlates with the business opportunities mapped, highlighting the potential for these sectors to drive Zambia's green transition[2].

National Energy Policy (NEP 2019) in Zambia aims to guide the country's energy sector towards achieving reliable, sustainable, and affordable

[1] Japan International Cooperation Agency (JICA), 2008. "The Study for Development of the Rural Electrification Master Plan in Zambia". Available online: REMP for Zambia Final Report Summary (jica.go.jp). Accessed on 5 July 2023.

[2] Federal Ministry of Environment, 2013. "National Policy on Climate Change (NPCC)." Available online: Available online: National Policy on Climate Change (NPCC). | UNEP Law and Environment Assistance Platform. Accessed on 22 July 2023.

energy services by 2030. The policy focuses on increasing access to electricity, promoting energy efficiency, and diversifying the energy mix through the exploitation of renewable energy sources. It also emphasizes the importance of private sector participation, innovation, and research in driving the sector's growth[3]. Key renewable energy technologies identified by the policy, including solar, wind, biomass, and waste-to-energy, align closely with the investment opportunities highlighted in this study.

Energy Efficiency Strategy and Action Plan (EESAP 2022)

in Zambia aims to promote the efficient use of energy across various sectors, reduce energy costs, and enhance economic growth while minimizing greenhouse gas emissions. It seeks to achieve a 2% annual decrease in Total Primary Energy Supply (TPES) by 2030 through regulatory frameworks, energy audits, and market-based mechanisms that drive the adoption of energy-efficient technologies. It serves as an implementation guideline for the National Energy Policy (NEP) 2019. The EESAP defines specific actions, targets, expected outcomes, and timelines, along with designated implementation bodies, to drive energy efficiency across the residential, industrial, and transport sectors. These sectoral action plans form a valuable database for private investors looking to contribute to the national target of increasing energy efficiency[4]. The business opportunities identified in this study align with the EESAP by covering energy efficiency initiatives alongside renewable energy supply, supporting Zambia's broader green transition goals.

Renewable Energy Strategy and Action Plan (RESAP 2022)

The strategy was developed to provide a roadmap for renewable energy (RE) development in Zambia from 2022 to 2030, specifically targeting barriers to the RE transition and aiming to accelerate it. It focuses on increasing both grid-connected and off-grid renewable energy systems, as well as biofuels and biomass, by setting technology-specific targets that catalyse the markets for the investment opportunities identified in the study. In addition to setting these targets, the RESAP outlines detailed action plans designed to create significant impact, with specified timelines and responsibilities defined and adopted by the Ministry of Energy. Furthermore, the strategy includes an action plan for developing and implementing financing mechanisms and capacity-building initiatives[5].

The Interim Guidelines for Handling of Carbon Markets and Trading in Zambia (2022)

was issued by the Ministry of Green Economy and Environment (MGEE). The Interim Guidelines provide preliminary administrative measures and procedures to regulate and manage Zambia's carbon market until the Climate Change Act is enacted. They identify eligible projects across various sectors, including renewable energy promotion, fuel switching, energy efficiency, agriculture, transportation, waste management, and reforestation. The guidelines also aim to promote renewable energy sources, encourage the transition from high-carbon fuels to lower-carbon alternatives, and enhance energy efficiency on both the supply and demand sides[6]. The guidelines align with the business opportunities identified in the study, offering a framework for carbon trading that supports renewable energy and energy efficiency investments.

Nationally Determined Contribution (NDC) Implementation Framework (updated in 2023)

outlines the country's commitment to reducing greenhouse gas emissions by up to 47% by 2030 with substantial international support, focusing on key sectors like energy, agriculture, and waste management. One of the framework's main pillars is the promotion of renewable energy and energy efficiency, which directly aligns with the business opportunities identified in this study[7]. These opportunities, such as investments in solar energy, biogas, and energy-efficient technologies, are crucial for achieving the NDC's goals while fostering sustainable economic development and resilience to climate change in Zambia.

The National Adaptation Plan for Zambia (NAP 2023)

aims to enhance the country's resilience to climate change by identifying and addressing vulnerabilities across key sectors, including agriculture, water, infrastructure, and health. It outlines medium to long-term adaptation actions that integrate climate resilience into national, sectoral, and sub-national planning and budgeting processes. The NAP emphasizes strengthening institutional capacities, improving coordination mechanisms, and mobilizing resources for implementing prioritized adaptation strategies[8]. As Zambia increasingly experiences the adverse effects of climate change, including droughts, there is a strong push to diversify energy sources, reducing reliance on hydropower and charcoal as the main power and heat energy sources in the country. The business opportunities identified in this study align with these goals, offering pathways to diversify the nation's energy mix and decrease dependence on fossil fuels.

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[3] Ministry of Energy, 2019. "The National Energy Policy 2019." Available online: The National Energy Policy 2019 - Ministry of Energy Integrated Resource Plan (moe.gov.zm). Accessed on 22 July 2023.

[4] Ministry of Energy, 2022. "Zambia Energy Efficiency Strategy and Action Plan 2022."Available online: Zambia-Energy-Efficiency-Strategy-and-Action-Plan-2022.pdf (moe.gov.zm). Accessed on 22 July 2023.

[5] Renewable Energy Strategy and Action Plan, Ministry of Energy, Republic of Zambia, 2022. Available online: https://www.moe.gov.zm/wp-content/uploads/2022/08/Renewable-Energy_final-file_for-web.pdf, Accessed on: 27 December 2023.

[6] Ministry of Green Economy and Environment, 2022. "Zambia Carbon Markets and Trading Interim Guidelines." Available online: https://www.moiramukuka.com/zambia-carbon-markets-and-trading-interim-guidelines/). Accessed on 2 February 2024.

[7] Government of Zambia, 2021. "Revised and Updated Nationally Determined Contribution (NDC) 2021." Available online: Microsoft Word - Final Zambia_Revised and Updated_NDC_2021 .doc (unfccc.int). Accessed on 2 February 2024.

[8] National Adaptation Plan for Zambia, Republic of Zambia, 2023. Available online: https://unfccc.int/sites/default/files/resource/NAP-Zambia-2023.pdf. Accessed on 10 January 2024.

The Eighth National Development Plan (8NDP) for Zambia, covering the period from 2022 to 2026, is centred on the theme of «Socio-Economic Transformation for Improved Livelihoods». The 8NDP is structured around four key strategic development areas: Economic Transformation and Job Creation, Human and Social Development, Environmental Sustainability, and Good Governance Environment. These areas are designed to address the country's most pressing challenges, including low economic diversification, high unemployment, and significant poverty and inequality. The 8NDP emphasizes the importance of economic transformation through job creation, industrialization, and diversification of the economy, particularly in sectors like agriculture, mining, tourism, and manufacturing. Additionally, the plan underscores the need for investments in energy, ICT, and infrastructure to support these sectors[9]. The business opportunity mapping conducted on renewable energy and energy efficiency aligns closely with the objectives and priorities outlined in the 8NDP. By identifying and prioritizing key opportunities within Zambia's energy sector, the mapping exercise directly supports the plan's goals of economic diversification, sustainable development, improved livelihoods, and environmental sustainability.

Selected Standards, Laws, Regulations, and Decrees Zambia has taken important steps to create a robust governing environment that supports sustainable development and energy security. The below sample of standards, laws, regulations, and decrees alongside the aforementioned national strategies and plans, like the National Energy Policy and the National Adaptation Plan, establish a healthy enabling environment for the business opportunities identified in renewable energy and energy efficiency as well as other climate-resilience and sustainability related initiatives. Together, they foster investment, innovation, and sustainable practices that are critical for advancing Zambia's green economy.

[9] Ministry of Finance and National Planning, 2022. "Eighth National Development Plan (8NDP) 2022-2026." Available online: 8NDP (2022-2026) - Ministry of Finance and National Planning (mofnp.gov.zm). Accessed on 10 January 2024.

Category	Title	Relevance
Climate resilience	Environmental Management Act – Act No. 12 of 2011. In 2023, the was also amended.	- Provides a framework for integrated environmental management, the protection and conservation of the environment and the sustainable management and use of natural resource.
Sustainability Reporting	Zambia Institute of Chartered Accountants (ZICA) adopted two sustainability reporting standards, IFRS S1 and IFRS S2	- Promotes green and sustainability efforts. These standards are mandatory for listed companies and optional for others, with reporting set to begin in January 2026. - ZICA advises entities to implement these sustainability standards alongside the Integrated Reporting framework for reporting periods starting January 1st, 2025, leading to reporting initiation in 2026. - Non-listed firms can voluntarily adopt the Integrated Reporting framework. - ZICA plans training sessions in 2024 and 2025 to aid members, including accountants, in understanding and implementing these standards. - Furthermore, the Green Finance Mainstreaming Working Group has arranged consultations between BIOFIN consultants and ZICA's technical committee from March 18th to 28th, 2024.
Energy security and stability	Electricity Act – Act No. 11 of 2019[1]	- Regulates the generation, transmission, distribution and supply of electricity to enhance security and reliability of electricity supply - Provides for the sale and purchase of electricity within and outside the Republic under net metering. - Facilitates adequate levels of investment in the electricity sector. - Provides for a multi-year tariff framework. - Promotes transparency in the identification and allocation of risks, costs and revenues within and between participants in the electricity sector.
Energy use, access and efficiency	Zambian Distribution Grid Code of 2016	Establishes the basic rules, procedures, requirements and standards that govern the operation, maintenance, and development of the electricity distribution systems in Zambia to ensure the safe, reliable, and efficient operation of distribution system[2].
	Energy Regulation Act – Act No. 12 of 2019	Establishes the Energy Regulation Board (ERB) mandated to (1) determine, regulate and review charges and tariffs in the energy sector, and (2) approve, review and regulate PPAs and power supply agreements.
	Statutory Instrument No. 5 of 2023 of Act No. 12 of 2019	- Provides for the procedure applicable in the Tribunal mandated to hear appeals against decisions of the ERB that a party is aggrieved with. - Establishes a fair and efficient means to challenge perceived unfair or incorrect decisions, thereby contributing to the integrity and effectiveness of the energy regulatory system[3].
	Rural Electrification Act – Act No. 5 of 2023	- Promotes and enhances rural electrification. - Continues the existence of the Rural Electrification Authority and re-defines its functions. - Continues the existence of the Rural Electrification Fund.

[1] The Electricity Act, 2019, National Assembly of Zambia. Available online: https://www.parliament.gov.zm/node/8267. Accessed on 10 January 2024.

[2] Zambian Distribution Grid Code, Energy Regulation Board. Available online: https://getfit-zambia.org/wp-content/uploads/2019/07/ZambiaDistributionCode00457395xB0385.pdf. Accessed on 10 January 2024.

[3] Energy Laws and Regulations 2024, Zambia. Available online: https://www.globallegalinsights.com/practice-areas/energy-laws-and-regulations/zambia. Accessed on 10 January 2024. Ministry of Agriculture, 2022. "National Agricultural Policy 2022." Available online: zam219945.pdf (fao.org). Accessed on 16 August 2023.

As of 2023, Zambia has not yet enacted the planned Climate Change Act, but climate change-related provisions are embedded within existing laws, particularly the Environmental Management Act of 2011, which was amended in August 2023. These amendments strengthen the legal framework for environmental protection by integrating climate change adaptation and mitigation measures. Key changes include promoting low carbon emissions, conducting greenhouse gas inventories, ensuring equitable sharing of benefits from environmental resources, enhancing resource efficiency, and advancing green economy principles. The amendments also introduce stricter regulatory requirements for environmental assessments and improved monitoring of compliance in key sectors[10]. This integration aligns with Zambia's climate goals and supports business opportunities in renewable energy, energy efficiency, and sustainable practices.

Private Sector-Related Policies and Support Programs

Zambia has established a number policies and programs that directly support businesses willing to invest in renewable energy and energy efficiency measures. The Zambian government is striving for a supportive investment environment by promoting adequate foreign investor policies. In this section, some support programs for renewable energy projects are listed.

ZDA Act No. 17. The Zambia Development Agency (ZDA) issued an Act in 2006 and extended it in 2022 to define fiscal and non-fiscal incentives for different investment categories[11]. Investors who invest USD 500,000 or above in the Multi Facility Economic Zones (MFEZ) or a priority sector or product under the ZDA Act are entitled to a five-year exemption of the import duty rate and an accelerated depreciation on capital equipment. Investments of USD 250,000 and above in a Multi Facility Economic Zone, an Industrial Park, a Priority Sector and investment in a Rural Enterprise under the ZDA Act are entitled to investment guarantees and protection against state nationalization and free facilitation for a number of application of permits from the government.

Zambia Scaling Solar Programme. is in force since 2015[12]. Scaling Solar is based on the principle of tariff minimization and uses a competitive auction bidding process to determine the lowest tariff and consequently the winning bid to develop the allocated amount of solar PV power at a given location. As a result of this programme, the first round of the Zambia Solar PV Tender was issued in 2016 for proposals for 100MW of solar PV power under 25-year Power Purchase Agreements (PPAs). The second round was issued for 300MW in 2017 and multiple projects have been implemented under the Scaling Solar Programme. A second Scaling Solar project has been awarded in 2018 by the International Finance Corporation (IFC), a member of the World Bank, and the Canadian government with a total fund of approximately USD 25 million[13].

GET FiT and REFiT Zambia is another support mechanism funded by the KFW for the period 2018-2024 to support the procurement of renewable energy capacities in Zambia[14]. Some objectives of the programme are the procurement of 200MW of renewable energy capacity and diversifying the Zambian energy mix for Zambian end users. The GET FiT programme also includes debt and risk mitigation and grid facilities, as well as viability gap funding and technical assistance for key stakeholders in Zambia.

Alternatives to Charcoal is a USAID-funded project for the period from January 2021 – January 2026 with a total budget of USD 24.9 million. The aim of the project is to use a market-driven approach to shift the dependence of urban household cooking away from charcoal towards private sector-led, low-emissions technologies and fuels to reduce deforestation and carbon emissions[15]. This project supports investments in the biomass and biofuel sectors that are hindered by cultural barriers and who suffer from poor business enabling conditions and value chain inefficiencies.

ElectriFi is an EU-funded impact investment facility for the period January 2016 – January 2032 to finance early-stage and small-sized projects focusing on electricity access and generation from renewable energy sources. The project is targeting sub-Saharan Africa with a total budget of EUR 254 million and has specified country windows, where Zambia has been allocated a EUR 31 million budget. ElectriFi project provide equity, quasi-equity, debt or guarantee for typical business models including mini-grids, solar home systems, independent power projects (IPP) and captive power production. Ticket sizes range from EUR 0.5 – 10 million capped at 50% of the project cost[16].

While this section offers a snapshot of the growing and improving environment for investment opportunities in renewable energy, energy efficiency, and other green economy aspects, it is not exhaustive. The presentation

[10] Ministry of Agriculture, 2022. "National Agricultural Policy 2022." Available online zam219945.pdf (fao.org). Accessed on 16 August 2023.

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[14] GET FiT project. Available online: https://getfit-zambia.org/about-get-fit. Accessed on: 9 January 2024.

[15] Alternatives to Charcoal Project. Available online: https://www.usaid.gov/zambia/fact-sheet/alternatives-charcoal. Accessed on 12 January 2024.

[16] EDFI ElectriFI project. Available online: https://www.electrifi.eu/about/mandate-funders/. Accessed on 12 January 2024.

of this information is not intended to be fully cohesive, as there are many more initiatives, programs, and enabling environment aspects that contribute to Zambia's evolving green economy landscape. This section serves to illustrate the positive trajectory and the increasing support for sustainable investments in the country.

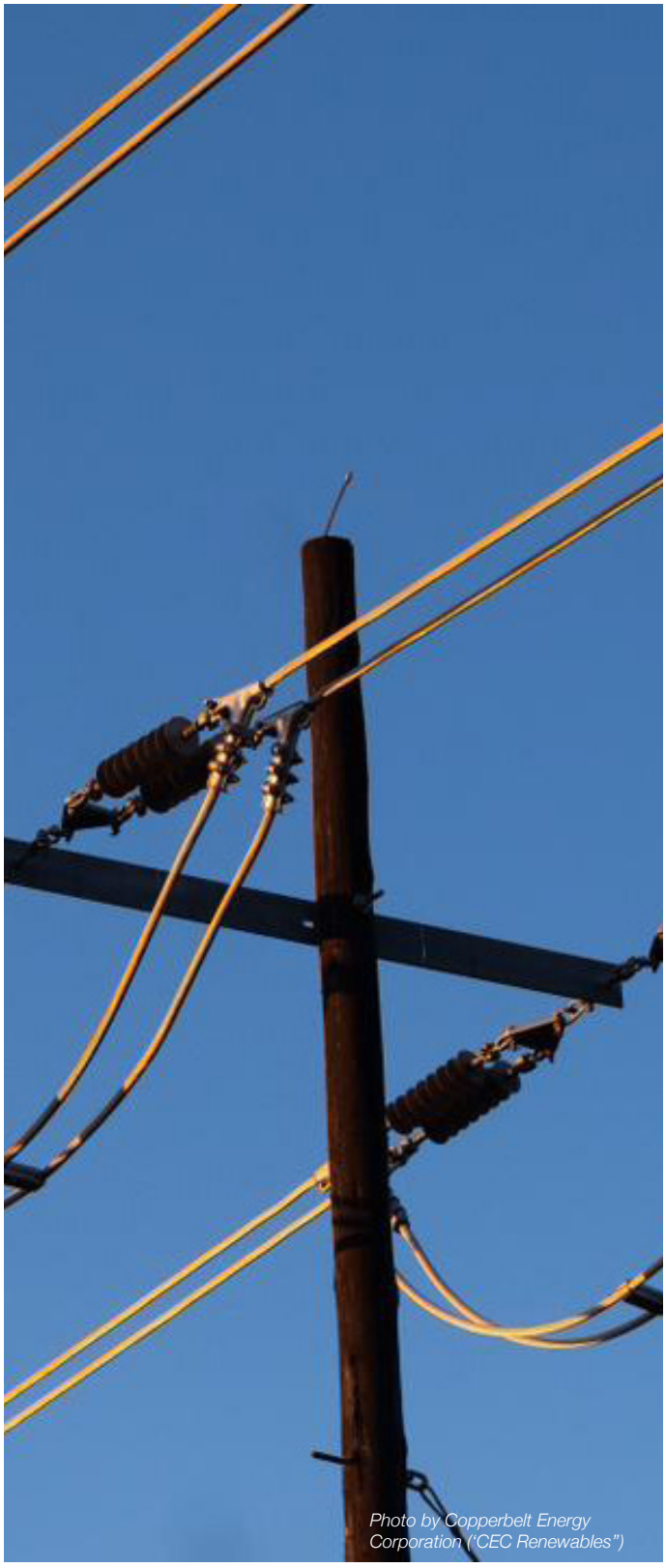
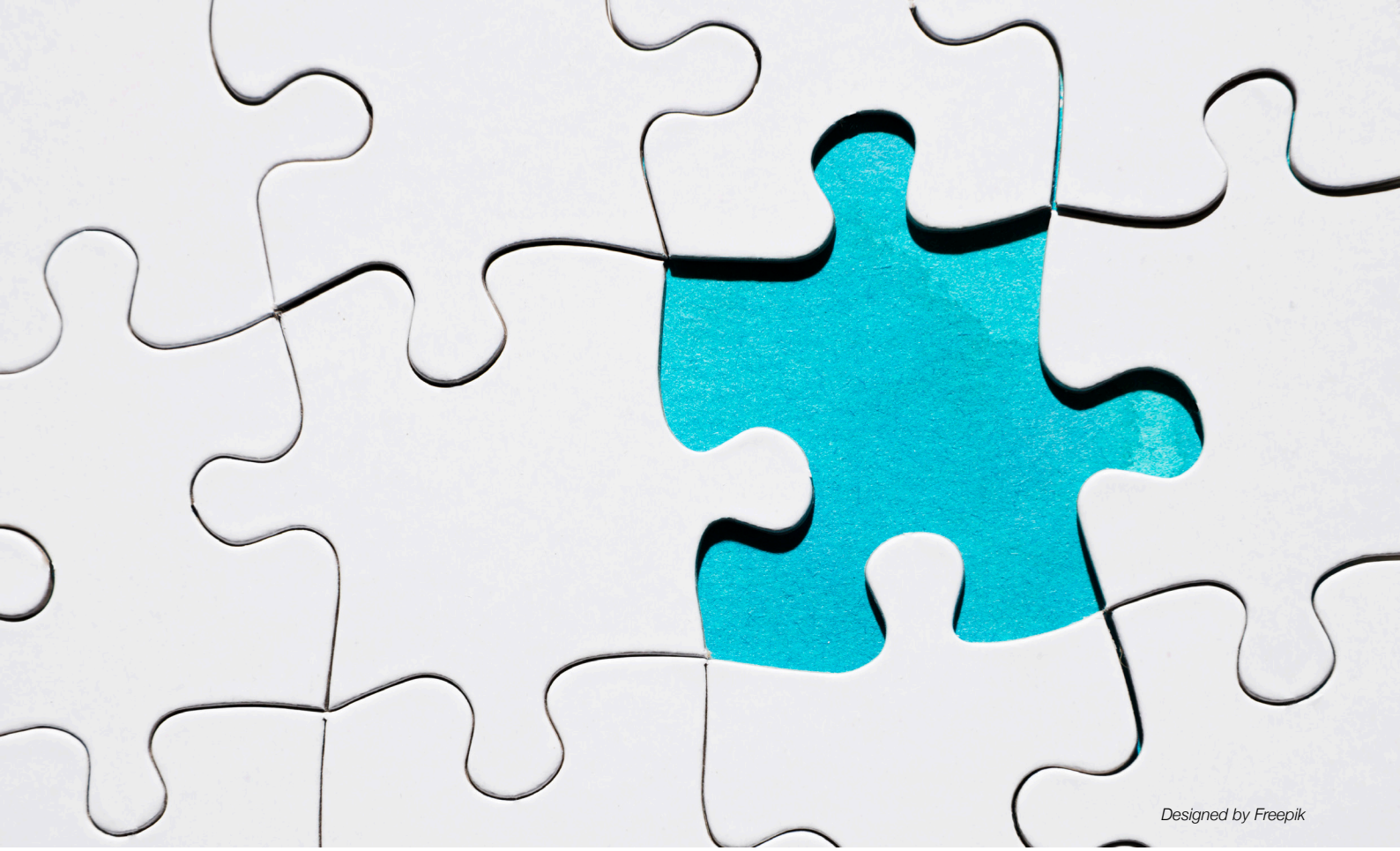


Photo by Copperbelt Energy Corporation ("CEC Renewables")

SECTION 5

CONCLUSION & WAY FORWARD



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Conclusion and Way Forward

The study underscores the significant potential and diversity of business opportunities (BOs) within Zambia's renewable energy and energy efficiency sectors. By mapping and prioritizing opportunities with a high likelihood of success, the study aims to stimulate investment, drive economic growth, and deliver substantial social and environmental benefits.

Designed to guide investors, market enablers, and SMEs, the study provides critical market insights and helps bridge information gaps. The Business Opportunity Mapping (BOM) methodology employed, incorporating desk research, stakeholder consultations, and expert input, ensures that the identified opportunities are well-aligned with Zambia's national priorities and prevailing market conditions. The approach not only identifies but also prioritizes high-potential business opportunities, thereby enhancing market visibility and enabling stakeholders across public, private, and non-governmental sectors to strategically allocate resources towards impactful investments.

Through a systematic process, the study identified and ranked 20 promising BOs, ultimately narrowing the focus to the top 10 opportunities based on a multi-dimensional set of criteria. These criteria considered various factors, including market demand, growth potential, supply chain simplicity, access to finance, job creation, environmental impact, and regulatory clarity. The mapping exercise reveals a diverse array of high-potential business opportunities within Zambia's renewable energy and energy efficiency markets, spanning technologies such as waste-to-energy (from biomass and municipal solid waste), solar PV, solar thermal, energy efficiency, and electric mobility. These opportunities cater to a wide range of sectors, including agriculture, commercial enterprises, and industrial entities, and can be realized across different timelines, from short-term to long-term.

By providing expert-driven and stakeholder-informed insights into market opportunities, this study aims to shed light on promising avenues for investment. It serves as a complement to, rather than a replacement for, more detailed feasibility studies. By enhancing access to comprehensive market information and directing efforts toward viable opportunities, the study facilitates informed decision-making and supports sustainable economic development in Zambia. While the study may not cover every possible opportunity given Zambia's dynamic landscape, it serves as a springboard for further exploration, investment, and the development of renewable energy and energy efficiency solutions. Moreover, it aims to highlight opportunities that align with Zambia's key national strategies and contribute to the country's green transition.

Way Forward

The study highlights a targeted subset of near-term opportunities that are closely aligned with current market dynamics and supportive regulatory frameworks, complementing Zambia's national strategies as of 2023. Serving as an initial business opportunity mapping exercise, the study aims to spark further market analyses, detailed feasibility assessments, SME support initiatives, and investment promotion activities within Zambia's renewable energy and energy efficiency sectors.

Drawing from the stakeholder engagement conducted during the study, the following low-hanging fruit actions are recommended for immediate follow-up to capitalize on these identified opportunities.

- ***Comprehensive Market Studies:*** Stakeholders are encouraged to undertake detailed market studies on the identified business opportunities to gather more data that can shape future projects. These studies should provide critical market insights, such as the market size of these opportunities and the volumes and growth rates of municipal and agricultural waste generation. Additionally, stakeholders are urged to develop pre-feasibility studies for selected business opportunities (BOs) and detailed feasibility studies for the most promising ones. These studies should delve into key market, technology, policy, regulatory aspects, and financial indicators, ultimately further demonstrating the bankability of selected BOs and creating a pipeline of investable projects.

- ***Investment Promotion Events:*** It is recommended to organize investment promotion events to disseminate the findings of this study. These events could include informational webinars, business-to-business (B2B) networking sessions for stakeholders engaged with the BOs, and peer-to-peer knowledge exchange workshops. Featuring investors and entrepreneurs already working in these sectors, such events can facilitate access to vital information, foster linkages with key stakeholders, and unlock market-centric financing opportunities, along with tailored technical assistance programs.

- ***Sector-Specific Support Programs:*** There is a pressing need to expand the availability of high-quality, vetted private sector service and solution providers to meet the growing demand for renewable energy and energy efficiency solutions. These providers are crucial for technology transfer, deployment, and after-sales services, and can help lower adoption barriers by offering access to knowledge and financing for key end-users, including farmers and factories, while building a compelling business case. However, there are limited enterprise support programs in Zambia and across Africa that provide tailored technical assistance and investment readiness programs for private sector entities, including start-ups and SMEs. Expanding such programs is essential, as these enterprises form the backbone of African economies and are pivotal in driving the clean energy and resource-efficient transition.

- ***Tailored Financial Instruments:*** The development of innovative green financing instruments is essential to enable both providers and adopters of renewable energy and energy efficiency solutions. These instruments are crucial for supporting widespread adoption and the development of sustainable projects, particularly given the high upfront cost for many of the technologies mapped for end-users. There is a need for readily available financial products that can help end-users adopt these typically capital-intensive solutions. Additionally, tailored financing programs for start-ups, SMEs, and large-scale projects deploying these solutions, such as mezzanine financing products, green bonds, and carbon credits, are vital to driving the growth of Zambia's green economy.

The study is intended to catalyse informed decision-making and strategic investments within Zambia's renewable energy and energy efficiency sectors. By fostering an enabling environment and encouraging sustainable investment practices, the study aims to position Zambia as a regional hub for green investments. This effort is expected to attract international partners and drive innovation in green financing instruments, ultimately contributing to Zambia's leadership in the transition to a sustainable and resilient energy future.

SECTION 6

ANNEX

Business Opportunity Factsheets

Having identified the top ten business opportunities, a factsheet for each BO was developed to present key data and information. Below is a sample business opportunity (BO) factsheet. Each factsheet provides the necessary information pertaining to each opportunity and the base for further elaboration. The factsheets cover the following six main aspects of the business opportunity:

1. Market
2. Process
3. Business linkages
4. Economic features
5. Considerations
6. General impact

The factsheets provide an overview of the main pillars that shape an investment decision. If a business opportunity is deemed of interest, then the information presented in the factsheet can be used to assess the feasibility of the opportunity. Below is a description of the factsheet and the factsheets for the top 10 BOs.

The fact sheets serve as a foundational guide for SMEs, investors, market enablers, and policymakers to identify and capitalize on the most promising renewable energy and energy efficiency opportunities in Zambia.

• For SMEs and start-ups, this document offers a crucial starting point that provides initial insights into viable business models. However, it is essential for these enterprises to build upon this base, developing more detailed strategies and innovations that cater to their specific contexts. The identified opportunities are not exhaustive, and there remains potential for further innovation and expansion beyond what is mapped here.

• Investors can utilize the factsheets as a valuable tool to navigate the market, understand the landscape of existing and emerging opportunities, and align their investments with high-potential sectors. The insights provided on CAPEX estimates, market demand, and risk factors will be instrumental in guiding investment decisions, while the data can also support due diligence processes and feasibility assessments.

• Market enablers, including incubators and accelerators, can leverage the factsheets to better tailor their support programs, focusing on sectors and opportunities that demonstrate strong market demand and potential for social and environmental impact. This approach ensures that their interventions are both impactful and aligned with national development goals.

• Policymakers will find the factsheets useful for shaping supportive regulations and policies that encourage the growth of green industries. By expanding on the concepts introduced in this study, they can drive targeted support to the identified opportunities, fostering innovation and ensuring that the green economy in Zambia grows sustainably and inclusively.

BO FACTSHEET #: Title of business opportunity	
Market	
Final Products	Provides a general description of the final product.
Required Inputs	Required supply (feedstock, raw material), equipment, etc. to realize the BO.
Level of Competition	Description of the level of existing competition (low – medium – high)
Process	
Complexity - Type of Process	Assesses the level of complexity of the typical operational processes (simple- moderate – high). Also, illustrates the categorical type of the production process.
Technology	Mentions what is perceived to be the most appropriate technology
Equipment & Material	The main required equipment and material (not exhaustive).
Human Resources	Presents the key operational human resources needed
Business Linkage	
Forward Linkage	Types of markets/clients.
Backward Linkage	Types of suppliers.
Economic features	
Key Revenue Stream(s)	Refers to main revenue streams (not exhaustive).
CapEx	Describes the CapEx (High – medium – Low)
OpEx	Describes the OpEx (High – medium – Low)
Considerations	
Key Challenge(s)	Key challenges that the business model must tackle.
Advantages	Highlights key advantages of the opportunity compared to others in the markets and given the project objectives.
General Impact	
Environmental	Highlights possible environmental impacts in its broader context of resource preservation or energy efficiency.
Social	Highlights possible social impact, including improved livelihood, job creation and the integration of vulnerable communities.

BO FACTSHEET 1: Standalone Solar PV-powered irrigation systems and other farming equipment for agriculture applications	
Market	
Final Products	Solar PV-powered irrigation and other farming equipment (such as including pesticide sprayers, greenhouse ventilation, milking machines)
Required Inputs	Electric components and equipment
Level of Competition	Medium competition - diesel-powered pumps and rainfed irrigation
Process	
Complexity - Type of Process	Medium - integration process
Technology	Design, assembly, and installation
Equipment & Material	Solar PV panels, inverters, electric pumps, supporting frames
Human Resources	Manual labour, technicians, and electrical engineers
Business Linkage	
Forward Linkage (Clients)	Farmers
Backward Linkage (suppliers)	System and component suppliers
Financial features	
Key revenue stream(s)	Sales and maintenance of solar irrigation systems
CAPEX	Medium – system components and equipment
OPEX	Low - salaries and maintenance
Considerations	
Key Challenge(s)	• Lack of end-user awareness requiring effective marketing Depending on imported components might lead to failure to meet market demand • High initial cost for end-users • Limited availability of certified suppliers, which increases competition from uncertified suppliers • Heavy reliance on imported components can be a risk due to challenges related to importing or currency volatility • Lack of end-user financing options and instruments • Lack of end-user awareness regarding any available financing instruments and products

Advantages	• Abundant solar irradiance • Reduced operations and maintenance costs compared to traditional diesel-powered systems • Reliable alternative to rainfed irrigation • Time saving for farmers compared to diesel-powered irrigation • Growing demand for irrigation due to reduced and fluctuating rainfall patterns
General Impact	
Environmental	• Reduced CO^2 emissions compared to conventional energy sources • Reduced air pollution compared to conventional energy source • Potential increase in yield
Social	• Sustainable and more reliable energy access for farming • Improved farmer livelihoods due to potential increase in yield • Development and expansion of irrigation in rural and off-grid locations

BO FACTSHEET 2: Decentralized Solar PV systems for mining, residential, street lighting, food packaging, commercial and industrial facilities	
Market	
Final Products	Decentralized solar PV systems
Required Inputs	Electric components and equipment
Level of Competition	Medium competition - existing access to the grid and diesel generators
Process	
Complexity - Type of Process	Medium - integration process
Technology	Design, assembly, and installation
Equipment & Material	Solar PV panels, inverters, electric pumps, supporting frames, and batteries
Human Resources	Manual labour, technicians, and electrical engineers
Business Linkage	
Forward Linkage (Clients)	Mining, commercial, industrial, and residential sectors
Backward Linkage (suppliers)	System and component suppliers
Financial features	
Key revenue stream(s)	Sales and maintenance of solar PV systems
CAPEX	Medium to high, depending on the scale – mainly driven by the cost of system components and equipment
OPEX	Medium - salaries and maintenance
Considerations	
Key Challenge(s)	• Non-cost reflective tariffs lead to longer payback periods • For large-scale projects, higher technical experience and skills are required • High initial cost for end-users • Limited access to certified suppliers, which increases competition from uncertified suppliers • Heavy reliance on imported components can be a risk due to challenges related to importing or currency volatility

Advantages	• Provides a reliable source of energy and strengthens energy security for clients • Reduced energy costs compared to traditional energy sources from the grid • Abundant solar irradiance
General Impact	
Environmental	• Reduced CO^2 emissions compared to conventional energy sources • Reduced air pollution compared to conventional energy source
Social	• Sustainable and reliable energy source that increases energy access in off-grid and rural areas

BO FACTSHEET 3: Small-scale biogas units for on-farm usage	
Market	
Final Products	Small-scale biogas units (Energy + Bio-fertilizers)
Required Inputs	Steel sheets and fittings
Level of Competition	Medium competition - fertilizers, compost agricultural waste, butane tanks, and fresh manure
Process	
Complexity - Type of Process	Low - mechanical process
Technology	Machining, assembly, and installation
Equipment & Material	Welding machines, manual tools, steel sheets, pipes, fittings, and mechanical testing
Human Resources	Manual labour, technicians, chemical and mechanical engineers
Business Linkage	
Forward Linkage (Clients)	Farm owners
Backward Linkage (suppliers)	System and component suppliers
Financial features	
Key revenue stream(s)	Sales and maintenance of biogas units
CAPEX	Low - cost of machinery
OPEX	Low - cost of materials processing, and operations
Considerations	
Key Challenge(s)	• Long starting time and technical failures • Lack of farmers' awareness of system benefits • Lack of end-user awareness requiring effective marketing
Advantages	• A simple and effective waste management solution through the complete utilization of available waste to produce bio fertilizers and energy • Minimum transportation required by the end-users because the needed waste is available on-farm • A cost-saving solution to produce biofertilizers and energy

General Impact	
Environmental	• A source of bio-fertilizers that promotes sustainable and organic agriculture • Safe disposal of agricultural and animal waste • Provides renewable energy source that leads to CO^2 emissions reductions and smaller carbon footprint
Social	• Cost-saving solution for farmers which allows them to strengthen their revenue and eventually improve their livelihoods • Cleaner neighbourhoods from animal and agricultural waste, which reduces disease-related risks • Creates job opportunities for unskilled labour in the installation of the units

BO FACTSHEET 4: Shredded Refuse-Derived Fuel (RDF) from municipal solid waste for energy intensive industries	
Market	
Final Products	Shredded Refuse Derived Fuel (RDF) (Energy)
Required Inputs	Combustible municipal solid waste and machinery
Level of Competition	Medium competition- fossil fuels and biomass
Process	
Complexity - Type of Process	Medium - material handling and processing
Technology	Collection, sorting, shredding
Equipment & Material	Press, baler, and shredding machinery
Human Resources	Manual labour, machine operators, and drivers
Business Linkage	
Forward Linkage (Clients)	Energy-intensive industries
Backward Linkage (suppliers)	Landfill operators, waste management companies, and system and component suppliers
Financial features	
Key revenue stream(s)	Sales of shredded RDF
CAPEX	Medium - cost of machinery
OPEX	High - working capital to process material and transportation
Considerations	
Key Challenge(s)	• High initial investment cost • Complicated or unclear regulations for landfill concession can lead to uncertainty in permitting and licensing • Maintaining the calorific value and moisture content for RDF • Scarcity of local expertise in maintaining and processing RDF processing plants • Local traders and informal waste collection can affect the supply levels of MSW

Advantages	• Can satisfy the energy demand in energy-intensive industries • Provides a reliable source of energy compared to conventional energy sources
General Impact	
Environmental	• Reduces landfill disposal, which preserves valuable land space • Provides a sustainable energy source and reduces the reliance on fossil fuels, which decreases greenhouse gas emissions • The segregation and screening of MSW offer the opportunity to enhance the recovery of resources that can be recycled and reused
Social	• Creates employment opportunities in waste management, processing, and transportation subsectors • Increased return on MSW

BO FACTSHEET 5: Solar food drying for local consumption and export	
Market	
Final Products	Solar drying bins
Required Inputs	System components and equipment
Level of Competition	High - open field drying
Process	
Complexity - Type of Process	Low - thermal process
Technology	Design and assembly
Equipment & Material	Solar collector, drying chamber, vents, temperature and humidity controls (optional)
Human Resources	Manual labour, technicians, and electrical engineers
Business Linkage	
Forward Linkage (Clients)	Farmers
Backward Linkage (suppliers)	System and component suppliers
Financial features	
Key revenue stream(s)	• Sales and maintenance of solar dryers • Providing contracted drying services to end-users
CAPEX	Low – system components and equipment
OPEX	Low - cost of maintenance and salaries
Considerations	
Key Challenge(s)	• Lack of end-user awareness requiring effective marketing • High initial cost for end-users • Lack of end-user financing options and instruments • Lack of end-user awareness regarding available financing instruments and products
Advantages	• Less dependent on external weather conditions compared to open field drying • Consistent output quality, increased nutrient retention, and longer shelf life • Controlled and enclosed drying attracts fewer flies, microbes, and dust

General Impact	
Environmental	• Adds value to harvested produce • Reduced food loss and waste • Reduced reliance on fossil fuels in hybrid drying systems, which decreases greenhouse gas emissions
Social	• Increases farmers' income by transforming their harvested produce into storable and tradable goods that can either be sold off-season at higher prices or exported

BO FACTSHEET 6: Solar water heating residential and industrial applications	
Market	
Final Products	Solar water heaters
Required Inputs	System components and equipment
Level of Competition	High - traditional heating systems
Process	
Complexity - Type of Process	Medium - integration process
Technology	Design, assembly, and installation
Equipment & Material	Solar collector, insulated tank, heat exchanger, pumps, supporting frame, and pipes
Human Resources	Manual labour, technicians, and electrical engineers
Business Linkage	
Forward Linkage (Clients)	Residential and industrial clients
Backward Linkage (suppliers)	System and component suppliers
Financial features	
Key revenue stream(s)	• Sales and maintenance of solar water heating systems • Sales of hot water to the end users
CAPEX	Medium - system components and equipment
OPEX	Medium - salaries and maintenance
Considerations	
Key Challenge(s)	• High initial investment cost for end-users • Lack of end-user financing options and instruments • Lack of end-user awareness regarding available financing instruments and products • Limited access to certified suppliers, which increases competition from uncertified suppliers • Heavy reliance on imported components can be a risk due to challenges related to importing or currency volatility

Advantages	• Abundant solar irradiance • Lowers energy consumption and reduces electricity costs • Solar water heaters provide a reliable and consistent source of hot water, particularly during peak demand hours • Energy-efficient water heating process compared to traditional heating
General Impact	
Environmental	• Reduced CO^2 emissions compared to conventional energy sources • Reduced air pollution compared to conventional energy sources
Social	• Creates employment opportunities in the solar energy sector

BO FACTSHEET 7: Efficient (renewable powered) cold rooms	
Market	
Final Products	Efficient (renewables powered) cold rooms
Required Inputs	System components and equipment
Level of Competition	Low - existing cold chain solutions
Process	
Complexity - Type of Process	Medium - mechanical cooling
Technology	Vapor compression
Equipment & Material	Compressor, condenser, expansion valve, evaporator, refrigerant, and insulation
Human Resources	Manual labour, technicians, and electrical engineers
Business Linkage	
Forward Linkage (Clients)	Farmers and wholesale markets
Backward Linkage (suppliers)	System and component suppliers
Financial features	
Key revenue stream(s)	• Sales and maintenance of the units • Rental and pay-as-you-store of storage space for wholesale markets or smallholder farmers
CAPEX	Medium - system components and equipment
OPEX	Low - energy costs and maintenance
Considerations	
Key Challenge(s)	• High initial investment cost for end-users, especially farmers • Lack of end-user financing options and instruments • Lack of end-user awareness regarding any available financing instruments and products • Heavy reliance on imported components can be a risk due to challenges related to importing or currency volatility • Low end-user awareness regarding potential benefits

Advantages	• Availability of various flexible business models, such as pay-as-you-store and rental models, can maximize the revenue streams • Ability to upscale the solutions by establishing partnerships with institutions that support smallholder farmers • Low operating cost systems in comparison with electricity-powered cold storage units. • Ability to integrate different types of renewable energy sources offers operational flexibility
General Impact	
Environmental	• Reduces food loss and waste due to product quality preservation • Increases product shelf-life • Reduced CO^2 emissions compared to conventional cooling systems
Social	• Improved smallholder farmers' profitability by allowing them to store their produce and to strategically sell it when the market supply is weak

BO FACTSHEET 8: Utility scale wind and solar	
Market	
Final Products	Wind and solar energy systems
Required Inputs	System components and equipment
Level of Competition	Medium – conventional energy sources
Process	
Complexity - Type of Process	High - Design and integration
Technology	Design, assembly, installation, and integration
Equipment & Material	Solar PV panels, inverters, batteries Wind turbines, blades, towers, nacelles, control systems
Human Resources	Manual labour, technicians, and electrical engineers
Business Linkage	
Forward Linkage (Clients)	Agricultural, commercial, and industrial end-users
Backward Linkage (suppliers)	System and component suppliers
Financial features	
Key revenue stream(s)	• Sales and maintenance of energy systems • Sales of electricity via Power Purchase Agreements (PPAs)
CAPEX	High - cost of system and components
OPEX	Medium - salaries and maintenance
Considerations	
Key Challenge(s)	• Lack of technical expertise in mega-scale renewable energy systems • Additional infrastructure might be required due to on-grid connection challenges • High upfront investment • Heavy reliance on imported components can be a risk due to challenges related to importing or currency volatility

Advantages	• Abundant solar irradiance • Reduces reliance on expensive, volatile-priced fossil fuels • Acts as a reliable and steady energy source by mitigating grid instability and potential blackouts • Helps in achieving energy security by relieving the reliance on hydropower as the main energy source
General Impact	
Environmental	• Reduced CO^2 emissions compared to conventional energy sources • Reduced air pollution compared to conventional energy sources
Social	• Create new employment opportunities in the manufacturing, installation, and maintenance of system components and related infrastructure • Strengthens the access to electricity for end-users

BO FACTSHEET 9: Efficient motors, pumps, and VSDs in industry and commercial application	
Market	
Final Products	Efficient motors, pumps, and VSDs
Required Inputs	System components and equipment
Level of Competition	Low - limited competition from energy efficiency solutions
Process	
Complexity - Type of Process	Medium - integration and installation processes
Technology	Installation
Equipment & Material	Variable Speed Drives (VSDs), pumps, and efficient motors
Human Resources	Manual labour, technicians, and electrical engineers
Business Linkage	
Forward Linkage (Clients)	Industrial and commercial clients
Backward Linkage (suppliers)	Component suppliers
Financial features	
Key revenue stream(s)	• Sales and maintenance of the components • Rental and leasing of equipment • Subscription services for equipment and related services like monitoring, maintenance, and performance optimization • Performance contractual agreements
CAPEX	Medium – system components and equipment
OPEX	Low - maintenance and salaries
Considerations	
Key Challenge(s)	• Lack of awareness for the potential savings associated with energy efficiency solutions • Dependence on imported components might lead to failure to fulfil market demand
Advantages	• Enhances operational energy consumption that leads to electricity savings • Energy efficiency equipment and components can optimize performance and ensure efficient operations

General Impact	
Environmental	• Reduced CO^2 emissions compared to conventional energy sources • Reduced air pollution compared to conventional energy sources
Social	• Creates job opportunities for engineers and technicians

BO FACTSHEET 10: Biodiesel and pyrolysis oil from used cooking oil and tires	
Market	
Final Products	Biodiesel and pyrolysis
Required Inputs	Used cooking oil, waste tires, and machinery
Level of Competition	Medium - traditional lubrication oil and diesel
Process	
Complexity - Type of Process	High - Chemical processes
Technology	Transesterification for biodiesel and pyrolysis for pyrolysis oil
Equipment & Material	For biodiesel production: Reactor, filters, purifier, tanks, testing equipment For pyrolysis oil: Shredder, auto-feeder, pyrolysis reactor, buffer tanks, condensers, and cooling towers
Human Resources	Manual labour, machine operators, and drivers
Business Linkage	
Forward Linkage (Clients)	Industrial, commercial, and residential end-users
Backward Linkage (suppliers)	System and component suppliers Biodiesel: Residential and food sectors for the biodiesel Pyrolysis oil: Tires waste generators from any type of vehicle (commercial, residential, or industrial)
Financial features	
Key revenue stream(s)	Sales of biodiesel and pyrolysis oil
CAPEX	Medium – cost of machinery
OPEX	High - working capital for material processing and transportation
Considerations	
Key Challenge(s)	• Unclear regulations about waste management, processing, and standardization of final product • Time-consuming environmental permitting processes • Logistical challenges in collecting and processing used cooking oil and waste tires • Ensuring consistent quality of feedstock waste • Access to affordable financing for processing facilities

Advantages	• Avoid shortages and fluctuations in fossil fuel prices • High availability of unutilized supply of used cooking oil and waste tires • Conversion of waste into energy sources offers a cost-effective fuel alternative for industrial facilities Conversion of waste into energy sources contributes to the circular economy
General Impact	
Environmental	• Reduced CO^2 emissions compared to conventional energy sources • Reduces landfill disposal, which preserves valuable land space
Social	• Creates employment opportunities in waste management, processing, and transportation subsectors

SECTION 7

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