EVALUATING INVESTMENT INCENTIVES AND POLICY FRAMEWORKS FOR SCALING UP SOLAR ENERGY DEPLOYMENT IN ZAMBIA

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Approval of the Thesis

EVALUATING INVESTMENT INCENTIVES AND POLICY FRAMEWORKS FOR SCALING UP SOLAR ENERGY DEPLOYMENT IN ZAMBIA

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Doctor of Philosophy (PhD) in Business

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Abstract

EVALUATING INVESTMENT INCENTIVES AND POLICY FRAMEWORKS FOR SCALING UP SOLAR ENERGY DEPLOYMENT IN ZAMBIA

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Zambia’s pursuit for sustainable economic development relies on energy access, particularly in off-grid areas. Despite high solar energy potential, private-sector investments in the country remain low, raising questions about the status of institutional policy and deployment support mechanisms. This study investigates the suitability of financial, fiscal, and non-monetary incentive mechanisms for public and private solar institutions, and their influence on solar-sector investments. Anchored on the Technological Innovation Systems (TIS) perspective, the study addresses a gap between resource potential and investment outcomes by evaluating existing incentive structures in the context of policy, markets, and deployment.

A quantitative, correlational approach was employed to examine relationships between institutional investment incentives and private-sector solar investment performance. Low electronic response rates in the pilot stage prompted face-to-face administration of structured questionnaires to participants across solar related public and private organisations including donor and intermediary institutions in the solar sector value chain. Probability sampling from a purposively defined sampling frame was applied. Data analysis was through the use of IBM SPSS statistical tool to establish relationships and effects of incentives on outcome variables, namely private-sector investment rates (PSIR) and return on investment (ROI).

Findings revealed that financial incentives such as loans and grants, exhibited weak to non-significant effects on investment outcomes, suggesting limited standalone influence. Fiscal incentives demonstrated varied, mostly weak relationships with investment performance, indicating partial effectiveness of incentives thus requiring complementary approach with other incentives. Non-monetary incentives showed the most varied results where measures aimed at lowering initial costs and improving affordability, positively correlated with investment, while location, value or type based measures exhibited negligible effects. Overall, incentive effectiveness was modest and uneven, highlighting the need for integrated, context-specific, and scale-appropriate frameworks supported by stable regulatory, institutional, and market environments.

The study's implications underscore the necessity for inclusive policy designs, streamlined working processes, and capacity-building initiatives to strengthen private-sector participation. Additionally longitudinal, comparative, and contextual research to evaluate incentive performance over time is recommended. Empirical evidence on incentive effectiveness, from this research contributes to theory, informs policy and practice, and offers actionable guidance to policymakers, investors, and development partners in Zambia's solar energy sector.

Declaration

I declare that this thesis has been written exclusively by myself and that it has not been previously submitted, either in whole or in part, in any application for a degree. Except where stated otherwise by reference or acknowledgment, the work presented is entirely mine.

AI Acknowledgment

Use of AI:

I acknowledge my use of Chat GBT (https://chat.openai.com/) to paraphrase and summarize some sections of this dissertation including introduction, literature, methods and findings. This action was completed in 10th November 2024.

The prompts used included: ‘Concisely summarise’, ‘appropriately rephrase’, ‘Rearrange information’ and ‘Restructure’

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Dedication

I dedicate this dissertation to my beloved wife Abigail, whose encouragement and understanding helped me through the challenges of this academic journey. To my children, Mwiza and Wane, ‘Your naive boundless enthusiasm towards life inspired me to persist and achieve this milestone’. My gratitude extends to the Zambia Air Force for the generous support towards a successful pursuit of this study. Special appreciation to my supervisor, Dr. Sayyed Ziaei Mahdi, for his relentless guidance and invaluable mentorship through the research process.

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TABLE OF CONTENTS

List of Abbreviations

ACE-TAF	Africa Clean Energy Technical Assistance Facility
AfDB	African Development Bank
ASS	Affordability of Solar Services.
B-PPA-IPPs	Bankability-Power Purchase Agreements/Independent Power Producers
CAPEX	Capital Expenses
CEC	Copperbelt Energy Corporation
DBZ	Development Bank of Zambia
DFID	Department of International Development -UK
DV	Dependent Variables
E8NDP	Eighth National Development Plan
EFI	Effect of Fiscal Incentives
EIB	European Investment Bank
EIZ	Engineering- Institution of Zambia
ERB	Energy Regulation Board
ESCO	Energy Service Companies
ESMF	Environmental and Social Management Framework
EU	European Union
FDI	Foreign Direct Investments
FIAL	Financial -Incentives Accessibility level.
FPI	Framework and Package of Incentives
FPV	Floating Photovoltaic
GCF	Green Climate Fund

GDP	Gross -Domestic Product
GET-Fit	Global Energy Transfer Feed in Tariff
GHI	Global Horizontal Irradiance
GLAE	Great Lakes Africa Energy Ltd
IAEREP	Increased Access to Electricity and Renewable Energy
IBM	International Business Machines Corporation
IBR	Incentive Based Regulation
ICP	Integrative Collaborative Projects
ICSI	Initial Cost of Solar Investments.
IDC	Industrial Development Company
IEA	International Energy Agency
IEnv-PP-5Y	Investment Environment for IPPs in Past 5 Years.
IFC	International Finance Corporation
IFU	Danish Investment Fund
IoT	Internet of Things
IPPs	Independent Power Producers
IPPA	Investment Promotions and Protection Agreements
IRR	Internal Rate of Return
ISF	Innovation System framework
IV	Independent Variables
JICA	Japan-International Cooperation Agency.
kWh,	Kilo Watt hour
kWp	Kilo Watt Peak

LCOE	Levelized cost of electricity
LVTI	Location,-Value & Type based Investment incentives.
MFEZ	Multi Facility Economic Zone
MG	Mini Grids
MLP	Multi-level Perspective
MoE	Ministry of Energy
MPA	Multi-Phase Programmatic Approach
MWh	Megawatts Hour
MWp	Megawatts peak
NAPSA	National Pension Scheme Authority
NEAT	National Energy Advancement and Transformation
NECL	Ndola Energy Company Limited
NEP	National Energy Policy
NHRE	Non-Hydro Renewable Energy
NISIR	National- Institute for Scientific and Industrial Research
NPCL	Ngonye Power Company Limited
NSCI	Non-Significantly correlated Incentives
NWEC	North-Western Energy Corporation
OECD	Organisation for Economic Co-operation and Development (Countries)
OPEX	Operating Expenses
OPPPI	Office for Promoting Private Power Investment
P4ALL	Power for All

PPA	Power Purchase Agreement
PPP	Public Private Partnership
PSIR	Private Sector Investment Rates
PSA	Power Supply Agreement
RBF	Results-Based Financing
RE	Renewable Energy
REA	Rural Electrification Authority
REFiT	Renewable Energy Feed-in-Tariff
REF	Rural Electrification Fund
REI4P	Renewable Energy Independent Power Producers Procurement Program
REMP	Rural Electrification Master Plan
RETs	Renewable energy technologies
RIS	Regional Innovation Systems
RISE	Regulatory Indicators for Sustainable Energy- World Bank
ROI	Return on Investments
ROR	Rate of Returns
RR	Revenue Requirement
RQ	Research Questions
SADC	Southern Africa Development community
SAPP	Southern Africa Power Pool
SCI	Significantly Correlated Incentives
SCOT	Social Construction of Technology
SCT	Social Construction of Technology theory

SDG	Sustainable Development Goals
SE4All	Sustainable Energy for All' Initiative
SEFA	Sustainable Energy Fund for Africa
SFI	Suitability of fiscal Incentives.
SME	Small Medium Enterprises
SPSS	Statistical Package for Social Sciences
SPV	Special Purpose Vehicle
SREP	Supervisory Review and Evaluation Processes
SSA	Sub-Saharan Africa
TIS	Technological Innovation Systems Theory
TSE	Total Survey Error
TWh	Tera Watt hour
UAE	United Arab Emirates
UCTAD	United Nations Trade and Development
UNICAF	Unicaf University- University of Nicosia and African Partnership
UNIDO	United Nations Industrial Development Organization
UREC	UNICAF Research Ethics Committee
USAID	United States Agency for International Development.
VAT	Values Added Tax
VRE	Variable renewable energy
ZANACO	Zambia National Commercial Bank
ZDA	Zambia Development Agency
ZESCO	Zambia Electricity Supply Corporation

ZMW	Zambian Kwacha

List of Tables

List of Figures

CHAPTER 1: INTRODUCTION

The growing global population, combined with rapid technological advancements, has drastically increased energy demand, resulting in significant energy shortfalls. Challenges have further intensified due to consequences arising from shifts in climate patterns which have affected traditional modes of producing energy such as hydro power, highlighting immediate requirement to pursue energy options that are both environmentally friendly and capable of being replenished naturally over time. Among the alternatives, solar energy emerges as a viable option to meet both present and anticipated energy demands (Hoffmann & Wood, 2021). The reports by the agency responsible for world energy, the International Energy Agency (IEA), highlights significant challenges in energy provision. These challenges include the fact that approximately 620 million people, constituting the majority of Africa's population, and also a substantial portion of the global total lack access to electricity. (Zhou et al., 2022)

The disparity in energy availability between the developed and third world countries is predominantly evident in location south of the Sahara, in which the average yearly electricity use per person is just 170 kWh, despite the region's immense capacity potential to harness renewable energy sources (Quansah et al., 2016). Zambia, which is located in the southern region of Africa, has been experiencing environmental challenges such as elevated temperatures and unpredictable rainfall patterns due to climate change, which has drastically reduced water body levels and corresponding energy outputs from hydroelectric power generators (Balogun et al., 2013; Spalding-Fecher et al., 2016).

Regions in Africa with abundant solar radiation, long sunshine hours, and vast land suitable for solar infrastructure such as sub Saharan region where Zambia is located, should harness these natural geographical advantages to expand solar energy production and move toward universal electricity access by 2030, as emphasized by the World Bank and United Nations. (Mukhtar et al., 2023; Quansah et al., 2016). This study recognizes the important role that solar energy can play in meeting the region's energy needs and focuses on specific aspects influencing the investment landscape. Specifically, the research analyses policies related to economic incentives, tax-based incentives, and investment environment-based incentives to explore their influence on solar sector investment. This study aims to contribute to the ongoing discourse on improving solar energy investments by evaluating relevant policy frameworks. Such improvement can be achieved through enhanced regulatory approaches that promote private sector participation in solar energy production, thereby aligning with global objectives for sustainable energy development (Ayeni, 2025). Advancements in renewable energy technologies, particularly solar PV, represent a critical step towards achieving sustainable energy solutions globally. However, a significant barrier to the broad utilisation of solar power is the substantial upfront investment costs. While operational costs are notably lower compared to fossil fuel alternatives, the substantial upfront investments act as a deterrent to potential investors (Labordena et al., 2017). In addition to technical feasibility such as system performance, appropriate site selection, and the availability of technical expertise for PV energy production, the economic viability of solar systems is an important aspect of practicality. Economic aspects which include capital costs, operation and maintenance, access to financing, and expected returns on investment, greatly effects the practicality and sustainability of deploying solar PV systems. Collectively, technical and economic considerations determine feasibility and success of solar PV installations; hence the aspect levelized cost of energy generation with solar highlights the critical importance of upfront financing and investment incentives, which are key drivers for achieving cost competitiveness with conventional hydropower and fossil fuels (Babu et al., 2025).

Zambia’s geographical location in Africa is endowed with extended sunshine hours and optimal temperatures, hence stands out as a region with immense potential to harness solar energy to address its energy deficits. However, despite governments’ efforts in the region to provide investment incentives, international financing, and encouraging private sector investments, the actual utilization of solar energy remains significantly below its potential where a mere 1.5 GW of electricity is generated by photovoltaic technology in the region, reflecting a stark disparity between potential and actual implementation (Li et al., 2020). The region south of the Sahara, such as where Zambia is located, holds exceptional potential for solar energy generation, possessing nearly 60% of the world’s unmatched solar resource. Yet, despite this vast endowment, only about 1% has been harnessed through actual installations (IEA, 2022). African countries, particularly in the SSA region, are richly endowed with significant but underutilized renewable energy resources. The projected solar generation capacity is approximately 1000 GW (Bishoge et al., 2020), however total energy being attained from currently fitted solar infrastructure in SSA is less than 500 MW (Detollenaere et al., 2013). This accounts for only 1% of the total solar PV capacity installed worldwide. Accordingly, this disparity underscores the imperative requirement to attend to the investment obstacles being faced in the solar energy sector in Zambia and the region in general, by shifting from purely considering technological aspects, to include the role of incentives in fostering private sector investments (Fischer et al., 2011).

The case of Zambia reflects broader regional challenges in parts of Africa south of the Sahara, highlighting the urgent need for decentralized renewable energy solutions. Approximately 98% of rural communities, representing 65% of Zambia's population, lack access to electricity in their homes and rely heavily on fossil fuels (Chanda, 2025). As the entire region south of the Sahara in Africa grappled with a mere 80 GW of electricity availability by 2018 statistics, the broader economic reality relating to ongoing underdevelopment is justified. With the population estimated to increase to approximately 2.1 billion by 2050, the need for alternative energy sources like solar becomes imperative (Heubaum & Biermann, 2015).

In spite of the general global growth and declining costs of solar technology, institutional drawbacks pose substantial barriers to its widespread utilization in Zambia. Similarly while smart grid technology and the expansion of the photovoltaic production industry have greatly reduced the price tag on photo-voltaic products and technology, the effective deployment of solar energy is hindered by institutional shortcomings. Notably, there is lack of institutional support for private sector solar energy investments, characterized by inadequacies in the deployment of financial, fiscal and non-monetary incentives (Avila et al., 2017).

This study acknowledges the positive trends in the global solar industry but seeks to address the persistent challenges in Zambia, focusing on institutional support and effective financial and fiscal incentives aimed at encouraging private sector investments. By incentivizing renewable energy deployment and providing enabling frameworks, the research aims to attract private investment, empower local entrepreneurs, in supporting the decentralization of alternative sources of energies in the affected parts of Africa, south of the Sahara desert (Avila et al, 2017).

From a broader perspective, the escalating energy needs associated with high economic growth in Zambia and similar regions of Africa necessitate a shift toward identifying new energy sources and the need to optimise existing ones. The depletion of conventional energy resources highlights the urgency for alternative and sustainable solutions, particularly in the context of smart grid technologies (Kulatilaka et al., 2013). Scholars emphasize that solar energy is a critical component of the twenty-first-century energy landscape, offering potential solutions to electricity access challenges, especially in areas where a significant proportion of the population remains off-grid (Amankwah-Amoah, 2015; Gregory & Sovacool, 2019)

Despite acknowledging solar energy as a prospective and vital aspect for improving trade and industrial growth in the larger part of Africa, numerous drawbacks continue to impede the full utilisation of the resource to its full potential. Barriers range from reluctance of independent investors in electrical energy due to poor investment environments to high upfront investment costs and lack of sufficient or appropriate financial, fiscal and non-monetary incentives (Amankwah-Amoah, 2015; Gregory & Sovacool, 2019). The complex solar sector landscape demands comprehensive research efforts to address gaps in technological capabilities, policy frameworks, and economic initiatives to foster the development of the sector involved in harnessing energy from the sun. There has been notable successes in existing research to propose solutions such as technological leapfrogging, up-scaling of business models, and innovative financial mechanisms like Feed-in Tariffs and Power Purchase Agreements (Amankwah-Amoah, 2015; Couture & Gagnon, 2010). However, there is still critical need to undertake more empirical studies to assess the efficiency of proposed solutions particularly for parts of Africa with good solar irradiation.

Furthermore, while efforts have been made to explore aggregated energy generation and corresponding financial, fiscal and non-monetary investment incentives, they have not received adequate attention in existing studies as evidenced by lack of content regarding meticulous examination of these incentives. Accordingly this research identifies a knowledge gap in literature in which the coverage of the nuanced aspects or attributes of investment incentives in solar energy lacks, therefore this study aims to contribute empirical insights to enhance the understanding of incentives’ characteristics and inform policy decisions regarding their incorporation in solar incentives deployment (Egli et al., 2018). The identified lack of technological capabilities, combined with ineffective policies and incentives, poses a substantial challenge to independent power producer investments in the solar energy sector, resulting in a diminutive sectoral growth.

This study undertakes the critical task of examining the ineffective, inconsistent, and non-comprehensive policies related to investment incentives and concessions for solar energy development. By doing so, the research seeks not only to identify underlying challenges but also to propose actionable solutions for enhancing the involvement of private sector entities in advancing renewable energy sources like solar power, which hold immense potential to alleviate energy deficits in Zambia and in the entire Sub region with similar geographical characteristics.

Aligned with its objectives, this study employs a data-driven approach to explore the associations between institutional financial, fiscal, and non-monetary incentives designed for independent power producers in the private solar energy sector. These incentives function as the explanatory variables, while the resulting private sector investment outcomes, including increases in investment volume, improved service delivery, and higher returns on investment, act as the response variables.

Institutional support is categorized into various forms of incentives, such as financial benefits, tax-based measures, and investment concessions, which are based on various factors like geographical position, nature of investments in terms of industrial or economic criteria, and scale of the investments (Bowa et al., 2017). In assessing the advancement of solar photovoltaic energy in Zambia, the analysis of institutional support serves to uncover inefficiencies and gaps that hinder optimal solar energy use. This examination ultimately provides strategic recommendations for enhancing solar energy adoption and utilization.

The increasing energy poverty in tandem with population growth underscores the urgency of incorporating the private investors to drive renewable energy development agenda, an undertaking that can help to considerably boost solar energy utilization (Baumli & Jamasb, 2020). With the advent of climate change and corresponding capital scarcity, balancing green energy pursuits with climate change mitigation measures becomes imperative for achieving sustainable economic growth (Olabi & Abdelkareem, 2022). In many of the Sub-Saharan African countries, the study identifies institutional quality traits and complex government legislatures as factors affecting private sector investment in Zambia which contribute to low investments in the solar energy sector (International Financial Law Review, 2017). The limited access to electricity, particularly in rural households, coupled with weak regulatory frameworks for off-grid infrastructure, creates challenges for solar energy expansion. The organizational challenges related to the effective dissemination of investment incentives further compound the complexities of the sector. Similar to numerous other nations within Sub-Saharan Africa, the study highlights institutional inefficiencies and intricate government policies as key factors hindering private sector participation in Zambia, leading to minimal investments in the renewable energy domain, particularly solar power (International Financial Law Review, 2017). Limited electricity access, especially among rural communities, combined with inadequate regulatory structures governing off-grid solutions, poses significant barriers to the growth of solar energy. Additionally, challenges in effectively administering investment incentives exacerbate the complexities faced by the sector. The study not only acknowledges the potential of renewable energies to reduce energy costs but also emphasizes that incentivizing solar energy is pivotal to increasing production, attracting investments, and reducing consumer prices (Oluoch & Susaeta, 2021; Reuter, et al., 2012). This research, therefore, endevours to unravel reasons causing the investment gaps in renewable energies, focusing principally on the dissemination of investment incentives for renewable energy investments, which essence are a major driving force in these investments (Avila et al., 2017).

Statement of the Problem

A clear and concise Statement of the Problem provides a solid foundation for any research study, as it outlines a specific issue or gap within a particular field or in existing knowledge that the study seeks to examine, and justifies why this examination is necessary. It also provides a focused pathway for the research approach to appropriately address the research questions. By clearly outlining what is not yet understood or is missing, and explaining why it matters in the field or in practice, this section grounds the study in a meaningful context, ensures that the research remains purposeful, and informs readers of the relevance and significance of the study (Kehinde, 2025).

Therefore, although Zambia possesses considerable solar resource endowments—characterized by long sunshine hours, abundant solar radiation, and an estimated technical potential of approximately 2,300 MW—the fact that only about 76 MW has been installed to date clearly indicates significant underinvestment in the country's solar energy sector (Mhango et al., 2017). Furthermore, despite several utility-scale projects having been initiated between 2019 and 2024 such as the Bangweulu, Ngonye, Riverside and Itimpi solar projects, overall progress remains modest relative to untapped potential against rising demand for energy in the country (CEC, 2025; Chitandula et al., 2024). This contrast between resource endowment and actual deployment highlights the significance of the study on investments incentives corresponding to the national requirement of scaling solar energy.

The statement of the problem is therefore that, Zambia experiences severe energy deficits and underinvestment in solar energy despite its high technical and geological potential. This situation is highlighted by the large gap between theoretical capacity of approximately 2,300 MW and installed capacity of approximately 76 MW revealing a possible systemic deficiency to transform existing solar resource potential into sustained private-sector electricity energy deployment (Mhango et al., 2017).The observed underinvestment can largely be attributed to possible fragmentation or ineffectiveness in existing investment incentives and weak institutional frameworks. The absence of comprehensive policy approaches to integrate financial, fiscal, and non-monetary incentive support mechanisms has capability to misalign and create implementation gaps that can adversely undermine effective private investment (Schmidt et al., 2023). Reports of financing and regulatory barriers or abrogation have possibly further constrained project realization; for instance, the GET FiT Zambia Solar Program awarded six IPP projects of 120 MW each in 2019 however, by 2022, none of the projects had been implemented due to financing and regulatory impediments (USAID, 2022). Broader institutional inconsistencies and incoherent investment and tax frameworks across the regionals has had reported negative effects on private solar investments as they affect incentive innovations of individual countries (International Financial Law Review, 2017; Kulichenko et al., 2011).

The impact of low levels of solar investment is the exacerbation of Zambia’s energy deficits especially in the off-grid remote areas and also the ever growing overreliance on hydropower, a situation made more acute by climate change induced droughts that reduce hydro generation capacity and ultimately threaten socio-economic growth for the country (Olabi & Abdelkareem, 2022). Energy poverty is widening as population and demand for energy grows: evidently only about 31% of the population had electricity access as at 2021, with rural household access particularly noticeably low (Milonova, 2021). The combination of limited solar deployment and the overly stressed hydro systems undermines the country's resilience and broad electrification effort to improve energy access levels (Baumli & Jamasb, 2020).

Noticeably, while prior documents highlight aspects relating to Zambia's energy resource potential, cost disparities between solar and conventional energy sources such as hydropower and institutional investment support constraints, there emerges an existing gap in empirically linking the design and implementation of financial, fiscal, and non-monetary incentives to computed private-sector investment outcomes across varying scales, locations and types. In line with the outlined energy deficits, it is paramount to interrogate measures for scaling up solar energy as it has potential to stall energy development, as evidenced by diminutive growth over the years (Avila et al, 2017). Existing studies indicate that solar energy remains less affordable for consumers than conventional hydropower, especially for those with grid access, largely due to high initial infrastructure costs and additional logistical challenges in remote areas. Operations expenses further increase the cost burden. This affordability gap underscores the need for good investment incentives to expand solar deployment and reduce initial and operational costs for end users (Fajardo et al., 2025; Mukoro et al., 2022). While existing studies show that solar PV can be more cost-effective than fossil fuels for many off-grid communities, long-term operating and maintenance costs, closely shaped by geographical conditions significantly constrain affordability (Szabó et al., 2021; Wesseh & Lin, 2016). Benchmarked grid cost/tariff structure, in contrast to LCOE for solar, indicates lower residential tariffs than many small off-grid solar mini-grid costs, hence grid users often find solar less affordable without incentives. Additionally, typical solar mini-grid case shows an LCOE around EUR 1.57/kWh, which is higher than Zambia's grid tariffs at ZMW 1.15/kWh for 101–300 kWh consumptions as in the year 2021 (Energy Regulation Board, 2021a; GET.invest, 2019). This study therefore endeavours to examine whether existing incentives have favourable or adverse influence on private solar investment trends and solar utilization in Zambia, with the focus on identifying inefficiencies and inconsistencies and to ultimately generate evidence-based recommendations for aligning incentives with type, scale and location of solar investments, additionally, to improve affordability by, and accelerating sustainable solar deployments (Hussain et al., 2025).

Affordability remains one of the most significant challenges to solar energy diffusion in rural Zambia, where energy poverty is high and most households depend on seasonal incomes from farming. Rather than reducing tariffs, which risks undermining the financial viability of solar investments, targeted, time-bound, and results-based incentives have been recommended as a more sustainable solution (World Bank, 2025). Such incentives can help lower upfront costs for low-income communities by leveraging innovative financing mechanisms, including Pay As You Go (PAYG), rent town schemes, and demand aggregation, while aligning repayment schedules with income timing so that seasonal earners can make payments during harvest periods (Babayomi et al., 2023).In addition, electrification efforts can be directly linked to income growth by promoting productive uses of energy, such as solar-powered irrigation, milling, and small-scale enterprises, which enhance rural earning potential (Wamalwa, 2024). On the supply side, phased connection fee reductions and seasonal or off-peak tariff rebates can encourage adoption and help households gradually adapt to standard solar tariffs, and by combining time bound subsidies with productive use linkages, exemplified by approaches like the Demand Stimulation Incentive, rural communities can be able to generate additional income required to sustain long-term energy access and affordability (Yadav et al., 2019; World Bank, 2025).

Purpose of the Study, Aims and Objectives

The purpose of a study clearly states the principal intention and envisioned result of a research study, thereby guiding the choice of the study approach, data collection, and analysis. Its importance is in the fact that it provides focus and course of the study, ensuring consistency through all stages of the research process, and consequently assists readers to clearly understand what the intent of the study is and why it is important (Barroga & Matanguihan, 2022).

The purpose of this research study is therefore to quantitatively examine the relationship between institutional investment incentives and private-sector solar energy investment outcomes in Zambia. Ultimately the study endevours to generate evidence-based insights and recommendations that can guide policymakers and stakeholders in strengthening incentive mechanisms, thereby helping to improve solar sector performance, and promote sustainable solar energy utilisation in Zambia.

Accordingly the aim of the study is to analyze how financial, fiscal, and non-monetary institutional incentives influence private sector solar investment outcomes in Zambia, with a view to identifying gaps and proposing measures to enhance solar energy utilization. A quantitative examination is identified to establish the relationships between institutional investment incentives designed to support the private solar industry and the resulting investment outcomes in the sector. Specifically, the study focuses on three categories of incentives, namely financial, fiscal, and non-monetary which are independent variables, and evaluates their influence on outcome variables such as private-sector investment levels, return on investment, and service delivery standards. By analyzing how these incentives are shaping investment behavior, the study seeks to identify inefficiencies and inconsistencies that limit solar energy investment and utilization in Zambia. In doing so, it aims to generate insights into remedial measures by informing the formulation of incentive frameworks to strengthen coordinated deployment of incentives. The research aligns with established renewable energy investment support mechanisms, including flexible loan availability, supportive fiscal and policy mechanisms, robust regulatory structures, and the strengthening of intermediaries' roles in project evaluation and implementation (Sweerts et al., 2019).

In conformity with the outlined study purpose and aims, the study objectives are designed to address identified problems of underinvestment in Zambia's abundant solar resource by guiding planned empirical examinations of how institutional incentives in form of financial, fiscal, and non-monetary relate to investment outcomes, specifically private-sector investment rates and return on investment (ROI). A purposive, face-to-face quantitative survey of stakeholders across the solar value chain will be used to collect data for testing whether incentive types and implementation features are positively or adversely correlated with investment outcomes. This is in order for the analysis to identify statistically grounded relationships and gaps, and to enable targeted recommendations such as streamlining loan facilities, refining tax measures, and strengthening regulatory and market support that have ability to improve investment attractiveness and raise ROI. Ultimately by linking the problem to objective-driven empirical evaluation, the study aims to inform pragmatic, policy-relevant interventions that translate Zambia's solar potential into sustained private-sector investment. In order to achieve this, the study pursued three salient study objectives as follows:

1. To assess the effect of financial incentives, including loans, subsidies, and grants, on the growth of solar sector investments in Zambia.
2. To examine the influence of fiscal incentives, comprising tax based benefits such as credits, deferments or exemptions for private sector investments in solar energy.

3. To investigate the impact of non-monetary incentives, encompassing regulatory, policy capacity and market support on solar sector investments.

In this study, the arising research questions are derived directly from the research aims and objectives and provide a clear conceptual focus by defining the specific issues under investigation. Accordingly, the study is guided by three research questions: RQ1-To what extent do financial incentives, including loans, subsidies, and grants, influence the growth of private-sector solar energy investments in Zambia? RQ2 - What is the relationship between fiscal incentives, such as tax credits, deferments, and exemptions—and the investment needs of private-sector solar energy investments in Zambia? RQ3- How do non-monetary incentives, including regulatory frameworks, policy support, institutional capacity, and market facilitation mechanisms, affect private-sector solar energy investments in Zambia? These research questions structure the empirical inquiry and directly inform the formulation of the study's testable hypotheses (Creswell & Creswell, 2017).

Research Hypotheses

In quantitative research, a research hypothesis represent clear, testable statements predicting the anticipated association between variables, derived from research questions and informed by literature which helps to organise various aspects of a study from a central point of view in refining the research problem, guiding data collection and analysis approaches, and also in providing a standard for interpreting the findings and the drawing of conclusions. Well formulated hypotheses help to enhance the clarity, course**,** and methodical consistency of an academic report by connecting objectives to observed tests. Ultimately hypotheses help to establish whether observed findings conform or contradict theoretical anticipations, thereby strengthening the study's contribution to knowledge (Ghasemi et al., 2025)

The research hypotheses for this study were formulated to directly address the identified problem of existing t underinvestment in Zambia’s solar energy sector and to fulfil the study purpose of examining how institutional incentives affect private-sector investment landscape. In line with the Technological Innovation Systems (TIS) theory framework, incentives in the categories of financial, fiscal, and non-monetary are identified as key factors that methodically influence solar technology diffusion, market availability, and the general investment atmosphere to spur investor confidence. The hypotheses formulated therefore serve as the guiding suppositions that guide the entire study design, which include operationalisation of the variables, statistical procedures pursued, and ultimately the recommendations and conclusions emerging from the research findings.

The identification of financial, fiscal, and non-monetary incentives as independent variables was guided by both theoretical reasoning aligned with the TIS theory which suggests that targeted incentives can reduce structural barriers, mobilise resources, and stimulate innovation oriented investment (Bergek et al., 2015). Empirically the evidence across developing-country renewable-energy markets, Zambia inclusive confirm that incentive structures significantly shape private-sector participation patterns and that their effectiveness varies depending on design and deployment. These variables were further selected because they are directly measurable, relevant to policy and practice, and sufficiently diverse in the context of the purposively sampled population to support robust quantitative analyses. Practical and statistical consideration for variable selection include conciseness and the potential to generate appropriate findings to inform recommendations and conclusion (Creswell & Creswell, 2017; Hair et al., 2010).

Grounded in the study’s theoretical and empirical foundations, and in order to avoid redundancy given that the research questions are directly reflected in the hypotheses, this study adopts hypothesis testing as the primary analytical pathway. The hypotheses provide a clear, testable framework for examining the effects of financial, fiscal, and non-monetary incentives on solar energy sector performance outcomes, specifically private-sector investment levels and returns on investment in Zambia. The study hypotheses are hereby listed below.

H01: Financial incentives are not significantly suitable for private-sector solar energy investments in Zambia.

H02: Fiscal incentives do not have a significant relationship with the needs of private-sector solar energy investments in Zambia.

H03: Non-monetary incentives do not have a significant effect on the requirements of private-sector solar energy investments in Zambia.

Nature and Significance of Study

The nature and significance of a study is in a way extended from the purpose of the research statement by further clarifying the study’s coverage, approach, and most importantly its procedural orientation or nature, while outlining the value and anticipated contribution of the research to the body of knowledge. The section explains why the study is necessary by further delineating benefits of research findings and ultimately the study’s relevance in addressing identified gaps (Hiebert, et al., 2022).

This research adopts a quantitative correlational approach to analyze the impact of incentives on investment outcomes focusing on financial, fiscal and non-monetary incentives. Financial incentives, included loans, subsidies and grants, which have direct financial benefit to investors as criterion constructs; similarly fiscal incentives comprised tax based incentives to alleviate investment barriers; finally non-monetary incentives, included policy, regulation, and market aspects of the soar sector investments in Zambia. Specifically, the research attempted to examine the extent to which these incentives affect performance indicators like private sector investment levels and return on investments. Financial incentives encompassed direct monetary support like loans and grants, while fiscal incentives included tax related benefits such as tax holidays, corporate tax reductions, and waivers on excise and import duties. Additionally, non-monetary incentives in contention in this study involve support mechanisms such as regulatory support, policy and market access including capacity building initiatives in line with solar sector investments in different locations, different types and investment values (Qadir et al., 2021). By analyzing these relationships, the research's aim is to provide insights into the effectiveness of different types of incentives in driving private investment and promoting the growth of solar energy in the country.

The collection of raw data began with the identification of both private and public institutions involved in the solar project deployment chain, whether as financiers, implementers, equipment providers, or traders in order to ensure the study targeted knowledgeable and strategically positioned respondents. Using a quantitative research methodology, this study examined the correlation between key incentive variables in form of financial, fiscal, and non-monetary, with outcome indicators such as private sector solar investment rates and returns on investment. In order to ensure the collection of credible and representative data, structured survey questionnaires with closed-ended questions were administered and retrieved through face to face engagement, minimizing response apathy and securing consistent, categorical insights from targeted respondents (Curtis et al., 2016). Participant responses were measured on a Likert scale which gives clear rank order and allows quantification of abstract concepts like stakeholder perceptions by assigning them specific numerical value which ultimately are fit for statistical analyses (Batterton & Hale, 2017). Eligible participants had to be persons from institutions that are involved in aspects of the solar energy value chain, with sufficient expertise or knowhow in either financing, planning, sourcing or supply of solar equipment or implementation of solar projects. After data collection, relevant variables were identified and survey questions were formulated based on existing incentive structures and performance outcomes. Correlation analysis, using linear regression, was then conducted to examine the relationships among these variables. Data collection tools were carefully selected to ensure accurate and representative information collection which was aligned with research questions and objectives (Du & Evans, 2011). The structured questionnaire was designed to facilitate systematic data gathering, testing of assumptions, and assessment of results, in line with research goals (Kabir, 2016).

The quantifiable research methodology is intended to examine the relationships amongst variables of interest while avoiding prior assumptions and causal interpretations. It focuses on enhancing efficiency and minimizing intrusion by collecting objective data, free from the influence of the researcher on participants' responses. This approach utilises structured questions included in research questionnaires, which were administered through face to face distribution and was effective in averting response apathy (Leedy & Ormrod, 2010; Neuman, 2012). The handling of research raw data involved the systematic arrangement and summarisation of data related to occurrences and descriptive information relating to the study. IBM SPSS software was then used to provide a characterization of the sample. The research study specifically applied correlational analysis to identify trends, associations, and relationships among variables, thereby highlighting key insights relating to independent and dependent variables (Hazra, 2017). Statistical tests were conducted on variables calibrated on Likert scales to employ correlation and regression methods to compute the correlation coefficient (r) in determining the level of correlation between sets of normally distributed predictor and criterion variables and also the predictive effect in the outcome variables. Additionally, Cronbach’s alpha was employed to assess the internal consistency of the questionnaire items, determining how well the test variables correlated with each other and ultimately evaluate the reliability of the scale in capturing the underlying concept of correlation and effects of incentives on performance outcomes (Arkes, 2023). The pilot study tests yielded a Cronbach’s alpha result of 0.71, indicating borderline reliability. After refinement of the questionnaire by removing ambiguous items and adding targeted questions, reliability improved to 0.74**,** demonstrating acceptable internal consistency. The statistical analytical tool (SPSS) was specifically identified for application due effectiveness and easy with which analyses are done, which eliminates tedious lengthy manual computations. SPSS is extensively used in research for statistical and predictive analysis owing to its ease of use, comprehensiveness, and robust analytical functions for determining correlations, visualisations, accuracy, including data management (Dixon & Woolner, 2012). Comprehensive and accurate collation of data and interpretation of results was achieved by focusing on the research study topic, corresponding research questions, and purpose of the research study in order to attain accurate informed conclusions. Additionally, comparisons with findings in existing literature was incorporated in order to draw broader inferences and enhance the study's validity (Choy, 2014). This systematic approach ensures rigorous analysis and comprehensive understanding of the research outcomes, thereby effectively contributing to knowledge to address gaps in the solar energy field.

The study employed a quantitative correlational approach, because it is suitable for identifying relationships between predictor and criterion variables. This method is effective for analyzing variables from multiple populations or a single population, as was the case in this research. Quantitative correlational technique was suitable for the research considering that no manipulation of independent variables was required, but rather required prior identification of research tools, target population, key variables and consequent framing of a conceptual framework outlining relationships between predictor and criterion variables prior to the process of collecting statistics (Maltby et al., 2014). Furthermore this approach enabled predictions and formulations of hypotheses for the research and ultimately enabled the analysis of significance of correlations, direction of correlations and also the degree of variations in independent variables in relation to variations in dependent variables (Leedy & Ormrod, 2010).

This study is significant because it addresses the critical need for Zambia to enhance electricity access across the country. As the population grows and economic demands increase, expanding the solar energy sector can provide sustainable energy solution to meet rising energy needs. By identifying and overcoming the barriers to solar energy development, this study will contribute to improved energy security, economic growth and social development for communities throughout Zambia. In order to meet Zambia's projected energy requirement of 42.54 TWh by 2035, a significant increase in installed capacity is imperative. Currently, Zambia's installed capacity stands at only 2.9 GW, necessitating an additional 10.4 GW to meet future demand (Kakoma-Bowa, 2020). To achieve universal access to affordable and reliable electricity in Sub-Saharan Africa by 2030 requires significant investment in renewable energy, particularly solar power. The International Energy Agency (IEA) estimates about USD 25 billion per year needed to meet this goal, specifically focusing on grid expansions and deployment of off-grid solar in remote areas. (International Energy Agency, 2022). In Zambia, the government aims to increase the share of non-hydro renewable energy in its generation mix to 33% by 2030, with a focus on solar and wind energy. This initiative includes development of 3,000 MW of solar through private sector investments. The total estimated cost for the country's energy requirement is USD 11.9

billion, of which USD 9.5 billion is expected to be contribution from private sector investments (ConstructAfrica, 2023). These efforts highlight the need for coordinated investment strategies that incorporate effective incentives to accelerate the deployment of solar energy solutions in the region. It is crucial to streamline investment strategies that incorporate effective and efficient financial, fiscal and non-monetary incentives for renewable energies such as enhancement of current policies and introducing new measures that can attract private sector investments, reduce initial costs, and mitigate investment risks. These steps are essential for scaling up solar sector investments and ensuring a sustainable energy future for Zambia.

In examining the effectiveness of existing incentives for the solar sector investments, the study will help policy makers, financiers and implementers to make informed investment decisions towards achieving improved utilisation of solar energy resource in Zambia (Kakoma-Bowa, 2020). This objective translates into a goal to achieve energy access of up to 90% in built up areas and 51% in remote country regions by 2035. Diversification of the energy sector by integrating alternative energy sources into the current energy supply system, which relies heavily on climate-vulnerable water driven power generation, is essential (Mwanza & Ulgen, 2020). To enhance solar energy adoption, leveraging Zambia's favorable climatic conditions for solar generation, it is crucial to evaluate existing investment strategies, particularly financial and fiscal incentives, to stimulate growth in the solar sector.

In terms of solar generation capacity, Zambia’s capacity stands at 3030MW, and the country intended to install 500 Megawatts of renewable solar energy by the year 2023; however presently merely approximately 91MW of solar has been connected representing a very sluggish growth rate for solar in the country (USAID, 2021). Furthermore, it is worth noting that hydro generated electric power in the country accounts for a significant 85% while the general electricity distribution accounts for only 40% of the country’s population indicating insignificant levels of electricity penetration in the country, therefor validating the importance of this study for Zambia and it quest to achieve the 2035 energy goals. This significance of the study is augmented by the fact that hydro generated electric power, seldom generate to capacity due to climate change effects resulting from erratic rainfall pattern. On the other hand, the fact the country typically gets a significant 2,000 to 3,000 hours of sun exposure in a year which is a good opportunity to generate adequate solar energy to complement hydropower generation (Quansah et al., 2016). The study finding will certainly positively inform those in policy making positions on solar energy utilisation and help to mitigate levels of energy deficiencies in the Zambia, considering that substitute renewables energy implementations require substantial initial investment capital investments and also good sustainable planning for long term operations and maintenance (Usher, 2019)

To sum it up, this study employed a correlational analysis approach to examine the impact of financial, fiscal, and non-monetary support mechanisms on the performance of Zambia's solar energy sector. Financial incentives encompassed access to loans and grants, while fiscal incentives included tax waivers, reductions, or deferments. Non-monetary incentives comprise policy-driven support such as regulatory frameworks, market policies, and infrastructure development. The collection of data targeted private organizations involved in solar project implementation, utilizing structured survey questionnaires administered both in person and electronically. Responses were measured using an interval scale to ensure the accuracy, reliability, and validity of the collected data. Subsequent to data collection, variables were identified based on existing literature concerning support mechanisms and perceived performance levels. Correlation and regression analyses were conducted using SPSS software, facilitating a comprehensive statistical evaluation of the data. This methodological approach ensured a thorough analysis, yielding credible and reliable results pertinent to the effectiveness of various incentive types in enhancing the performance of Zambia's solar energy industry.

Finally, this study is important as it will inform the country’s strategy to attain the projected 2035 energy demands, which require significant increase in installed capacity, through a diversified energy sector which incorporates alternative green energies such as solar. The study's findings will help policymakers, financiers, and implementers to make informed investment decisions towards achieving improved solar energy diffusion in Zambia. Additionally, the research study addresses the country's energy access projections and also challenges arising from negative effects of rising temperatures and erratic rainfall patterns on hydroelectric power generation. With Zambia's abundant sunshine hours annually, there is a significant opportunity to generate solar energy to complement hydropower generation and alleviate energy poverty. Overall, the study contributes to the body of knowledge on solar provide knew knowledge in terms of solar sector investments strategies, especially considering that there is a noticeable paucity of literature on the subject of investments incentives effectiveness, thereby also setting a platform for future research.

In conclusion, the nature of this study is quantitative and correlational design, which systematically examines the relationships between financial, fiscal, and non-monetary incentives and key performance outcomes, namely private-sector solar investment levels and returns on investment in Zambia’s solar energy sector. Operationalisation of incentive mechanisms across different project scales, technologies, and locations, allows the study to adopt a thorough, data-driven approach to assess the effectiveness of existing investment support structures. The significance of the study is anchored in its contribution to addressing Zambia’s critical energy access and diversification challenges, particularly in the context of climate induced hydropower vulnerability and the growing electricity demand. Findings provide empirical insights to inform policy reform, investment strategy optimisation, and incentive redesign aimed at accelerating solar energy deployment. Hence the study not only supports national energy targets and private sector participation but also contributes to the limited empirical literature on the aspect of incentives contribution to solar energy investments in Sub-Saharan Africa.

CHAPTER 2: LITERATURE

Literature Review chapter is a critical component of a research study because it properly positions the envisaged study or examination within the wider context of the existing body of knowledge amalgamated from various components of existing information, thereby helping to identify gaps that validate the necessity for new or further research on a particular topic. By meticulously analysing and organising appropriate studies, this section offers a clear perspective for the research problem at hand**,** informing theoretical and identifying appropriate methodology options for the study, and further helping to demonstrate how the prevailing study or work converges with, diverges from, or furthers previous knowledge. A systematic literature review guarantees that the study contributes meaningfully to the field of study by building on already established information, thereby averting needless replication of efforts, but rather appropriately recognizing aspects needing additional examinations (Saharan et al., 2024).

In this study, the investigation of measures to scale up solar sector investments in Zambia is of paramount importance because of the noticeable low investment levels in solar energy utilisation in the country. The review therefore interrogates factors contributing to low investment and identifies strategies to enhance them, thereby creating a solid foundation for evaluating solar energy growth and development in Zambia. This literature review is structured to elucidate the solar sector status and provide a pathway for an orderly analysis of solar energy investments in Zambia. It begins with theoretical foundations to guide the study, before laying out Zambia’s energy landscape. The review then examines policy and regulatory environment shaping renewable energy investments, followed by a discussion of the key challenges and incentives influencing solar uptake. Focus then turns to strategies for expanding and scaling solar deployment, ultimately leading to the development of the study's conceptual framework. The literature review is designed to provide a basis for examining ecosystems among existing financial, fiscal and non-monetary investment incentives intended to support solar investments in the privates sector through quantitative correlational approach. Ultimately to provide insights into the effectiveness of incentives and to identify gaps for future research. The review prioritises peer-reviewed literature from the past five to ten years.

To effectively inform the study objectives, the review is orgainised into themes, namely theoretical framework, Zambia's energy status, policy and regulatory setting, challenges and incentives, expansion/scaling strategies, followed by synthesis and comparative evaluation of performances models to assess local applications and contrast them with regional and global practices. This structured approach is instrumental in generating the insights required to answer the study's research questions and to justify the subsequent empirical design which culminates into a Conceptual framework.

This thematic organisation aligns the literature with the study's empirical focus on financial and fiscal and non- monetary incentives as independent variables and Private sector investment rate /ROI as dependent variables (Zulu et al., 2021), outlining the pivotal role these incentive categories play for both local and international investors and supporting institutions. Thematic review enables a focused synthesis of evidence on concessional financing, subsidies and grants (Fotio et al., 2022), as well as fiscal and non-monetary incentives such as tax reductions, waivers, tax credits including environmental conditions (Šimović & Žaja, 2010; Qadir et al., 2021). The literature review followed a step-by-step search and selection process of data bases interrogated. Major academic databases used include Aqualine, CAB Abstracts, Engineering Village, ENDS Report, Greenfile, IEEE Xplore, and ProQuest Natural Science; search engines such as Google Scholar, Microsoft Academic, CORE, and Science.gov were also employed to broaden coverage. Key search terms included “Solar Energy utilisation”, “Renewable energies for SSA”, “Investment incentive in renewable energy”, “Financial support mechanisms for solar”, and “Solar investment policies”. Selection criteria emphasised peer-reviewed publications from the last five years for approximately 85% of sources used in order to ensure contemporary relevance; however, older publications were included where literature on incentives and certain investment mechanisms relating to solar energy remained limited.

The dependent variables analysed in this study pertain to private-sector investment rates, evaluated through outcomes influenced by economic, regulatory, operations and in form of service levels, industry expansion, and profitability (ROI). Accordingly, the literature review is orgainised into sections that examine current levels of solar utilisation in Zambia, government policies and regulatory frameworks governing renewable energy investments, and theoretical frameworks models that best support the study objectives.

Theoretical Framework

A theoretical framework identified for this study offers a foundation of the concept applied in the research study where the examinations are anchored within defined theory and consequently help to guide the formulation of research questions, hypotheses, methodology and explanation of the final results. It is designed to ensure that the study is logical, focused, and founded in prevailing understanding, thereby enabling researchers to appropriately explain associations between main variables of a study, justify methodological choices, and position research results within existing wider academic deliberations, and ultimately uphold the consistency, significance, and trustworthiness of the study (Van der Waldt, 2024)

This study is underpinned by the Technological Innovation Systems (TIS) theory, which has emerged over the last two decades as one of the most widely applied frameworks for analysing processes of technological change, particularly in the field of energy transitions. Gong & Andersen, (2024) state that the main aspect of the TIS theorem is the emphasis that innovation is not simply the development of new technologies, but rather the systematic application of those technologies within networks of actors, institutions, and markets in order to produce broad, sustainable, and socially beneficial solutions. The theory's functional approach, which was originally conceptualised by Jacobsson and Bergek as far back as the year 2004, is particularly relevant to the context of developing countries such as Zambia, where factors like resource mobilization, institutional capacity, and policy alignment have ability to significantly influence the success or failure of technological diffusion (Köhler et al., 2016). Aside from focusing only on the technological innovation itself, TIS brings into view the web of relationships and systemic functions that shape how technologies are introduced, scaled, and sustained.

Contextual Relevance of Technological Innovation Systems Theory

The Technological Innovation Systems (TIS) theory has a strong foundation in innovation studies developed over time by various scholars (Lundvall, 2022). Two major paradigms shape innovation studies and are well applicable to the context of Renewable Energy Technology (RET) utilisation. The first is the neoclassical paradigm**,** which attributes barriers to market inconsistencies, and the second is the systemic model**,** emphasising on broader social-economic obstacles that inhibit diffusion (Tabrizian, 2019). Modern innovation theories can be traced back to Schumpeter who in simple terms outlined innovation as a structured process as far back as 1911, and building on it scholars identified three key themes in innovation systems, namely critical role of interactions between firms, institutions, and networks; the importance of learning and future expectations; and the influence of institutional frameworks on the pace and direction of technological progress (Pedersen, 2020). In line with foundational scholars and specifically targeting renewable energies, contemporary scholar like Binz and Truffer (2020) re-emphasised the need for a functional and sector-specific perspective in innovation systems, arguing that RETs require focused analysis of functions (e.g., resource mobilization, market formation, legitimacy building) rather than broad system-wide analysis. Additionally in an effort to demonstrate how systemic innovation frameworks must account for regional realities particularly in SSA, Unuigbe et al. (2022) employed a grounded theory approach to identify localized drivers affecting renewable energy diffusion in commercial buildings in Nigeria, which include socio-cultural dynamics, financial constructs, and regulatory factors.

Technological Innovation Systems and Multi Level Perspectives

A fundamental and strong perspective of the TIS framework lies in its ability to highlight systemic interactions among diverse actors, such as governments, firms, research institutions, and financiers, as well as the role that both formal and informal institutions and supporting networks provide in innovation processes. These interactions are not chaotic but deeply interdependent in such a way that they influence the pace, scale, and sustainability of innovation processes. As Karltorp (2014) notes, the theory draws particular attention to the importance of linkages, the dynamics that accompany the penetration of new technologies into existing markets, and the broader mechanisms that ultimately shape innovation trajectories. This perspective is crucial for successful solar energy diffusion in Zambia, where multiple barriers in form of financial, regulatory, and infrastructural intersect and also where the interplay of local institutions with international actors can dictate the growth or indeed the stagnation of solar technologies and corresponding utilisation in the country.

Despite crediting TIS with significant explanatory value, scholars have increasingly recognized the value of complementing it with the Multi-Level Perspective (MLP) which extends the explanatory power of TIS by explicitly incorporating socio-technical dimensions at three levels, i.e., niche, regime, and landscape. Innovations often begin in protected niches where experimentation is possible, before interacting with incumbent regimes, governed by established technologies and institutional arrangements, and being shaped by broader landscape forces such as global economic trends, demographic shifts, and climate change considerations. Foundational works by Markard and Truffer and Geels et al in the year 2008 (Uriona & Vaz, 2017; El Bilali, 2025) were some of the first to articulate this established model. More recently, Bakhuis et al. (2024) systematically reviewed innovations across multiple sociotechnical systems and underscored the need of comprehending transitions across interacting levels and system phases. Their findings reinforce the MLP's relevance in complex, multi-system contexts. Similarly, a 2024 empirical study on solar energy storage transitions in Western Australia used MLP to demonstrate how niche-level solar and storage innovations are influenced by regime level policy and infrastructure, alongside landscape level renewable targets, thereby illustrating the MLP's current applicability to energy transitions (Jayaraj et al., 2024).

For renewable energy transitions, the identified framework helps explain why some innovations attain growth while others fail to break through. For instance, in developing country's contexts, niche solar innovations may depend heavily on donor funded pilot projects, while their long-term viability require integration with regime level institutions such as vertically integrated national utilities and energy regulators, as well as be responsive to landscape level aspects such as global financing conditions or international climate protocols and agreements. Edsand (2019) demonstrates how this layering of analysis helps outline the real world complexity of transitions, especially in emerging economies where weak institutions and financial constraints can easily derail promising innovations. Consequently, by identifying and combining TIS with MLP, this study acknowledges that solar energy development in Zambia cannot be fully understood by focusing only on system functions at the national level. Instead, it exposes the required attention to how local innovations interact with deep-rooted socio-technical regimes, such as the dominance of hydroelectricity in Zambia’s energy mix, and also how they are influenced by broader international and regional factors. This integrative perspective broadens the explanatory capacity of the theoretical framework and places the analysis within the wider deliberation on energy transitions.

Positioning TIS with Alternative Frameworks

While TIS and MLP form the pillar of the theoretical framework, it is important to position them side by side with other prominent theories that advocate for systematic technological change. The Innovation Systems Framework (ISF), for example, is one such theory that emphasises systemic dynamics across whole innovation networks of interlinked and co-dependent units, with a converging focus on processes of knowledge creation, diffusion, and utilisation within broader economic systems (Walz, et al 2016; Hamman, 2025). ISF is particularly appreciated for macro-level analyses but is often too drawn-out when the aim is to generate specific, policy-relevant insights about a particular technology sector such as solar.

Another closely related theoretical approach is the Social Construction of Technology (SCOT), which, however by contrast highlights the interpretive flexibility of technology through examining how various stakeholder groups allocate meaning to innovations. In the context of solar adoption, SCOT would emphasize how households, utilities, policymakers, and investors construe the costs, benefits, and risks of solar technologies differently (Planko et al., 2017). However despite the fact that SCOT provides rich insights into the social shaping of technology, it risks underestimating the structural and incentive-based instruments that are particularly vital in investment contexts. Last but not least, the concept of Regional Innovation Systems (RIS) extends TIS theory by providing a spatial lens to address regional diversity thus facilitating for a nuanced understanding of innovations and technological diffusion needs and identifying location-specific factors that influence investment decisions new innovations such as the solar sector at regionalised levels essentially addressing TIS's deficiency in managing regional diversity. This approach advocates for refined, place-specific technologies and policy interventions to enable economic competitiveness, novelty, and sustainable technological diffusion (Rohe & Mattes, 2022).

The Institutional Theory adds another angle by stressing the role of formal and informal rules, norms, and governance arrangements in structuring technological pathways. For instance, for solar sector investments in Zambia, this would highlight how licensing requirements, tariff structures, and policy consistency influence the sector's development. Nevertheless, while these perspectives are insightful, none of them offers the same structured "functions of innovation systems" approach that makes TIS particularly well-suited for policy-oriented energy transition studies (Andersen & Markard, 2024). When collectively analysed, these frameworks enhance understanding from various angles, i.e., the ISF with its focus on macro structures, SCOT with focus on social processes, Institutional Theory with its governance focus, Regional Innovation Systems (RIS) for its specific regional contexts (e.g., urban areas or off grid remote areas) and ultimately TIS stands out as the most comprehensive and directly applicable for this study.

The choice to apply TIS over other alternative theories is determined both by conceptual alignment and empirical applicability to the study. Markard, et al. (2015) and Bergek (2019) point out that unlike the broader ISF, which can become less specific due to its generality, TIS offers a sharper analytical focus through its mapping of functions such as knowledge development, market formation, resource mobilization, and legitimacy building essential for guiding policy design, particularly in energy and climate sectors. (Edquist, 2018; Walz, et al 2016). This functional breakdown of innovation aspects is especially important in policy studies, where the objective is often to ascertain systemic flaws and recommend appropriate targeted interventions. SCOT, on the other hand, while valuable in emphasizing explanatory and social nuances, inclines to downgrading the structural role of incentives, policies, and markets, elements that are critical for explaining and understanding investment behavior such as in the solar energy sector. Institutional Theory, for its part, offers a strong view of approach on regulations and governance issues but does not sufficiently address how systemic technological change builds up across networks and markets. Recent studies support TIS's comparative advantages of the others; for instance Andersson et al. (2023) argue that TIS is distinctively appropriate for policy-relevant energy transition studies because it combines structural and functional analysis, thereby allowing scholars to establish systemic weaknesses in their quest to provide prescriptive solutions. Li, Heimeriks, and Alkemade (2022) further show how TIS can be protracted to identify and address global knowledge flows in renewable energy, an aspect which is of particular significance for Zambia, where international financing, donor support, and technology transfer play crucial roles. It is evident therefore that, TIS captures both theoretically robustness and also empirical adaptability to innovative investments such as Zambia's specific context.

Another important strength of TIS is its methodological adaptability where the functional perspectives of TIS, i.e., the analysis of innovation by focusing on the key functions or activities that drive the development, diffusion, and technology usage; can be operationalized through measurable constructs, thereby ensuring alignment between theory and empirical testing. For instance, in this study, investment incentives are treated as independent variables, while return on investment and solar sector uptake serve as dependent variables. Sauerbrei et al. (2020) further emphasises the importance of careful variable selection and functional alignment in empirical applications of TIS. By linking or mapping of TIS functions directly onto quantifiable incentive mechanisms, in this case fiscal, financial, and non-monetary instruments, this study ensures consistency between conceptual framing and empirical analysis.

TIS Relevance in Solar Energy Investment Incentives

Technological Innovation Systems (TIS) theorem conceptualises innovation as a consequence of interdependent functions performed by a number of actors within a specified system. For the case of Zambia's solar energy sector, these functions can be directly mapped onto different categories of incentives such as financial, fiscal and non-monetary. Resource mobilization for instance, are advanced through fiscal and financial incentives such as concessional loans, tax credits, and direct subsidies, which lower entry barriers and encourage private capital participation (Qadir et al., 2021). Similarly market formation emerges when supportive mechanisms such as feed-in tariffs, regulatory guarantees, and favorable investment climates are established, providing predictable demand indicators for solar developers. Meanwhile, as a guide to the search of appropriate aspects of investment in the solar energy sector, TIS provides another critical function through the articulation of clear renewable energy targets and policy frameworks that shape investor expectations and ultimately channel capital flows. Finally, legitimation is achieved through non-monetary incentives such as regulatory support and structured stakeholder engagement, both of which build investor confidence and reduce perceptions of policy or market risk. This mapping underscores a crucial point as it clearly identifies and positions incentives not as isolated interventions but rather, as integral components of systemic functions that shape the overall effectiveness of an innovation system. In the Zambian context, recognizing these linkages makes it possible to identify underdeveloped functions, such as limited knowledge diffusion in relation to solar energy or weak legitimation. Strengthening legitimation through the provision of clear policies, consistent regulatory support, and stable legal frameworks helps build credibility, acceptance, and trust around solar investments. Most importantly, it reassures investors, policymakers, and the public that such investments are both viable and low risk. In addition, legitimation encompasses social acceptance, whereby stakeholders such as communities, industry associations, and international partners endorse the technology, thereby reducing uncertainty and perceived risks.

In summary, the TIS framework, extended through complementary insights from the Multi-Level Perspective (MLP) and informed by contemporary studies, provides a robust analytical basis for this study. Its strength lies in capturing not only the structural but also the functional and policy-relevant dimensions of innovation systems, while maintaining direct linkage to measurable constructs such as financial, fiscal, and non-monetary incentives. This makes TIS not only theoretically sound but also highly practical for diagnosing systemic weaknesses and designing interventions that can strengthen the solar investment landscape in Zambia. By situating this analysis within the broader subject on energy transitions, the study leverages TIS as both a diagnostic and prescriptive tool, allowing deeper understandings into how incentives, systemic functions, and market dynamics interact to shape the trajectory of solar energy in Zambia. The theoretical foundations outlined above provide the basis for understanding how innovation systems shape energy transitions, which is critical to contextualising Zambia’s current energy mix and potential for solar expansion.

Status and Prospects of Energy Utilisation in Zambia

In order to effectively comprehend existing levels, upcoming projections, and existing limitations in the utilization of renewable energies in Zambia, it is imperative to examine the existing capacities, demands, and obstacles encountered in scaling up renewable alternative energy investments in the country and consequently lay out the prospects for the future research and practice. The focal point being the governance framework for the Zambia's energy sector primarily designed by the National Policy formulated in the year 1994 and also the act governing electricity regulations and policy passed in the year 1995, which ultimately led to the established the Energy board (ERB) to regulate energy activities or dealings in the country (Kruger & Eberhard, 2019),.

Zambia's energy division spearheaded by a government ministry is structured into three main categories: conventional electricity which is predominantly hydro power and renewable energies which includes solar, wind, and biomass, and also fossil fuels comprising petroleum and coal, all of which are overseen by the Ministry of Energy (MoE). The task of electricity power generation, transmission and distribution is bestowed upon ZESCO Limited, a vertically integrated government organisation which provides predominantly hydro-generated electric power which ultimately makes the country susceptible to droughts and raising concerns as many studies on climate change have projected increased incidences of dry years in the Southern Africa region (Tembo & Merven, 2013). However ZESCO is augmented by state-owned mini-hydro projects and Independent Power Producers (IPPs) such as Lunzua, Chishimba, Itezhi Tezhi hydro power stations, including North-Western Energy and, Lunsemfwa Hydro etc. (Energy Regulation Board, 2020a, 2020b;). According to documented market updates for renewable energies, light is shed on the obstacles and also on emerging trends in renewable energy investments across Sub-Saharan Africa. They particularly examine the impact of vertically integrated electricity systems on the effectively driving the growth and diffusion of renewable energy in the region and beyond (International Energy Agency [IEA], 2023). Notably, systemic barriers to renewable energy diffusion are introduced through the existence of vertically integrated electricity systems in most countries of Sub-Saharan region (Alemzero et al., 2023)

Hydropower: Status and Contributions

As of 2021, Zambia's installed hydropower generation capacity recorded a substantial increase compared to 2020, largely due to the completion and commissioning of two generators at the Kafue Gorge Lower Hydropower Plant. Consequently, the country's total installed generation capacity rose from 3,011.2 MW in 2020 to 3,318.4 MW in 2021. This growth was mainly attributed to the commissioning of 300 MW out of the total 750 MW installed capacity at the Kafue Gorge Lower project, together with the addition of 6 MW from the Lusiwasi Upper Hydropower Plant, which has a total installed capacity of 15 MW. As a result, the share of national installed capacity derived from hydropower increased from 79.6% in 2020 to 81.5% in 2021 (Energy Sector Report, 2021)

Hydroelectricity remains the main source of electricity in Zambia, with key installations such as Kafue Gorge, Kariba North Bank, and Victoria Falls jointly contributing to the bulk of national generation capacity (Nyoni, 2021).The dominance of hydropower which accounts for about 80 to 85% of the country's installed electricity generation capacity, makes the country susceptible to water variability related and climate change impacts. Table 1 presents the key hydro power satiations' outputs in the country showing how generation output notably reduced particularly form the year 2015 through to the year 2020 due to varied rainfall patterns hence clearly demonstrating the vulnerability of hydro power to climate change (Energy Sector Report, 2021)

Table 1

Electricity Generation from Zesco's Key Hydro Power Plants from 2010 to 2021

Station/ Year	**Kafue Gorge**	**Kariba North Bank**	**Victoria Falls**	**Kariba North Bank Extension**	**Grand Total**
2010	6,841	2,777	724		10,342
2011	7,183	3,451	747		11,381
2012	7,376	3,668	810		11,854
2013	7,463	4,507	810		12,780
2014	6,666	4,999	811	1,162	13,638
2015	6,417	4,316	785	1,179	12,697
2016	5,853	2,964	754	672	10,243
2017	7,363	2,689	684	599	11,335
2018	6,527	3,597	723	1,611	12,458
2019	6,165	3,021	725	1,363	11,274
2020	6,027	3,431	764	1,494	11,716
2021	7,185	4,288	1,571	731	13,775

Note. Generation electricity output from 2010 to 2021 in *in GWh*, showing variations in line with rainfall patterns. *Source*: (Energy Sector Report, 2021b)

Despite Zambia's substantial hydropower generation potential which is estimated at approximately 6,000 MW while only about 30% of this resource had been harnessed by 2017. At the time, the country's total installed electricity generation capacity stood at approximately 1,900 MW, comprising predominantly large hydropower stations alongside several mini-hydro projects distributed across the country (Bowa et al., 2017). ZESCO Limited (2025) outlines subsequent planned expansion of installed generation capacity and targeted increase in non-hydro renewable energy within Zambia's national energy landscape under which the current national installed generation capacity was projected to increase from about 3,307.43 MW in 2021 to approximately 4,457 MW by 2026. A central objective of this strategy is to accelerate the deployment of alternative renewable energy sources particularly solar and wind with the ultimate aim of increasing the share of non-hydro renewables from roughly 3% to at least 10% of the national installed capacity within the planning period. This transition reflects a strategic move toward reducing over-reliance on climate-sensitive hydropower while enhancing energy security and sustainability.

This marks a strategic shift toward green energy solutions, with growing investments in solar energy supported by improved power purchase agreements. However, despite the ambition outlined in this roadmap, various challenges could hinder the realization of these goals. (Industrial Development Corporation Limited, (2024). Infrastructure limitations faced by ZESCO, an institution at the center of the vertically integrated system, may not support the anticipated electricity uptakes. Regulatory and policy inconsistencies pose additional barriers. Significant capital requirements for unprecedented electricity upgrades present another challenge, given Zambia's current economic standing. Finally, the technical capability of ZESCO to integrate new renewable energy sources into the grid requires capital funding, posing further technical difficulties (Eighth National Development Plan, 2022; Hossain et al., 2020).

In accordance with Zambia’s rising energy demand, existing planning records for the electricity sector, there is projection of substantial increase in national electricity demand leading to the year 2035. The increases are principally due to increased mining activities, broader industrialisation, urban population growth, and overall economic expansion as outlined by percentage figure in table 2 and line graph with a corresponding pie chart in figure 1 (Energy Regulation Board, 2022; Ministry of Energy, Republic of Zambia, 2021; Ministry of Energy, Republic of Zambia, 2023). Figure Xa clearly displays a significant amount of energy consumed by the mining sector as the largest consumers of energy. With a noticeable increase in energy demand in industries, it is apparent that there is a requirement to expand the energy source combination to include other types of energy, such as solar energy which is emerging as a prominent and fastest growing contender for incorporation.

Table 2

Electricity Consumption by key economic sectors in Zambia (2020 & 2021y)

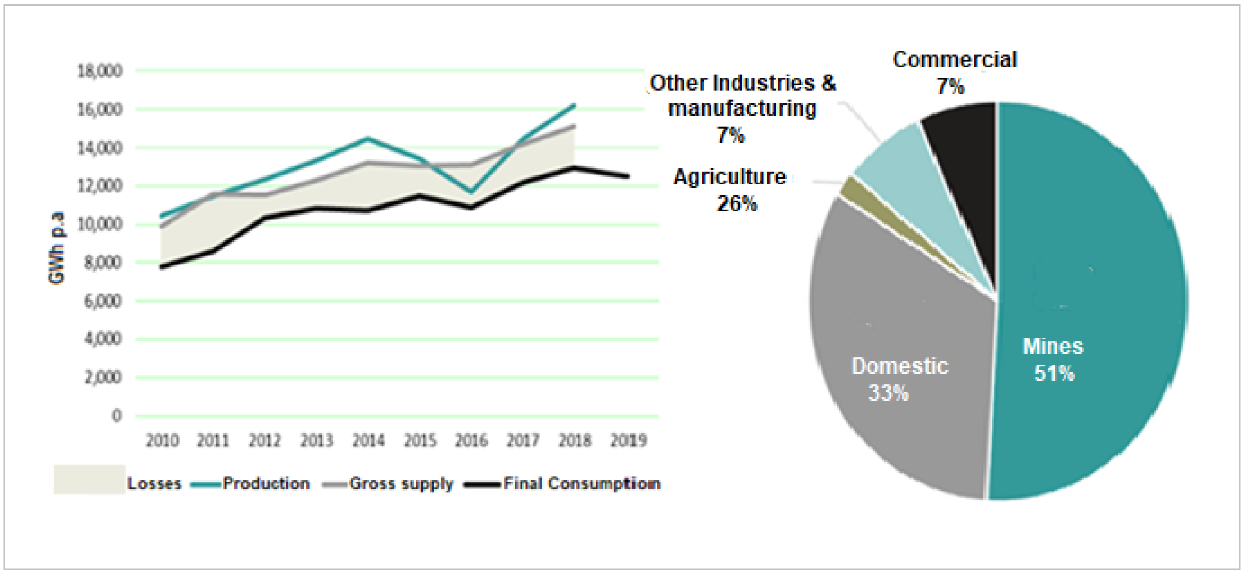
Electricity Consumption	**2021**	**% Share**	**2202**	**%Share**
Mining(Quarries)	6,551.3	51.1%	7,355.1	53.4%
Domestic(Including Households)	4,477.3	34.9%	4,548.5	33.0%
Finance and Property	835.4	6.5%	908.3	6.6%
Manufacturing	375.4	2.9%	384.6	2.8%
Agriculture	293.7	2.3%	286.5	2.1%
Energy & Water	113.7	0.9%	106.8	0.8%
Trade	82.8	0.6%	87.8	0.6%
Others	60.5	0.5%	56.2	0.4%
Transport	31.84	0.2%	36.9	0.3%
Construction	9.4	0.1%	7.3	0.1%
Total National Consumption	12,831.4	100.0%	13.777.9	100.0%

Note. Electricity demand and consumption analysis per economic sector indicating mining sector dominance. Source: Energy Regulation Board (2022)

Future projection studies further indicate consistent disparity between supply and demand, hence in order to meet growing electricity demand will necessitate the incorporation of alternative renewable energy sources, particularly solar and wind, into the national energy mix. This requirement is largely attributed to the adverse effects of climate change on water bodies, which are expected to constrain hydropower generation capacity (Daka & Farzaneh, 2023; Ndopu & Odongo, 2025).

Figure 1

Electricity Consumptions in Zambia for 2010 to 2019

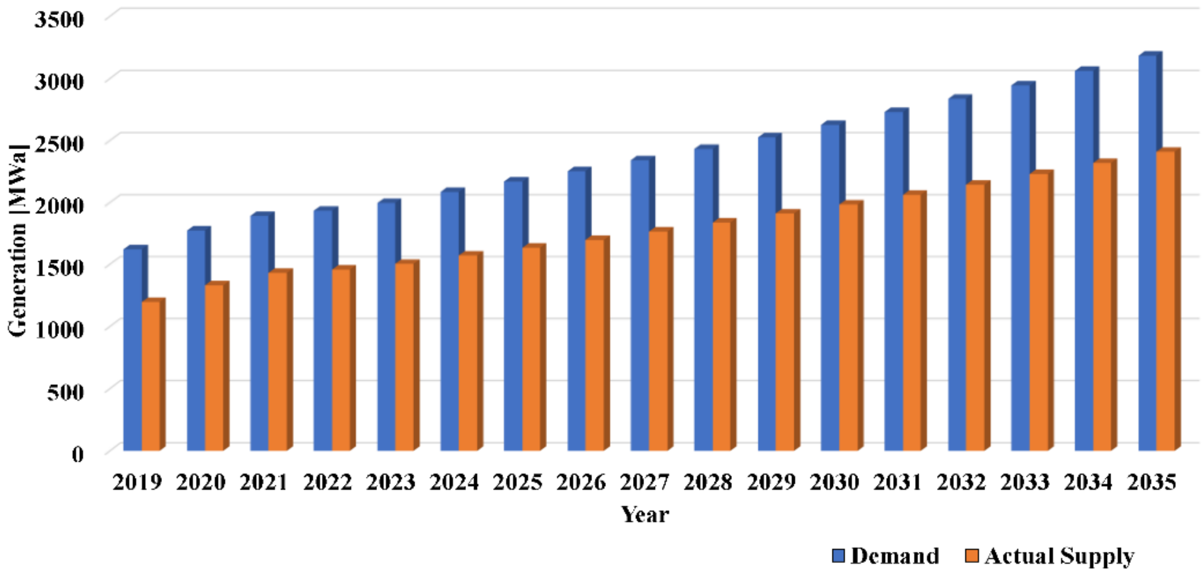


Note. Electricity Demand Development in Zambia (2010–2019*)*.Highlights key changes in consumption patterns. Source: Ministry of Energy, Republic of Zambia (2021)

Particular consistent growth in energy demand has been projected between 2019 and 2035 indicating continued deficits in energy access under existing growth trajectory of the energy sector. The relationship between demand and projected supply levels are outlined in **figure 2**. The trend underscores underlying structural demand issues, largely associated with the high energy intensity requirements of mining sector activities, thereby highlighting the necessity to speed up and scale up the diversification rate of the energy mix to ensure energy security and improved access (Daka & Farzaneh, 2023; Ministry of Energy, Republic of Zambia, 2021).

Figure 2

Zambia's Forecasted Electricity Demand against Actual Supply.



Note. Projected Consistent electricity demand deficit with prevailing trend in energy mix implementations. *Source*: (Daka & Farzaneh, 2023).

Solar Energy Status and Contributions

Zambia's renewable energy sector includes various initiatives such as solar mini-grids, isolated solar arrangements designed for individual for houses, and large-scale solar installations. Notable mini-grid projects include installations at Mpanta (60 kWp), Chibwika (32.4 kWp), Chitandika (28.35 kWp), Chitamanda (51.8 kWp), Magodi (48 kWp), and Sinda (24.4 kWp). These systems primarily cater for remote off-grid areas, for example Mpanta solar mini-grid, located in the northern part of the country, supports approximately 50 households. Additionally, around 250 solar photovoltaic systems have been installed in educational institutions and the residences of local leaders through initiatives led by the Rural Electrification Authority. Moreover, a pilot program under Energy Service Companies has provided 400 solar-powered systems for individual households. Small to medium scale off-grid solar mini-grids in Zambia, such as the Magodi, Katamanda, Chitandika, Muhanya, and Chibwika mini-grids, show potential for providing sustainable electricity to rural areas, however they noticeably face several significant challenges. Financial sustainability is hindered by unaffordable reflective tariffs for rural communities, while inadequate technical support, poor operations, and maintenance practices stem from issues like incorrect sizing and substandard infrastructure. Additionally, the ineffective use of subsidies for private power producers and ad-hoc structured tariff rates further exacerbate these challenges, highlighting the need for comprehensive solutions to guarantee longstanding feasibility of affected solar mini-grid initiatives in order to attain consistent, maintainable, and flexible power sources for local requirements that can add to economic growth and social goals (Cyril, 2024; Energy Regulation Board, 2019). The dire viability issues in mini grids due to investments and operational costs and also the failures of the local communities to afford solar amenities often rendering them non-viable. Annual Revenue and total annual cost of the solar mini-grid systems and corresponding sustainability statuses are presented in table 2 and table 3 respectively for notable mini grids installations in Zambia.

Table 3

Zambia Annual Revenue and Total Annual Cost of the Solar Mini Grid Systems

Solar Mini-Grid	Revenue ($)	Maintenance($)	Overhead Costs($)	Total Costs($)
Chibwika	4,200	14.784	16,200	30.984
Chitandika	8,213	4,525	16,200	20,725
Katamanda	2,547	18,964	16,200	35,164
Magodi	5,475	23,857	16,200	40,057
Sinda	6,750	7,286	16,200	23,486

Note. Annual revenues, maintenance costs, and overhead expenses influencing viability of mini-grids. *Source*; Kapole et al. (2023).

Table 4

Economic Sustainability of the Five Solar Mini-Grids in Zambia

SMG	Ownership	Tariff Type	Current tariff/ Household ($)	Sustainable Tarff ($)	Tariffs Sustainability
Chibwika	Community	Fixed	3.13 to 6.25/ Month	0.57/kWh	No
Chitandika	Private	Prepaid	0.38 to 1.13./kWh	0.43/kWh	Partially Yes
Katamanda	Community	Fixed	0.75 to 1.25/Month	0.40/kWh	No
Magodi	Community	Fixed	1.88/Month	0.50/kWh	No
Sinda	Private	Prepaid	0.31/day	0.56/kWh	No

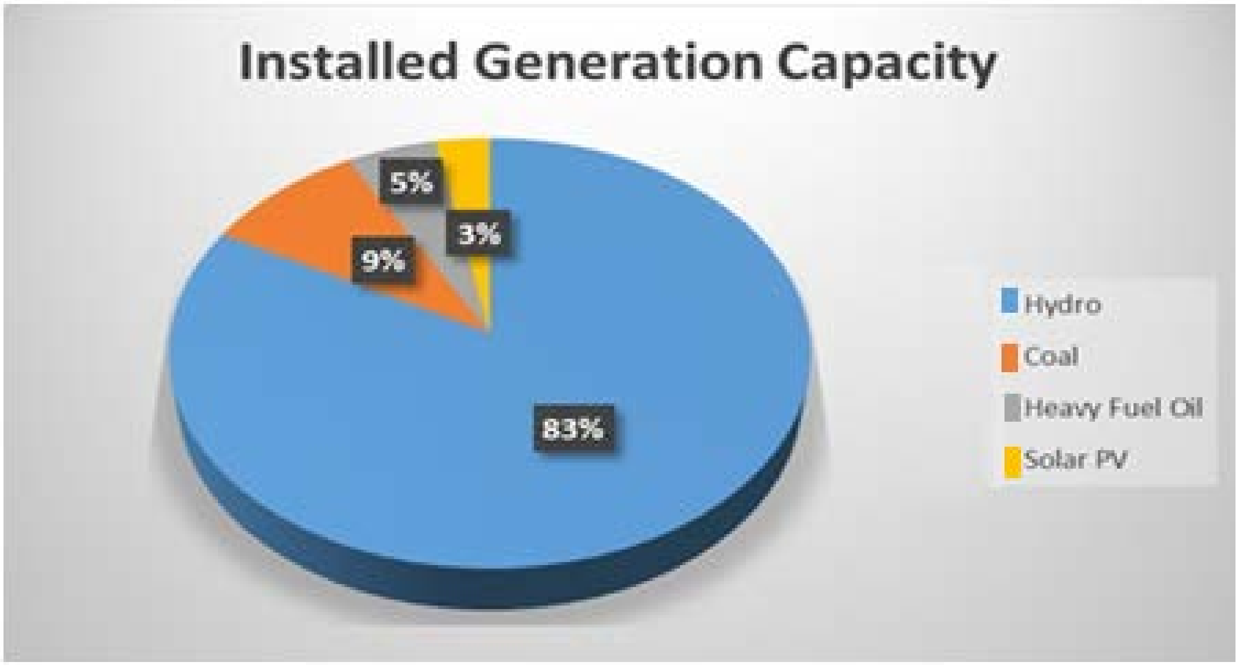
Note. Tariff types, Tariffs per household, sustainable tariff, and sustainability statuses for Mini Grid (SMG) systems. *Source:* Kapole et al. (2023).

Solar energy utilization in Zambia currently stands at a meagre 0.03 of the total energy output of 3356.6 MW, which is predominantly from hydroelectric plants (Ministry of Energy, 2022). Over the past decades efforts to diversify the energy generation mix by incorporating clean energies like solar, however empirical studies indicate that the utilization of solar energy has remained diminutive in the recent past decades (Imasiku, 2021). This is despite the potential that solar energy as to effectively contribute to the Zambia's energy landscape. Studies suggest that with better policies for solar sector investments support, its energy generation capacity could reach up to 3,000 MW, which is substantial in augmenting the country's energy capacity (Bowa et al., 2017). Furthermore, Zambia's geographical and climatic conditions, being in sub-Sahara Africa, offers great potential for solar energy generation from across its nine vast provinces, covering approximately 186,121 square kilometers of suitable land area for solar/renewable energy technology (RET) implementations. Spatial analysis using ArcGIS software, based on data sets spanning a 22 year period from NASA's atmospheric science data center, revealed an estimated energy potential for solar in Zambia to be around 20,442TWh per year, and a typical annual solar radiation of 2109.97 kWh per square meter and approximately 4403.12 hours of sunshine (Mwanza et al., 2017).

Efforts to promote solar energy uptake in Zambia addresses various factors influencing adoption such as focusing on improving attitudes, perceptions, confidence in solar resolutions, and individual norms among stakeholders. By addressing these aspects, measures can be devised to enhance solar energy uptake across the country. Additionally, remotely located renewable energy installations, in form of photovoltaic small-grids, present a significant opportunity to advance energy access goals in developing nations like Zambia, aligning with global objectives. Despite their potential, these systems encounter challenges related to technical feasibility, financial viability, and social sustainability (Zulu et al., 2022). To efficiently address these obstacles there is a requirement for reliable empirical data to which will enable a better understanding of technical. Logistical and financial dynamics involved. Nevertheless, off-grid energy systems can achieve long-term operational success by offering affordable energy access and maintaining functionality throughout their lifespan, even when navigating complex interdependencies (Stritzke & Jain, 2021b). The incorporation of other energies such as solar into Zambia's energy amalgamation presents a noteworthy chance for enhancing energy security, promoting sustainability, and addressing the challenges associated with conventional energy sources. By harnessing Zambia's abundant solar resources and addressing obstacles to adoption, the country can unveil the maximum potential of energy to satisfy the rising requirements for energy as it advances to a more sustainable future (Mwanza & Ulgen, 2020). In general the renewable energy landscape for Zambia has been on the uptrend in the recent past years having been triggered and intensified by the increased climate change effects which have hampered the hydropower generation due to low water level in rivers and water bodies. This comprehensive overview sheds light on the evolving landscape of renewable energy utilization in Zambia, highlighting both the progress made and the challenges yet to be addressed. Figure 3 shows installed production levels by the year 2020 which stood at 3356.6 MW of the energy generation mix comprising hydroelectric power, thermal- coal, heavy fuel and solar PV generated electricity.

Figure 3

Installed Generation Capacity in Zambia



Note. Energy components distribution - Hydroelectric power dominance (83% of the total 3356.6 MW. *Source*: (Ministry of Energy, 2022).

Zambia has seen significant investments in solar energy at the utility scale, with the Bangweulu Power Company leading as the country's first and largest solar photovoltaic plant. One of the largest utility scale solar installation is situated in a Multi-Facility Economic Zone in the south end of Lusaka (MFEZ). This plant has a production capacity of 54 MWp and the ownership is shared between Zambian Sunlight, a subsidiary of Neoen and First Solar and Industrial Development Corporation (IDC) a government institution at 80% and 20% respectively. It was established under a Public-Private Partnership (PPP) model, with ZESCO Limited serving as the off-taker of the electricity produced (Mwanza et al., 2017; Stritzke, 2018). Another significant solar initiative by IDC is the Ngonye Power Company, producing 34 MWp. This project is 80%

owned by Italy's Enel Green Power and 20% by IDC. It was bankrolled through contributions from the International Finance Corporation (IFC), the European Investment Bank (EIB), and the IFC-Canada Climate Change Programme (Industrial Development Corporation, 2024).

With the aforementioned investment trends and in an effort to fulfil the Eighth National Development plan (8NDP), Zambia is on the positive trajectory to mitigate electricity deficits in the country. Additionally through the IDC, more alternative energy projects of renewable nature are being planned like the anticipated development of a 120 MWp solar generation infrastructure in Siavonga south of Zambia and another 100MWp solar infrastructure in central Zambia's town of Chisamba, confirm these positive efforts to attain reliable energy generation capacity in the near future (Industrial Development Corporation, 2024). Notwithstanding, despite the notable trends in solar investments there are equally notable obstacles, including, regulatory and policy inconsistencies, and technical integration issues, which are important for integrations in order to comprehensively understand and mitigate challenges arising in the schemes to deploy large-scale solar energy projects in Zambia (Bowa et al., 2017). Building on this context, the next section relates to the policy, regulatory, and institutional frameworks that govern renewable energy development in Zambia, considering that these directly influence the translation of potential into actual investments.

Policy and Regulatory Interventions in Zambia's Solar Sector

Efforts to improve electricity access in rural Zambia are guided by the National Energy Policy (NEP) established in 1994, whose aim was to broaden electricity access by easing government control of energy market and encouraging decentralised renewable energies and technologies. In order to build up this policy, new energy legislation was introduced through the Electricity Act and the corresponding Act on Energy Regulation established in 1995. This legislation was intended to facilitate market liberalization and independent regulation to ultimately promote private sector involvement in energy development. (Bayliss and Pollen, 2021; Haanyika, 2008). The formation of the Rural Electrification Fund (REF) was followed by the launch of an authority in 2003, charged with a task to spearhead rural electrification undertakings in the country Notwithstanding, despite these institutional frameworks, there was no significant progress achieved in rural electrification, a situation which highlighting the necessity to enhance strategies that would effectively help to expand electricity access to rural communities (Malama, 2022).

A comprehensive understanding of existing government policies for alternative- renewable energy investments in the country can be reviewed by revisiting governance and policy indicators that influence energy promotion efforts. This section which addresses government initiatives for renewable energy investments in Zambia aims to outline policies, regulatory frameworks, transparency measures, and facilitations for stakeholder interactions, fostering inclusiveness and responsiveness in t governance of the energy sector (Stritzke et al., 2021). Reviewing policies for renewable energy investments necessitates a thorough examination of institutions, actors, and their interactions, in order to gauge their effect on policy approaches and results.

Likewise, identifying gaps in the planning, targeting, and implementation policies helps to consolidate subsequent policy formulation and implementations. Similarly interactions between the Ministries of Energy (MoE) and affiliated agencies is crucial for effective policy formulation (Boamah, 2020), hence clear descriptions of actor roles and responsibilities are essential so as to prevent duplication of contributing activities, procedures, or planning, which could hinder coordinated efforts and effectiveness in policy formulation, regulation, and dissemination to targeted stakeholders. Additionally, policy formulation should engage local stakeholders, including district and provincial-level representatives to ensure representative contributions to the preparation and enactment of working procedures that address local needs (Haney et al., 2019).

A complete review of existing policies for renewable energy investment in Zambia requires examining government energy policies, especially those related to renewable energies, from across various government publications or reports on energy policies, private institutions reports, scholarly academic research articles, and other documentations on projects that fall under the category on renewable energies etc. Guidance to optimize the advertisements on the conduciveness of private sector investments and benefits of using alternative renewable energies in the country are partly outlined by the National Energy Policy of 1994, which consequently facilitates socio-economic development while endeavoring to maintain safe and healthy investment environments (Mwenechanya, 2004). The establishment of a board in charge of energy regulation - ERB and the consequent enactment of domestic electricity and energy regulations were critical steps toward effective execution of energy policies (Nel, 2019).

The dominance and overdependence on hydropower generation in Zambia's electricity sub-sector poses risks of plunging the country into erratic power supplies and deficits especially with the advent of climate change induced rainfall deficits, which lead to inadequate water quantities in dams for hydro power production as experienced in 2020 (Energy Regulation Board, 2020a). In order to avoid the inevitable deficits due to climate change effects, the Zambian government embarked on policies to expand the energy combination through the national energy plan, aiming to increase solar energy utilisation by initiating a deployment of 500,000 solar home systems targeting to generate approximately 100 MW from solar PV farms by 2030 (Bowa et al., 2017).

Notable steps in addressing obstacles to energy initiatives include development of the operations code for the grid and policy formulations projecting necessities in the integrating of variable power from renewable sources like Photovoltaics into the national grid, Increased investments into ZESCO’s expansion, diversification of Copperbelt Energy Corporation (CEC) energy mix, and increase in the numbers of local Independent Power Producers (Nel, 2019). Furthermore, investment incentives were introduced for the renewable energy sector to cushion investment obstacles such as initial costs for equipment or infrastructure, ultimately reducing monopoly in the generation and supply of electricity monopoly mainly from hydro. In 2017, the government adjusted grid energy tariffs upwards, as they were non-cost reflective, to encourage private sector involvement; an important investments refining step relating to energy investments in renewables (Bowa et al., 2017). The ratification of the Power Purchase Agreements (PPAs) policy which backs agreements for purchasing power from independent power producers was a significant step in solar sector investments, playing a major role in helping to attract investments and ultimately mitigate energy deficits in the country (Energy Regulation Board, 2020b). Table 5 presents a summary of selected Power Purchase Agreements (PPAs) or Power Supply Agreements (PSAs) and their respective contracted capacities. It provides a concise overview of the structure, purpose, and operational features of solar PPAs in Zambia, including procurement approaches, tariff-setting mechanisms, contractual arrangements, and risk-sharing provisions designed to support private sector participation in solar energy investments (Haselip et al., 2015).

Table 5

Notable Achievements through Power Purchase Agreements in Zambia

Achievement	Description of Activity
Standardised PPA Framework	Developed standardised Power Purchase Agreements (PPAs) under renewable energy policy frameworks (including REFIT templates) to promote private sector participation through project financing (Mittler et al., 2025)
Expanded IPP Solar Capacity via PPAs	Ilute Solar Project (32 MW) under a market-based PPA with GreenCo Power Services Ltd, feeding into the Southern African Power Pool (SAPP), showcased innovative PPA structures avoiding sovereign guarantees & attracting private financing (African Development Bank [AfDB], 2025).
Regional Market PPA Models	Solar PPAs and Scaling Solar competitive procurement programme highlights PPAs' centrality to bankable projects and in mitigating investment risk through standardised legal and financial methods (Dobrotkova et al., 2018).
Regional Market PPA Models	SSA countries have started setting up competitive procurement programs for large-scale renewable energy projects and some are reaping the benefits, , primarily in the form of clean, low-cost energy financed, built and operated by the private sector (Kruger, et al., 2018)
Auction & PPA Integration	Renewable energy auctions (Scaling Solar) enabled competitive PPAs at low tariffs (e.g., approximately 6 Cents/kWh) & established models for utility-scale solar procurement & standardised PPAs in Zambia and Africa (Scaling Solar, n.d.; World Bank Group, 2019)
Policy & Regulatory Support for PPAs	RE Policies /regulations being aligned with PPAs for the expansion of private investments & decentralised solar, is a strategic pivot to renewables and private sector investments (Acharya, 2022).

Note. PPA = Power Purchase Agreement; IPPs = Independent Power Producers; RE= Renewable energies Outline of key characteristics of solar Power Purchase Agreements (PPAs) in Zambia, highlighting PPAs' facilitation of solar investments through improved bankability and enabling private sector participation. *Source*: (Haselip et al., 2015)

Power Purchase Agreements (PPAs) are long-term contracts between electricity producers and off-takers outlining conditions for the sale of power, pricing, period, and risk apportionment. In Zambia, the increasing PPAs adoption reflects their growing importance as a policy and investment instrument for scaling solar energy deployment, in a way that enhances revenue certainty, improves bankability, and facilitates conducive settings for private sector participation in RE markets. Therefore Power Purchase Agreements (PPAs) and Power Supply Agreements (PSAs) are critical to power generating institutions because they provide a predictable revenue avenue, thereby improving both the bankability and general viability of energy projects and making them more attractive to investors. Despite the notable growth in the use of PPAs, many existing agreements still contain structural limitations that offer limited scope for negotiation with independent power producers, particularly in the Sub-Saharan African context. Nevertheless, these agreements have played a significant role in stabilising energy pricing mechanisms, including transparent provisions for price adjustments linked to indices and other value variations. They also promote compliance with contractual terms, provide appropriate allocation and mitigation of risks arising from political instability, currency fluctuations, and changes in tariff and tax regimes, and also safeguard investor interests through step-in rights and clearly defined dispute resolution approaches through appropriate negotiation and arbitration procedures (Louw & Bhengu, 2012).

A major step toward enhancing Zambia’s solar energy policies was the active participation of the World Bank as the financial division of in the Scaling Solar initiative, spearheaded by the subsidiary financing member organisation – the IFC. This program helped in supporting and facilitating bankable funding, guarantees, and insurance for solar projects that are off the grid (Fergusson et al., 2015). However, several challenges and drawbacks emerged during the implementation. The first one was that, the state-owned Industrial Development Corporation (IDC) tasked with awarding installation bids for 600 MW of PV capacity, selected winning bids based primarily on price, which was Neoen and First Solar for 52 MW at a cost of US$c 6.02/kWh and ENEL Green Power for the 34 MW at US$c 7.84/kWh (Kruger et al., 2019). Additionally, the tariffs applied were non-indexed and comparatively low for utility-scale solar PV globally. Solvency issues at ZESCO, the government-owned electricity company acting as the off-taker for Power Purchase Agreements, further complicated the scaling agreement (Sargsyan, 2016; Trimble et al., 2016).

Another significant inadequacy was that while project developers and stakeholders in the special purpose vehicles (SPVs) owning and responsible for operating the solar plants were involved, they were not involved in selecting the project sites. The site selection process was entirely managed by the government with guidance from IFC advisors. The government's decision to solely select sites was attributed to enhancing bidder interest and competition, ensuring market suitability, reducing project failure risks, facilitating good comparability of the bids, shortening the project implementation timeline, to focus on a manageable number of projects, and to address political determination (Kruger et al., 2019).

Government policies for renewable energy investments for Zambia have encountered challenges due to institutional inexperience, limited capacity building, and a lack of impartial bodies to coordinate processes, resulting in project delays (Stritzke, 2018). To address these issues and in an effort to emphasize efficiency, Zambia Development Agency was established in 2016, to spearhead promotion of investments, business competitiveness, and enhanced exports for economic development, consequently ZDA was established under an act of 2006 (Zeng, 2016). The policies detailed in the ZDA Act address various sectors, including small enterprise growth, zones to process exports, export growth, denationalization, and energy sector investment. The

ZDA Investments Act seeks to enhance investment strategies by bring into line with government strategies for trade and industrial expansions. ZDA facilitates for the growth of the renewable energy utilisation, protects and nurtures emerging industries, encourages rural investments, ensures stable and secure private investment environments, and safeguards contracts with potential investors (UNCTAD, 2022).

Legislation and Promotions for Private Sector Investment

At the center of improvement efforts in energy promotions and regulations, is a government agency in charge of development, called the Zambia Development Agency (ZDA) which plays a critical role renewable energy investments in Zambia, primarily through key legislation and regulations in line the policies for energy improvements in the country in accordance with energy policies established in1994, which were further reviewed in 2008 (Walimwipi, 2012b). Within the framework of the National Energy Policy, designed to promote independent power producer involvement and protect consumer benefits, various legislative instruments were introduced. Among these, the Electricity Act of 1995 to regulate electricity production from generation to distribution and supply. Additionally, the Petroleum Act of 1995 oversees petroleum activities, while the regulation Act responsible for energy enacted in 1995, and updated in 2003, established the Energy Regulation Board with outlined roles to include the licensing of energy production and management activities. This act was an effective improvement on the previous acts aimed at boosting energy segment development, and additionally in 2023 the Rural Electrification Act was formulation which consequently led to the establishment of the Rural Electrification Authority and the corresponding Fund for the authority, with the mandate of extending the distribution of electricity to isolated regions far from the main grid. Furthermore the Zambia Development Agency established in 2026 stands out as a critical organ of government involved in spearheading the economic advancement agenda of the country by fostering trade and investment through streamlined, private sector-led approach (Walimwipi, 2012b). The objectives of the Zambia development Agency includes facilitating investment, supporting micro and small enterprises, promoting exports, reducing bureaucratic hurdles, facilitating infrastructure development, and encouraging Greenfield investments by promoting partnerships with local investors. The overarching goal of Zambia development agency is to ensure client-focused coordination, foster dialogue with the private sector, and to create a conducive environment to boost business confidence and entice investment inflow. One of the notable government investment initiative supported by the ZDA is the Ndola Energy Company Limited (NECL), a Heavy Fuel Oil (HFO) power plant of 105 MW completed in 2017 and owned by the Great Lakes Africa Energy Ltd (GLAE) a UK registered company which has a PPA with Zesco has recorded approximately 305 net profit margin since its establishment in 2013, earning after-tax turnover of more than US$41 m in the year 2018. The institution has greatly benefitted from the incentives introduced through Zambia Development Agency in form of tax waivers, exemptions or deferments for a predetermined period after inception of business (Bayliss & Pollen 2021)

In order to promote and ease private sector investments in energy, the Zambian government formulated policies aimed at promoting renewable energy investments through enhanced electricity access, improved efficiencies, and promotion of private-sector participation. Notably, a Framework to provide Incentives for electricity generation and supply from hydropower power stations were formulated and approved as early as 1998. These policies ultimately helped in the establishment of the office to promote private sector energy investments (OPPPI) to simplify procedures and regulations for investors in the energy sector, evaluating project proposals, negotiating contracts, and representing government interests (Walimwipi, 2012b). Programs for

Administration of Investment Incentives by Zambia Development Agency (ZDA) play a pivotal role in assisting businesses in securing necessary permissions, exemptions, licenses, and land from state institutions and licensees are offered various investment incentives including services assistance. The Zambian government designated energy investment as a priority sector under the expanded the scope of incentives available to all energy projects (ZDA, 2011). Additionally, an electrification organisation to spear head rural electrifications- REA, was formed with the aim of leading rural electrification in terms of mobilising funds, encouraging private-sector participation, and recommending suitable policies to the government for further facilitation of rural electrification efforts (Rural Electrification Authority, 2013).

Foreign Direct Investment and Financing Support

Foreign Direct Investment (FDI) plays a cardinal part in driving economic growth and development, particularly within developing African nations. Likewise, Economic Integration Agreements (EIAs) also function as broad investment frameworks that support inclusive development. Recognizing the importance of FDIs, Zambia began engaging EIAs as early as the year 2000 to launch unilateral investment liberalization initiatives in order to attract foreign investments. However, despite these efforts, the influx of FDIs into Zambia has been relatively low, necessitating additional strategies to enhance foreign investment attraction (Moono, 2024). In light of recent electricity supply deficits, the Zambian government has embarked on a campaign to promote investments in electricity projects by private institutions. The formation of a formulation of a framework to guide the renewable energy financing (REFF) helped to stimulate independent power producers (IPP) in attaining acceptable levels of renewable energy diffusion and ultimately foster the attainment of the desired electric energy mix (Environmental & Social Framework, 2017).

The Ministry of Energy (MoE) has significantly advanced its policy of expanding and expanding energy admittance in Zambia with the aid of external financial support. A notable initiative driving this effort is the "Zambia Renewable Energy Financing Framework," a program led by African Development Bank (AfDB) and funded through a donation of $100 million from the Green Climate Fund (GCF) under the African Fund for Sustainable Energy (African Development Bank Group, 2018b). This framework focuses on promoting private investments in small-scale renewable energy projects to boost Zambia's energy production, reduce reliance on imported electricity, and ease fiscal burdens during energy crises. The program adopts a Multi-Phase Programmatic Approach over ten years, targeting attainment of financial sustainability and operational reliability in the electricity sector. SEFA's grant focuses on supporting local financial institutions by providing technical assistance for renewable energy capacity building, project preparation, and credit policy development. A grant of up to USD 1.515 million is allocated for this purpose, complementing the GCF's funding for the public sector. The recipients of the grant included the Zambian Government, the National Pension Scheme Authority (NAPSA), and Zambia National Commercial Bank (ZANACO) through the Ministry of Finance. This financing framework is instrumental in advancing Zambia's energy sector, fostering private sector participation, and promoting sustainable development (Green Climate Fund, 2018; Sustainable Energy Fund for Africa, 2018).

The Environmental and Social Management Framework (2017) specifically outlines the forgoing debt financing of USD 100 million for selected Global Energy Transfer Feed-in Tariff (GETFiT) programs funded together with the Green Climate Fund (GCF), through banking institutions, and the National Pension Fund (NAPSA), who are designated to facilitate the implementation of feed in tariffs program under the Renewable Energy Feed-in Tariffs (REFiT), which included a 100MW, PV generation through solar power and also a small-hydropower of similar scale into the main national gridline within a period ranging from three to five years· An additional 5 million US dollars in technical assistance was reserved to help the Zambian government establish a favorable environment for private sector involvement in off grid and mini-grid energy investments. This funding also sought to further reinforce the capacity of selected indigenous renewable energy and corresponding infrastructure financing (Lieben & Boisvert, 2012; Michaelowa, et al., 2013)

The Ministry of Energy (Ministry of Energy, 2022) delineates Zambia's electricity market structure, as being characterized by a single-buyer model with ZESCO as a sole off-taker and wholesaler. Other private Producers of power contribute to electricity generation by selling to ZESCO through Purchase Agreements. Notable solar PV mini-grids in Zambia include Mpata, Engie Power Conner, Standard Micro Grid, Sorera, and Muhanya, spread across various districts. As earlier indicated, notable key initiatives for renewable energy investments included the execution of mechanisms and structures to allow for the introduction of solar and other alternative energies into the main electricity grid through Feed-in Tariff schemes, notably the Renewable Energy Feed in Tariff (REFiT) and other schemes to assist and spearhead the determination of tariffs associated to energy transfer through Global Energy Transfer Feed in Tariff (GET FiT), supported by KfW, and aimed at developing solar PV and small hydro projects. However, challenges in actualizing these strategies stemmed from off-taker related agreements with ZESCO. To coordinate off-grid electrification efforts, the government established the Off-Grid Taskforce platform, engaging representatives from ministries, private sector, and cooperating partners like the European Union, World Bank, IFC, Swedish Embassy, DFID, AfDB and USAID. (Ministry of Energy, 2022).

The National Energy Policy defines the Zambian government's comprehensive approach to energy resource utilisation, emphasising the need for institutional capacity strengthening, responsiveness to the country's energy needs, regulatory framework enhancement, promoting efficiency in energy resource utilisation, increased exploitation of renewable energy, and encouraging private sector participation to ensure sustainable growth (Ministry of Energy, 2019). Renewable energy policies are pivotal for the Southern African Development Community (SADC) region, in fostering a good investment environment for Independent Power Producers' participation in solar sector investments (Jadhav et al., 2017). However, the pace of IPP investments in Africa remains insufficient to address the continent's energy deficits. There is an urgent requirement for flexible and cost-effective strategies to plan new energy generation capacities. Additionally, establishing robust regulatory frameworks for Power Purchase Agreements (PPAs) is essential to maintain financial stability (Eberhard et al., 2016). The table at Annex A2, outlines IPP investments in Zambia by project, providing valuable insights into the renewable energy investment landscape.

External financing and investment support for renewable energy investments in Zambia has been instrumental in scaling up energy access and promoting renewable energy technologies. One such example is the program to expand renewable energies in low-income countries which is aligned with the Supervisory Review and Evaluation Processes (SREP), facilitating Investment strategies for alternative energy programs in Zambia. Up to 40 million US dollars funding from the World Bank was availed to help in financing power projects for private participating institutions (Ministry of Energy, 2018). Concurrently, Zambia's government aimed to grow solar energy to approximately 600MW, with the initial 100MW being awarded to two utility companies, in line with the 'Sustainable Energy for All' Initiative (SE4All), spearheaded by the African

Development Bank (AfDB), in order to achieve widespread provision of energy, improve rate of energy efficiency and also ensure effective contribution of renewable energy by 2030 (Ministry of Energy, 2018). Despite the hurdles faced by Zambia's electricity sector, such as increased tariffs and changes in regulations, initiatives like 'Scaling up Solar' and Global Energy Transfer Feed-in Tariff for solar PV auctions have successfully drawn interest from both local and international investors. 'Scaling up Solar,' spearhead by the International Finance Corporation (IFC), introduced a competitive bidding scheme for Independent Power Production of renewable energies in Zambia. Similarly, the Global Energy Transfer Feed-in Tariff program, was launched in 2010 by Deutsche Bank, aimed to encourage renewable energy investments in developing countries. While the program was scaled down, its model was adapted to facilitate renewable energy IPP contracts in Zambia (Kruger & Eberhard, 2019).

In March 2024, the World Bank's approved and disbursed a US$100 million grant to to the ministry of finance cater for the first segment of the Energy Advancement and Transformation project for Zambia - NEAT , with a projected duration of Ten years starting from 2023 (Ministry of finance & National Planning, 2024).This is evidence that financing from donor partners has a crucial part in boosting the growth of energy investments in Zambia, aligning with the government's expansion policy to improve available combinations energy sources. A overall amount of 700 million dollars was availed through the NEAT programme for a period of 10 years to cater for the augmentation of financial maintainability, consistency, and ability to withstand drawbacks in the power department of Zambia through a Multi-Phase Programmatic Approach (MPA).The NEAT Programme will provide essential financial support to ZESCO's operations and facilitate the procurement of non-hydropower renewables. By reducing the fiscal burden on the government and attracting private sector investment, it aims to bring about financial sustainability to ZESCO while expanding electrification throughout the country. Additionally the Programme also supports the electrification of remote areas through REA by reinforcing the Rural Electrification Fund, thus ensuring sustained financial support for rural electrification initiatives. Furthermore the initiative contributes to the energy sector's Integrated Resource Plan. Conclusively such donor funding serve as a vital catalysts in advancing the energy departments’’ objectives, promoting financial stability, attracting investments, and extending electricity access across the nation (Ministry of Finance & National Planning, 2024).

Net Metering and Grid Integration

The introduction of Net metering capability on Zambia’s national grid run by Zesco is being spearhead by the Energy Ministry of Zambia through subsidiary departments and organisations. Net Metering regulations are being formulated in line with the Energy Regulation Act of 2019 and they are intended to create a structured framework outlining the roles and obligations of licensed entities and prosumers involved in net-metering activities. Under the proposed Net-Metering Regulation, the relationships among electricity licensees, distribution/transmission network providers, and prosumers will be formally governed. The regulation includes guidelines regarding eligibility of technologies which can be incorporated into the main grid system through net metering; specifically renewable energy sources such as photo Voltaic, hydro power, geothermal, wind, and biofuels (Energy Regulation Board, 2024). Key aspects to be addressed in the regulations include defining eligible technologies and generation capacity limits, establishing the application process for prosumers, outlining licensing and connection agreements, addressing the cost of grid upgrading and connection for net-metering generation, and implementing a system for monitoring and managing net-metering generation.

Overall, these regulations aim to enable easy addition of sustainable- RE sources into the main power lines of the country while ensuring fairness and transparency in dealings between energy providers and prosumers (Energy Regulation Board, 2024).

It is recommended that policies framed for Renewable Energies (RE) in Zambia, take into account the forgoing mentioned aspects aimed at developing a conducive environment for government to boost its support and commitment to renewable energy investments. i.e., recognizing their potential to enhance economic production within the country (Felix et al., 2022). Additionally, there is a pressing need for improved land-use planning to assist in the optimal generation and measure to develop renewable energy sources across the nation. Similarly policy alignment is a crucial aspect requiring attention, to help in the clarification of the mandates of various institutions involved in renewable energy investments to enhance coordination and effectiveness in the delivery of renewable energies. Moreover, the government's RE policy should prioritize the creation of a more conducive and coherent atmosphere for private investments; entailing outlining support mechanisms in terms of bankrolling, infrastructure, and technological requirements to encourage investments in alternative energies. Robust awareness campaigns and training programs are essential in promoting new forms of energies renewable energy technologies (RETs) throughout Zambia in order to enhance renewable energy utilization, thereby accelerating transition towards sustainable energy sources. Felix et al. (2022), also suggest that the government should introduce incentives to support small and medium enterprises (SMEs) involved in alternative energy production. These measures should address social and economic challenges, particularly in remote, off-grid areas where communities face difficulties affording electricity. These incentives can stimulate SME participation in renewable energy projects, thereby fostering inclusive economic development and energy access. Conclusively, aligning government policies with renewable energy investments in Zambia requires addressing regulatory frameworks, enhancing coordination, attracting foreign investments, and implementing targeted strategies to encourage maintainable energy and consequent economic progress.

To sum it all up, this section of the literature review provided a detailed analysis of government policies for renewable energy investments in Zambia, highlighting the importance of evaluating governance indicators, regulatory frameworks, transparency measures, and stakeholder interactions within the energy sector. It underscores the need for comprehensive assessments of policy implementation strategies, institutional capacities, and stakeholder engagement to ensure comprehensiveness and receptiveness in energy access governance. Notably, the National Energy Policy of 1994 serves as a foundational framework, guiding Zambia's energy sector towards socio-economic development while addressing environmental concerns. The document highlights various initiatives aimed at diversifying Zambia's energy mix, including increasing solar energy utilization through the deployment of solar home systems and solar PV farms. It discusses efforts to integrate variable power into the national grid, incentivize renewable energy investments, and mitigate energy deficits through agreements for power purchasing (PPAs) and also agreement for power supplies (PSAs) with other Power Producing institutions (Kalunga & Mutale, 2020; Mwamba & Tevera, 2019).

Significant development occurred with the approval and release of a $100 million grant for the initial phase of Zambia's National Energy Advancement and Transformation (NEAT) Programme in March 2024.With a total budget of $700 million over ten years, its intention is to support energy sector diversification through improved financial, operational reliability, and resilience in the electricity sector. Additionally, $100 million in debt financing was approved for selected renewable energy projects i.e., GETFiT and REFiT in corroboration with local financial institutions and pension entities. The program also addresses challenges in institutional inexperience, capacity constraints, and coordination inefficiencies that cause delays in project execution. The Zambia Development Agency handles a critical role of promoting investments in the country, with initiatives like the Ndola Energy Company Limited (NECL) power plant serving as key example.

The document further explores the importance Foreign Direct Investment (FDI), including Economic Integration Agreements (EIAs) in stimulating economic growth and attracting foreign investments to the energy sector. It discusses financing approaches, in line with those provided by African Development Bank to support debt alleviation for renewable energy programs, and the importance of effective regulatory frameworks for Power Purchase Agreements (PPAs) to ensure financial sustainability (Dossou et al., 2023). Finally Recommendations for enhancing renewable energy investment policies in Zambia are provided, including increasing government support, improving land-use planning, enhancing policy alignment, and promoting private sector participation through financial and technical support mechanisms. The importance of awareness campaigns and socio-economic incentives for SMEs engaged in renewable energy utilization is also emphasized, aiming to foster inclusive economic development and energy access across the country.

Government Investment Interventions in Solar Sector

The pursuit of alternative, renewable sources for development can significantly be driven by governmental involvement to provide conducive investment atmosphere through various incentives (Energy Regulation Board, 2020b). An example is the establishment of the Bangweulu 54MWp solar mini-grid, where a record-low tariff of US$0.0602 per kilowatt-hour was achieved.

This project underscores the success of collaborations between government institutions and private sector investors. Such efforts, when supported by international financiers like the World Bank, demonstrate substantial progress in scaling of solar (Bowa et al., 2017; Elsner et al., 2021). The implementation of utility-scale solar PV power generation has marked a significant milestone in Zambia's pursuit of attaining Hydro-Solar energy mix, to increase electric energy production capacity and decrease reliance on hydro.

The Bangweulu Power Company, a utility-scale plant, generates 100,000 MWh of electricity, sufficient to power 30,000 households. This project was financed through the World Bank Group's Scaling Solar Project at a cost of $60 million, utilising a finance model based on de-risking strategies (Industrial Development Corporation, 2024). The successful implementation of this project relied on several key factors, including effective risk distribution, the involvement of skilled private sector stakeholders, strong political and collective backing from concerned settlements, and a clear and corrupt free purchasing and supply processes. Nonetheless, the project encountered delays due to inappropriate de-risking strategy, as the project over focused on mitigating market uncertainty risks, as risk awareness which was estimated to be 50% level and after de-risking, impact score of 4.15 out of 5 was archived. Additional delays arose during the negotiation of the Power Purchase Agreement (PPA) with ZESCO on risk-sharing responsibilities between the investors and ZESCO the designated electricity off-taker (Chama, 2020; Bayliss & Pollen, 2021; Walusa, 2022). Table 6 outlines financiers and ownerships of the two notable and largest scaling solar projects in Zambia, the West Lunga (Banweulu) and Ngonye with capacities of 54 MW and 34 MW respectively.

Table 6

Financing and Ownerships of Scaling Solar Projects, Zambia

SPV & Contract	Bangweulu Power Company (2017)	Ngonye Power Company Ltd (2018)
Owners of SPV	Neoen (France) (55%) First Solar (USA) (25%) GRZ (20%)	Enel (Italy) (80%) GRZ (20%)
Capacity	55 MW	34 MW
Total Cost	US$60.4 m	US$45 m
Financing	IFC A loan - US$13.3 m IFC Canada Climate Change Programe Loan: US$13.3 m OPIC Senior loan: US$13.3 m GRZ: US$4.09 m Neoen: US$11.26 m First Solar: US$5.12 m	IFC A-loan US$10 m IFC Canada Climate Change Programe Loan US$12 m EIB loan US$11.75 m GRZ US$2.25 m Enel US$9m
PPA duration	25 years	25 years
EPC contract	Sterling and Wilson (India)	Enel subsidiaries
Tariff / kWh	US cents 6.015	US cents 7.84
GWh per year	94	61

Note. SPV-Special Purpose vehicle; EPC- Energy Performance Contract. *Source*: (Bayliss & Pollen, 2021).

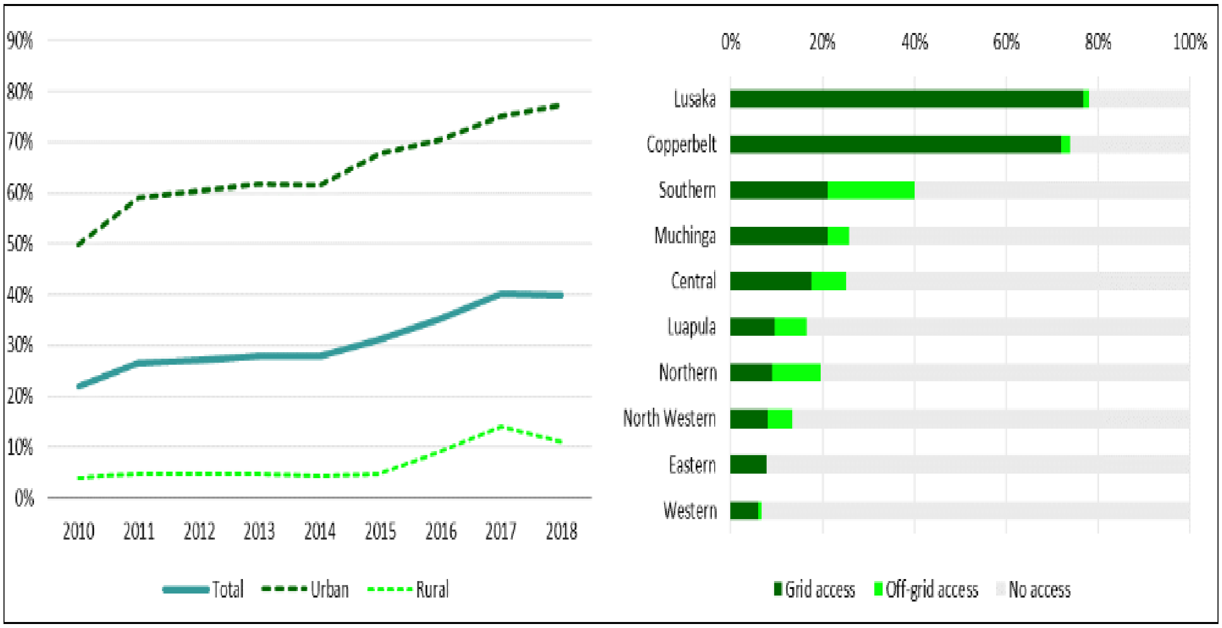
In an effort to effectively cater for the growing energy requirements, the government aims to significantly increase electricity production level from the existing 2.8 Giga watts up to 7.2 Giga Watts by the year 2030, alongside expanding the national grid by an additional 5,512 kilometers (Haselip et al., 2015). Efforts to increase electricity admittance in countryside areas are being spearheaded by Rural Electrification Authority (REA) which is an institution mandated with spearheading rural electrification and so far it has been able to oversee approximately 53 grid extension projects and t has implemented numerous isolated off-grid systems for solar provision to rural households (Bowa et al., 2017). The Rural Electrification Master Plan is a notable Collaborative program developed in partnership with the Japanese Government, which has effectively bolstered these efforts by supporting the deployment of grid extensions, construction of mini-hydro power stations, and providing solar energy at household level (Kachapulula-Mudenda et al., 2018).

Challenges and Incentive Structures for Solar Energy Investment

This section highlights the opportunities and potential pathways for expanding solar energy utilization in Zambia while also acknowledging the existing obstacles encountered. Despite forgoing achievements, there remain challenges in realising the maximum capability of attaining sustainable energy investments in Zambia, particularly in the operational stages. Some authors advocate for alternative strategies, such as the Integrative Collaborative Project (ICP) framework, to address capacity improvements, modernization networks, and the scaling up of sustainable energy projects. This approach emphasizes the need to describe existing practices, suggest improvements, and identify capacity building needs and networks to enhance the effectiveness of solar investments (Downs et al., 2020). Similarly the TIS theory framework can be of great benefit in coordinating the observed delays in implementing the West Lunga utility scale project (Bayliss & Pollen, 2021). Several challenges still remain amidst some notable progress made in the alternative energy sector for Zambia, in the quest to reach sustainable energy goals. For example, energy capacity levels saw only a slight increase of less than 1 GWh from 2019 to 2020. Hydropower, which constitute 90% of the total energy generation, experienced minimal growth due to the impact of climate change, and consequent lower water levels in reservoirs which drastically reduced hydropower capacity. Recorded increases were mainly due to coal-fired generation from Maamba Collieries, highlighting the need for a more diverse energy mix to build a sustainable energy foundation (Energy Regulation Board, 2020b). Electricity access indicated improvement between 2010 and 2018 and Figure 4 shows differences in electricity access between urban and rural communities, revealing a steady rise in access overall. However, urban areas had a comparatively higher growth rate than rural provinces (Ministry of Energy, 2021).

Figure 4

Electricity Access (2010 -2018) & Grid /Off-Grid Provinces Access (2017 /2018)



Note. Gradual increase in electricity access from 2010 to 2018, for different provinces. *Source*: (Ministry of Energy, 2021).

Sub-Saharan Africa (SSA) as a whole has experience a modest rise in energy investments in the past three decades. Similarly progress in deploying renewable energy has been limited. This is mainly due to investments being concentrated on off-grid renewable energy infrastructure in rural areas, where affordability and profitability are often low (Baye et al., 2021). In Zambia, a country within SSA, approximately 160 million people depend on hydroelectric grid power. However, energy generation and supply are frequently disrupted by climate change, which causes lower water levels in major rivers due to unpredictable rainfall patterns (Falchetta et al., 2019). Climate change presents a serious threat to existing hydropower plants in Zambia. Therefore, it is essential for hydropower projects to account for long-term climate change uncertainties during planning, as designs that do not consider these factors cannot be modified after construction (Lumbroso et al., 2015). As mentioned earlier, climate change is likely to affect water levels in key river basins like the Zambezi, Kafue, and Luangwa, directly impacting power generation (Hamududu & Ngoma, 2020). The drastic effects of climate change indicate the importance of factoring climate change effects in the planning of future hydropower expansions or upgrades as they have wide adverse implications on energy policy, practice and application (Spalding-Fecher et al., 2016; Spalding-Fecher et al., 2017).

Zambia needs to leverage on its substantial solar energy potential, given the country's 3,000 sunshine hours annually, the good levels of global and daily horizontal and direct normal irradiances respectively rated at 6.6 kWh/km², and over 2,410 kWh/km² yearly cumulative value for the latter (Imasiku, 2021; Policy Monitoring Research Centre, 2013). Despite policy efforts to increase the electricity delivery and access, ZESCO has struggled with small levels of investments arising from tariffs that do not reflective the actual cost of production. The government’s energy diversification plan included plans to adjust prices of electricity to a value that corresponds to the values of production i.e., be cost reflective by December 2015 and also to initiate Renewable Energy Feed-in-Tariff (REFiT) by 2017 to encourage Small and Medium independent power producer for project scales of up to 20 MW (Strategic Plan, 2017-2018).However, the government's initiatives to expand electricity generation and the grid extension, face several challenges. These include absence of funding to construct fresh energy infrastructure, failure to adjust tariffs that are not cost reflective, operating under unclear policies relating to partner autonomous power producers, and insufficient funding to effectively run a vertically integrated electricity institution ZESCO, the Rural Electrification Authority (REA), the main regulator for Energy in the country (ERB), and also ZAD as an investment promotion institutions (USAID, 2018). Additionally, although utility-scale solar plants like the Ngonye (34 MW) and Bangweulu (54 MW) in the Lusaka Multi-Facility economic Zone (MFEZ) have been commissioned, most investments in solar energy remain small to medium scale, such as household and mini-grid systems. Small to medium projects experience slow development because of the absence of knowledge and general awareness, poor harmonisation between the producers of energy and the consumers, duplication of services arising from lack of systematic or comprehensive approach to developmental undertakings, and limited capacities in terms of personnel and as organisations, including the countries primarily over focusing on hydropower generation schemes and grid expansions (Haselip et al., 2015).

Investors in Zambia's solar energy sector can be categoriesed as foreign investors or Foreign Direct Investments (FDI) and local investors. Similarly investment challenges vary depending on these two categories of investors. Local investors often face challenges specific to their locality, such as limited technical and financial expertise to handle bankable project proposals and also due to insufficient working capital to operate their investments. High-interest loan facilities and perceived high investment risks make financing difficult for local investors. Additionally, Foreign investors do face problems connected to the country’s foreign investment policies, which have been unattractive and not consistent with the UN’s sustainable development goals 2030 (Bowa et al., 2017), albeit with great improvements in the recent years.

Foreign investments in renewable energy are further hindered by governance and political issues, such as lack of financing from the banks or other financial institutions, unstable exchange rates, unfavorable or unpredictable tariff regulations, uncertainty of asset securities and revenues, dilutions in equity, rent-seeking, dishonesty under the table dealings, unrealistically low energy tariffs, vague and ineffective frameworks for policy and operations, unpolished code for the national grid, and absence of structures to accommodate voltage fluctuation prone renewable energy into the main grid, and lack of competitive markets (Gregory & Sovacool, 2019). These obstacles make it challenging for foreign investors to commit to large-scale solar projects in Zambia. Challenges also vary depending on the stakeholders involved. For rural households, affordability issues are a significant barrier which can be addressed through subsidization on initial investments capital I order to promote clean, reliable energy and stimulate extended use. However, solar subsidies based on long term operability of such firms often fail to encourage consumers to upgrade their services as per outlined plans preferring to maintain initial lower-cost offers hence foiling long term operability of solar investments. This suggests that progression up the energy ladder is not guaranteed, and poor households may revert to lower energy usage levels. This situation require the improvement of substitute frameworks, such as those requiring payment for services in accordance to energy used at every particular moment rather that advance payment combined with phased social support and infrastructure repairs support ingenuities (Amankwah-Amoah, 2015; Yadav, Davies, et al., 2019; Yadav, Heynen, et al., 2019).

Some literature proposes diversifying Zambia's energy mix by not only using Solar PVs deployed on land but also by deploying these on water bodies hence adopting low-water consuming technologies. The floating photovoltaic (FPV) and onshore wind turbines can be used in this regard thereby mitigating the country's heavy reliance on conventional hydroelectric power and also to alleviate the adverse effects of climate change on load management strategies. Globally, water reservoirs cover over 400,000 square kilometers, providing ample space for FPV installations capable of generating terawatts of electricity. Embracing such energy diversification approaches could lead to accelerated capacity development and entice be independent power producers (IPPs) investments in the country (Nyoni et al., 2021). However, in Zambia, FPV deployment can only be done on large water bodies like Lake Bangweulu, Lake Tanganyika, and other relatively smaller lakes, as the country has no access to sea or ocean coasts.

In the rural electrification programs, grid extensions have been spearheaded by ZESCO; however the coming on board of Rural Electrification Authority (REA), formed in 2006, has been a boost in the quest to hasten electrification expansion in the country. However, REA faces challenges because grid extensions linking to the national grid are slow and costly and to mitigate this obstacle, REA incorporated home solar electrification schemes and photovotaic mini grids that are completely off the main national grid to electrify rural communities, leveraging the favourable solar radiation conditions in the country (Bowa et al., 2017; Mwanza et al., 2017). One notable project undertaken by REA was the installation of approximately 60 kW located in a town called Samfya in Luapula Province north of Zambia which, supplying 50 households which are completely off the main grid (Mwanza et al., 2017). The growing requirement for electricity with corresponding declines in hydropower contribution from 2019 to 2020 underscored the necessity to improve up solar energy and to incorporate it in the electricity generation combinations.

In conclusion, in order to understand the status quo and future projections for renewable energy diffusion considering anticipated existing constraints and future prospects in renewable energy investments in the country, it is imperative to comprehensively explore the sector's capacities, demands, and hindrances to scaling up plans for energy capacity growth. The Zambian electricity sector is structured under the governance framework set by a Policy addressing energy in the country instituted in 1994 and the based on the act passed in 1995 to guide operations and investments in the energy sector, and in addition the supervision and regulation responsibilities was placed with the Energy Regulation Board. The energy department in Zambia can be viewed in two distinct categories, namely the conventional electricity generation and supply category and also the renewable energies, and petroleum, managed by the Ministry of Energy (MOE) with the focus on renewable energies. Zambia's electricity supply cooperation operates under a vertically integrated system, and it is the primary institution responsible for a larger part the country's electricity production, transmission, and supply. This structure is supported by state owned and private mini-hydro projects, along with contributions from Independent Power Producers (Adjei, 2024).

It is notable that despite vast untapped hydropower and solar energy potentials, Zambia's renewable energy sector remains underutilized, with only about 30% of its estimated 6000 Megawatts being exploited. The largest energy demand, primarily from the mining sector; however demands from other sectors continue to grow necessitating a diversification of the energy mix in which Solar energy emerges as a promising contender for integration, given the favourable generation conditions in the country. Initiatives in Zambia’s renewable energy sector are varied including solar off-grid mini-projects stand-alone home installations and utility-scale solar plants. Notable utility scale installations are the 60 kW Mpanta solar plant, the 54 MW Bangweulu- West Lunga solar plant, the 34MW Ngonye solar plant and many more all of which demonstrate efforts to expand renewable energy access throughout the country. The introduction of Public and Private

Partnership (PPP) and power purchase agreements (PPA) frameworks in of solar investments highlights the advent of collaborative endeavors which are cardinal in scaling up of renewable energies (Bayliss & Pollen, 2021; Nyoni et al., 2022)

Challenges impacting solar energy investment efforts in Zambia are evident in the limited scale of the sector. Despite Zambia’s substantial solar production potential and notable efforts to enhance this resource, solar energy utilization remains minimal. Notable hindrances to the growth of solar energy investments are in form of low awareness, coordination issues, and lack of institutional capacity. However, efforts to promote solar energy uptake continue to be promoted aggressively, focusing on improving the investment environment and simplifying investment processes and procedure of accessing financial and fiscal support. Some literature proposes the diversifying Zambia's energy mix by adopting technologies that are less dependent on water such as floating photovoltaic (FPV) and onshore wind turbines to reduce dependence on hydroelectric power thereby alleviating climate change impacts. With favorable solar radiation conditions and geographical diversity, Zambia holds significant potential for solar energy distribution and deployment of renewable energy technologies on land and on water bodies.

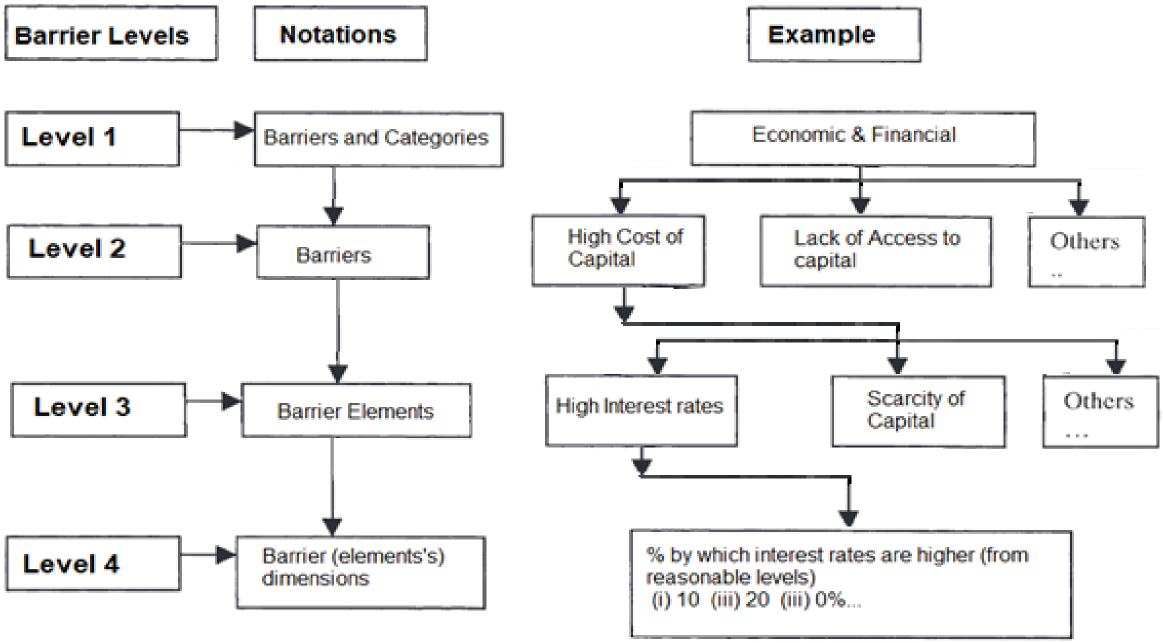
Additionally for future research and investments, further avenues to integration solar energy into the country’s energy amalgamation requires ardent pursuit in order to enhancing energy security and sustainability. By addressing obstacles to the adoption of solar as a substitute energy source and by leveraging on favourable conditions for generation, the country can unlock its full potential to meet the ever rising energy demands. Finally collaborative efforts, policy interventions to cater for tailored and easy access approaches to incentives dissemination and improvement of investment environments are cardinal to the attainment of more sustainable energy goals for Zambia (Pambwe, 2021; Stritzke & Jain, 2021a).

Barriers that face the energy industry investments, particularly for renewable energies, includes the following key aspects; technological, regulatory, financial, market, political, and socio-cultural obstacles, as well as insights relating to legitimacy of proposed approaches or solutions to these hurdles Kariuki (2018) and Oryani et al.(2021) offer structured approaches to identify factors that hinder advancements in renewable energy utilization, emphasising on the importance of selecting appropriate Renewable Energy Technologies (RETs) for specific locations or ad-hoc approach, conducting thorough literature surveys, undertaking project assessments, and stakeholder engagements. Figure 4 outlines in block form, the forgoing aspects consisting barrier levels, nature of notation of the barriers and appropriate examples

This section's overview outlines the obstacles to Renewable Energy Investments in Zambia in the lens of Technological challenges, Financial Constraints, Policy and Regulatory Hurdles, Market-related Challenges, Institutional Barriers, Governance Inadequacies and policy efforts and strategies. In line with the forgoing outlined barriers, Haigh (2023) concisely elaborates on several hurdles to renewable energy investments, highlighting issues of policies and regulations which arise with lack of clear guidelines for investors in the existing frameworks for sustainable energy, leading to uncertainties; and further points out the persistence of financial obstacles which despite ever decreasing costs of PV technologies, upfront costs for investments are still high thereby exacerbating difficulties in accessing funding for medium and smaller enterprises. Figure 5 outlines the layout of barriers in the renewable energy sector, at various levels, spanning from general to more specific perspectives. highlighting the significance of selecting appropriate RETs for specific locations or the adopting ad-hoc approaches, through thorough literature surveys, project assessments, and engaging stakeholders (Juszczyk et al., 2022; Obuseh et al., 2025)..

Figure 5

Barrier Levels, Notations and Appropriate Examples



Note. Barriers in renewable energy sector, at various levels. *Sources*: (Painuly, 2001)

Technological Challenges

There are several technological challenges in the deployment of renewable energies in Zambia, notable ones being lack of guidelines and avenues for solar integration into the main electricity grid network arising mainly as a result of challenges associated with lack of smart grid systems to enable effective integration of variable renewable energy (VRE) into the country's grid in a way which maximizes cost- effectiveness and maintains the stability and reliability of the grid system (Avila et al., 2017; World Bank, 2022).

Additionally despite the high solar resource potential across sub-Saharan Africa (SSA), other technological constraints that continue to hinder effective solar energy deployment are the harsh environmental conditions in these dry and semi-arid regions characterised by high temperatures and dust accumulation which reduce efficiency and increase maintenance needs (IRENA, 2023). Technical capacity gaps further exacerbate these challenges, as shortages of adequately trained personnel result in poor system installations, inferior maintenance practices, and reduced system lifespans (IEA, 2022). Inconsistent technical standards and fragmented regulatory frameworks across countries also limit system interoperability and cross border power trading (Eberhard et al., 2017). Finally, the limited availability of affordable and reliable energy storage technologies restricts the ability of solar systems to provide continuous and dispatchable power, reducing the effectiveness of solar based and hybrid energy systems (International Energy Agency, 2023)

Affordability and Financial Access Impediments

The forgoing outlined technological challenges faced in renewable energy sector are often associated with financial constraints in form of affordability levels among the consumers in paying for services and also the challenges of accessing financing for their initial investments capital and also for operational costs. Affordability as already alluded to in previous sections is a significant barrier to renewable energy investments, particularly at the household/ mini-grid deployment levels. The initial cost of solar investments is often prohibitive for rural communities, similarly deployment costs are high and affordability levels are low. Affordability challenge is caused by the substantial disparity between affordable and cost-reflective tariffs for mini-grid operations in Zambia. Despite decreasing costs for renewable energy PV technologies, high upfront costs, difficulties in accessing financing, adversely affect small and medium enterprises (Stritzke & Jain, 2021a)

The Sub-Saharan region has in recent decades witnessed a proliferation of isolated solar installations in individual homes, typically consisting of a solar panels, charge controllers, batteries, and inverters with power capacities of up to 100 Watts. While these technologies offer essential upfront access to electricity in off-grid communities, their cost which often range from US $300 to US $1,500 remains prohibitive for the poorest rural households (IEA, 2023b). As such, there is growing recognition of the need for more accessible, cost-effective alternatives. Decentralized solar mini-grids, for example, have emerged as a more scalable and economical solution, with the potential to deliver electricity at costs as low as US $0.20 per kWh—and projected to power hundreds of millions across the region by 2030 (World Bank, 2023). These mini-grids not only reduce per-unit energy costs but also enable broader socio-economic benefits, including improved education, healthcare, and income-generating opportunities, that small standalone systems cannot support (Town Carabajal et al., 2024).Furthermore, innovative financing mechanisms such as pay-as-you-go (PAYG) solar models and blended finance from international donors have proven as critical tools in overcoming upfront cost challenges, while also promoting equity in energy access (Yadav, Davies, et al., 2019; Yadav, Heynen, et al., 2019). These developments underscore the need for integrated policy support, community involvement, and coordinated investment in renewable energy systems to accelerate universal energy access in Sub-Saharan Africa.

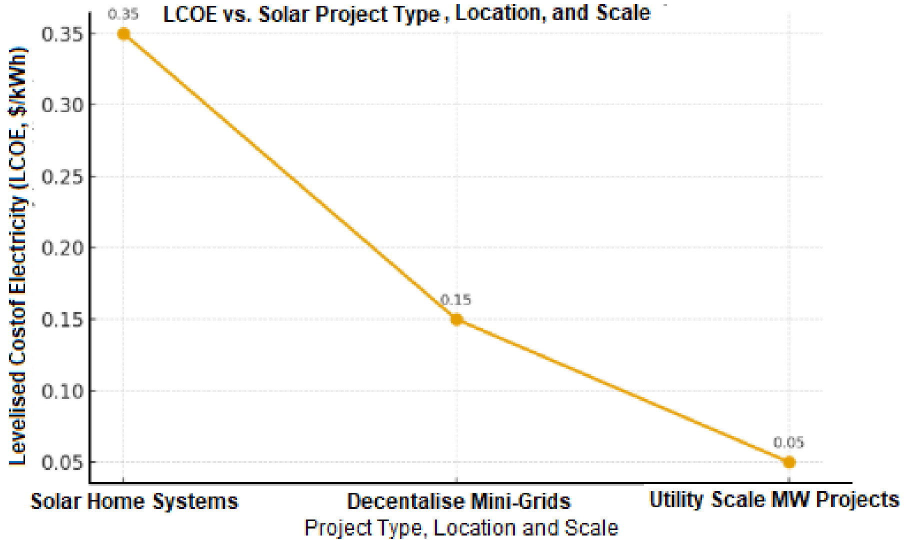
Energy provision landscape in Africa and Zambia in particular encompasses a diversity of systems, comprising isolated installations that are of the grid networks, decentralized systems, and centralized ones. With a notable gradual decrease in the cost of investments in solar, there is a corresponding increase in solar investments. The aforementioned different systems shape the cost profile of energy provision in a nuanced manner. However, challenges such as low coverage and unreliable electricity grids pose obstacles to the development of decentralized solar PV systems (Quansah et al., 2016). Figure 5 presents how different types of investments affect the cost of electricity. Additionally it has been established that Foreign Direct Investment (FDI) in Zambia encounters several challenges, which include low cost for energy, ineffective supervisory frameworks to guide investments, inadequate grid system coverage, and associated difficulties in integrating renewable energy into conventional grids, and also deficient equipment to test for quality and compatibility among energy production sources (Bowa et al., 2017)

As earlier mentioned**,** accessing financing for renewable energy projects in Zambia is difficult and is further exacerbated by stiff competition from well-established larger scale investments with better capital bases and reputability. Similarly limited awareness and familiarity with renewable energy technologies, high risk opinions, unreliability's in resource assessments, and absence of facts and lack of social or contacts with communities further contribute to the financial barriers. Despite the region's significant energy needs and potential to drive the green energy agenda, it accesses only a very small fraction of global climate finance, which could significantly help in promoting private sector solar investments (Mungai et al., 2022). In addition to these obstacles, inadequate availability of tailored financial tools for small and medium-scale renewable energy ventures continues to constrain investment flows. Conventional bank lending practices often require high collateral and offer short repayment periods, which are inappropriate for the long payback prospects from solar investments (Goyal et al., 2022). Innovative instruments such as green bonds, blended finance facilities, and results-based financing have been identified as potential pathways to reduce investor risks and attract better private capital. Expanding the use of such instruments in Zambia could provide a much-needed bridge between international climate funds and local renewable energy enterprises.

The Levelized Cost of Electricity (LCOE) for solar investments varies significantly depending on project type, scale, and location. Small-scale solar home systems typically exhibit the highest LCOE due to limited economies of scale, higher per-unit capital costs, and logistical challenges in isolated locations. In contrast, decentralized and distributed grid-connected systems, such as mini-grids, achieve moderately lower LCOE by spreading costs over a larger user base to benefit from localized demand aggregation. Understandably large-scale utility installations demonstrate the most competitive LCOE, often outperforming conventional energy sources, owing to substantial economies of scale, optimized siting in high solar resource zones, and access to advanced financing structures. Graphically, an LCOE vs. project type, location, and scale relationship in figure 6 illustrate a downward trend, from home systems to, mini-grids and to utility-scale projects at the bottom. This trend underscores the critical role of scale and geographic optimization in improving solar affordability (IRENA, 2023a)

Figure 6

Solar PV Application and Levelized Cost of Electricity Trends



Note. Relationship between type, location and scale of solar investment with Levelized cost of electricity (LCOE); *Source*: (IRENA, 2023).

Policy and Regulatory Impediments

Zambia has a vertically integrated energy system with the Zambia Electricity Corporation (ZESCO) as the main organisation for electricity generation transmission and distribution network. This arrangement however presents challenges for independent power producers (IPPs) whose involvement in various stages of energy production are largely curtailed. The consolidation of energy provision under a single utility organization limits opportunities which would otherwise be availed to private sector investors and also curtails innovation (Sikwanda, 2016). The vertically integrated energy system with its inflexible power purchase agreements rates and lack of well-defined policies for private participation creates difficulties for renewable energy projects diffusion in Zambia. Fluctuating costs and delays in project approvals further worsen the challenges faced by independent power producers and renewable energy developers (Bayliss & Pollen, 2021).The presence of Independent Power Producers (IPPs) signifies a conducive investment environment with clear policy and regulatory frameworks and reduced investment risks (Avila et al., 2017).

In an effort to restore financial stability, Zambia's state-owned power utility, ZESCO, introduced a 75% tariff increase in 2017, using a tiered pricing system for residential electricity. Under this system, the first 100 kWh cost \$0.03 per unit, consumption between 101 and 300 kWh was charged at \$0.05, and usage exceeding 300 kWh was priced at \$0.11 per unit, resulting in an average rate of \$0.0633. However, despite these adjustments, the prevailing tariffs are not commensurate to the full cost of electricity generation, distribution, transmission, and administrative both for ZESCO and independent power producers, which unfortunately remain unaffordable for many Zambian households (Bayliss & Pollen, 2021). More recently, the Zambia Electricity Supply Corporation (ZESCO) implemented additional and significant electricity tariff adjustments commencing in November 2024. These adjustments were primarily prompted by a severe drought that substantially reduced the country’s hydropower generation capacity, resulting in notable energy supply shortfalls. The resulting shortages compelled ZESCO to procure costly emergency power imports to mitigate prolonged periods of load shedding. To raise the required revenue during this emergency period, ZESCO expanded residential tariff bands from four to six, maintaining stable or reduced rates for low-consumption users while imposing substantial tariff increases on high consumption users across residential, commercial, and maximum demand categories (ZESCO Limited, n.d.). These increases were intended to offset emergency power procurement costs and support supply stability. The tariff adjustments were duly approved by the Energy Regulation Board (ERB) and aimed to balance revenue requirements with the provision of essential electricity services; however, they resulted in considerable cost increases for higher electricity consumers. The emergency tariffs were subsequently extended into 2025 as drought conditions persisted, with continued regulatory reviews leading to further adjustments and proposals to transition toward longer-term tariff structures (Energy Regulation Board, n.d.).

Bowa et al. (2017) highlight that high investment costs pose a great challenge to the growth of Zambia's renewable energy sector, emphasizing the importance of adopting cost-reflective tariffs in order to achieve desired growth in alternative energies use. Historically, the absence of such tariffs has made Zambia less appealing to investors in this sector. Additionally, inadequate infrastructure, including limited grid coverage and insufficient industrial capacity, further impedes the improvement in renewable energy utilisation. The off-taker market for off-grid renewable energy in Zambia primarily consists of low-income users who often cannot afford the service, making it less commercially attractive to international investors. As a result, the limited affordability in remote areas where mini-grids are deployed has led to a renewable energy landscape in rural Zambia that is largely dominated by indigenous private operators, with support from international partners (DT Global, 2021; GET.invest, 2019).

Sikwanda (2016, March) further highlights the importance of setting and implementing cost-reflective tariffs, either through a one-off adjustment or a phased approach, in Sub-Saharan Africa (SSA) or Zambia. Such tariffs are very important in the migration progression, and regular reviews are necessary to ensure that utilities collect sufficient revenue to cover their costs. In the Southern African Development Community (SADC) region, the frequently applied charge methodology is based on net gain or loss of a particular investment over a quantified time duration, articulated as a percentage of the investment's first cost commonly known as the rate of return (RoR). Table 7 provides an overview of various tariff-setting methodologies, defining the approaches applied and the methodological concepts of setting the regulatory energy tariffs for producers of Independent Power Producers (IPPs).

Some literature highlight a lack of clarity on electricity tariff issues, such as the implementation of cost-reflective tariffs, which pose significant policy and regulatory obstacles. This lack of clarity hinders effective planning because only with comprehensive and transparent information can there be a prudent assessment of charges and the elimination of inadequacies in the utilities to match set tariffs. Failure to implement cost-reflective tariffs effectively often leads to negative outcomes, including decreased production outputs across major service sectors. (Sikwanda, 2016, March).

Table 7

Regulatory Tariff Setting & Methodologies

Method	Definition
Price Cap	Price cap regulation sets a ceiling on the price charged to consumers, incentivizing operators to control costs. Operators save costs during the price-cap term, enhancing their rate of return. However, focusing solely on the price limit may lead operators to cut costs at the expense of service quality or reduce investment in infrastructure development.
Yardstick/Benchmark	Yardstick regulation sets prices based on comparative data from similar operators. If no similar operator exists, a model is defined for comparison (Carlos & Miguel, 2002).
Incentive Based regulation (IBR)	IBR sets electricity tariffs based on efficiency, considering only necessary capital and operational costs. It involves performance-based regulation with key performance indicators, applying incentives or penalties to utilities based on operational performance.
Rate of Return (RoR)	RoR methodology, also known as Revenue Requirement (RR) or Cost of Service approach, determines electricity tariffs by ensuring that regulated company's revenues cover operating costs, taxes, and depreciation, while also providing a fair profit on assets used for production and supply.

Note. An outline of methodologies applied and concept of setting the regulatory energy tariffs for producers of electricity/energy services. *Source*: (Sikwanda, 2016)

Conclusively, policy and regulatory impediments are a major barrier to scaling energy and renewable energy investments in Sub-Saharan Africa as it negatively affects market and investor confidence. High costs of compliance, inconsistent regulatory frameworks, and institutional inefficiencies raise project risks and prolong administrative processes. Constraints are worsened by insufficient financing, policy uncertainties, and overlapping institutional roles, which collectively deter private sector participation in the sector. Addressing such impediments improves the investment atmosphere, for capital investments and ultimate energy security (Adeyeye, 2025).

Market-Related and Institutional Barriers

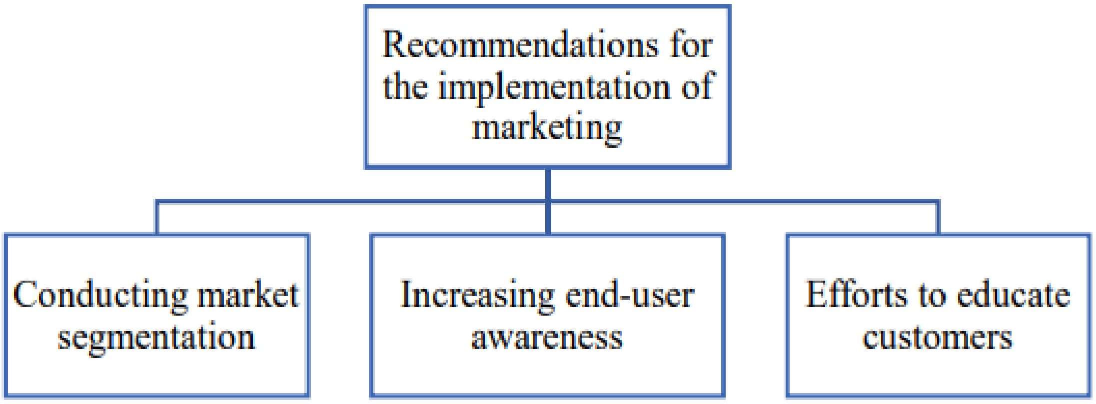
Marketing renewable energy deployment involves various essential activities aimed at fostering the adoption renewable/solar energy utilisation. Notable attributes of effective marketing includes market segmentation and targeting, where specific user groups are identified based on their unique needs and geographical locations. This aspect is complemented by customer education and awareness initiatives that effectively inform on the benefits of renewable energy. Dissemination of information can be done through appropriate channels suitable to the target audiences through such mechanisms as radio, social media, websites or community meetings in order to ensure that the message reaches the appropriate audiences Furthermore, developing a compelling value proposition is a crucial step in marketing strategies; this includes articulating the gains that renewable energy solutions bring forth, like energy independence, and at the same time addressing common misconceptions about high initial costs and reliabilities related to renewable energy technologies (Bowa et al., 2017; Falchetta et al., 2021).

In addition to the aforementioned, the aspect of monitoring and evaluation is integral to the assessment of efficiency in marketing campaigns, allowing for strategic adjustments and the incorporation of customer feedback to address concerns and proposals. Effective marketing strategies are vital not only for promoting renewable energy but also for addressing both functional and non-functional preferences that influence customers' choices between renewable and conventional energy sources. Marketing of renewable energies should be designed knowing that sluggish development in diffusion of renewable energy is often related to availability of other cheaper conventional fossil fuels and corresponding underutilization of sustainable resources in certain locations. Therefor for a successful marketing strategy priority mast be given to efforts which help to attain strategic market segmentation, enhanced end-user awareness, and comprehensive customer education to overcome existing misinformation and ignorance based hurdles and consequently encourage broader adoption of renewable energy utilisation (Eagle et al., 2017; Senyapar & Bayindir, 2023**).**

Challenges in promoting renewable energy technology are often compounded by insufficient supportive policies and financing to mitigate high cost barriers and investment incentives. Lack of adequate funding can hinder the effective marketing and renewable energy diffusion. To address these limitations, the shortfalls in governmental capacity to meet financing needs for green energy deployment can be supplemented by international financiers. This support is crucial in implementing green energy policies that align with global standards, such as those outlined in the Regulatory Indicators framework for Sustainable Energy by the World Bank -RISE tool (Mungai et al., 2022). Figure 7 presents some of the common marketing strategies to enhance the diffusion of renewable energies such as solar.

Figure 7

Effective Marketing Strategies for Small and Medium RE Sources



Note. The figure outlines three major components in marketing, namely market segmentation, end-user awareness and education, *Source:* (Lavrinenko et al., 2020)

Institutional Barriers are mainly due the absence of institutional innovations, coordination, and cooperation within the energy sector hinder policy implementation and commercialisation of renewable energy. Zambia's policy focus on grid-connected hydropower overshadows other renewable energy sources (Kachapulula-Mudenda et al., 2018). Governance inadequacies in form of poor financial governance and lack of good governance frameworks impede investment climate and lead to uncertainties in the investment environment. Effective governance is crucial for ensuring returns on investments and fostering a conducive environment for renewable energy projects (Gregory & Sovacool, 2019).Notable policy efforts to address these barriers include the adoption of auction programs and the Scale-up solar program, which aim to stimulate renewable energy markets and encourage private sector participation. However, overcoming forgoing obstacles requires comprehensive strategies that address technological, financial, regulatory, and governance challenges to unlock renewable energy potential for Zambia.

The lack of institutional innovations to create supportive environments for renewable energy utilisation, further slows down policy application and commercialisation of renewable energy technologies in Zambia. Additionally, inadequate coordination and cooperation within the energy sector lead to duplication of efforts and ineffective regulations, further impeding progress. Institutional barriers in the renewable energy sector often intertwine with market-related obstacles, leading to poor product development and limited market penetration. This occurs when market requirements do not align with the actual utilization needs identified by institutions engaged in Research and Development (R&D). Consequently, product development becomes supply-driven rather than being end-user driven. Fortunately, the introduction of Auction programs has helped minimize market hurdles by stimulating renewable energy markets and encouraging private sector participation. These programs facilitate the procurement of solar power at optimal prices through effective market designs aimed at reducing tariffs. One notable initiative in Zambia is the Scaling-Up Solar program, implemented with backing from the World Bank group program which aims to assists countries in Africa to purchase solar equipment or infrastructure requirements through an appropriately planned frameworks for power purchase (Mungai, & Kihoro, 2021; Kumar & Nanda, 2020).Policy Focus on Hydropower is an obstacles that overshadows other renewable energy sources in Zambia and limits their development and adoption as alternative source of energy for a considerable number of years. Notwithstanding, attempts to tackle a broader renewable energy outlook through consecutive renewable energy strategies, challenges in implementation still persist (Kachapulula-Mudenda et al., 2018).

Governance and Corruption Risks

Governance inadequacies pose significant obstacles to effective utilisation of renewable energy, spanning across financial, political, and technological investment governance. Financial governance deficiencies entail the absence of established rules and institutions to safeguard investments and ensure consistent returns. The lack of regulatory framework creates uncertainties within the investment climate, hindering the growth of renewable energy investments in Zambia (Gregory & Sovacool, 2019). Political governance concerns the management of the political economy and its indirect impacts on investments. In Sub-Saharan Africa, the leadership's understanding of the importance of accessing finance for constructing electricity infrastructure is crucial for enhancing renewable energy diffusion. Effective political governance has a big part in enabling pathway to finance (Gregory & Sovacool, 2019). Technological governance, viewed from a 'systems' viewpoint, examines extent to which prevailing structures and organization of the electricity delivery regime negatively influence investment. This perspective focuses on governance issues stemming from the broader system of organization and application of existing electricity provision technologies, also known as the electricity delivery regime (Gregory & Sovacool, 2019). Addressing these governance challenges is essential for creating a conducive environment for renewable energy investments and promoting sustainable energy development in Zambia and beyond.

Policy strategies refer to counter solutions aimed at mitigating policy challenges, notably the Ministry of Energy (MOE) formulated policies to address obstacles to solar energy investments. These creativities comprise enabling policies for renewable energy investments, financial metrics to widen pathways to financing, and risk mitigation initiatives to attract investors. Additionally, power sector reforms were formulated with the aim of enhancing the financial stability of utilities and promote community engagement to boost renewable energy adoption (Ministry of Energy, 2022). Ministry of energy (2022) further instituted the Action plans which included revising mini-grid regulations to align with the Electricity Act and simplifying licensing procedures for renewable energy developers through a streamlined process. Measures to improve financing mechanisms involved plans to review and rationalize electricity tariffs, increasing RE financial instruments, and introduce new financial instruments and risk mitigation facilities. Key actions in power sector reforms involve restructuring ZESCO as the sole off-taker for Independent Power Producers (IPPs) whose financial stability has been in jeopardy. Strategies to promote productive energy utilisation include community engagement, developing rural energy economic models, and establishing alternative payment systems for off-grid markets to address affordability issues. Additionally, the MOE strategises to streamline land permit processes, environmental impact assessment procedures, and develop new renewable energy standards to ensure quality control and ultimately boost market confidence. The ministry of energy also aims to enhance existing economic instruments and incentives, in order to make them more comprehensive and beneficial to both energy producers and consumers. Through these and many other RE investment strategies outlined by the ministry of Energy, Zambia pursues avenues to create an attractive atmosphere for investments in an effort to achieve its renewable energy targets.

In conclusion, the obstacles to renewable energy investments in Zambia span across multiple dimensions, including technological, financial, regulatory, market-related, institutional, and governance challenges. These barriers hinder the effective utilisation of renewable energy sources and consequently impede progress towards a sustainable energy assurance for the future. Notwithstanding, concerted efforts from institution participants, comprising governing Institutions, independent self-financing investors, and public societies are crucial in highlighting and overcoming these obstacles to unlock Zambia's renewable energy potential. By addressing technological complexities, enhancing access to financing, revising policy frameworks, stimulating market growth, fostering institutional coordination, and improving governance frameworks, Zambia can build a favorable atmosphere for renewable energy investments and achieve its renewable energy targets.

Through comprehensive strategies formulated by the Ministry of Energy (2022) and collaborative initiatives from all stakeholders, Zambia has great capacity to significantly grow its renewable energy resource base through articulate maturing of its plentiful renewable energy assets and to transition towards clean green energy solutions. By so doing, Zambia can partake in global efforts to combating depletion of the ozone layer, by promote sustainable development, and green energy for all. With determination and innovation, Zambia can overcome the hindrances to renewable energy diffusion and move forward towards a better and more reliable energy future for years to come. Table 8 outlines the barriers and effects in the Renewable Energy value chain.

Table 8

Barriers to RET Penetration from Different Barrier Categories

Barrier Category	Barriers to RETs	Remarks
Market Failure or imperfection	Overregulated energy sector	Diminishes investments in RETs
	Information gaps	Causes uncertainties & high costs
	Insufficient technologies	Causes inability to implement objectives
	Low competition	High product costs
	Elevated transaction costs	Poor Project executions.
	Lack of market infrastructure	Increased costs for the consumer
	High investment requirements	Discourages entrepreneurship
Market Distortions	Biased Aids favoring conventional energy	Negatively affects competition
	Tax burdens on RETs	High Costs for RETs
	Unaccounted external costs	Non-reflective energy costs
	Trade restrictions	High costs for RETs

Continued on next page

Table 8 (Continued)

Barriers to Rate of Penetration from Different Barrier Categories

Barrier Category	Barriers to RETs	Remarks
Economic	Not economically feasible	Need for Cost reduction in RETs
	Elevated discount rates	Initial-stage incentives necessary
	Long payback period	Causes non-viability of Projects
	Limited market size	Unattainable Economics of Scale
	High cost of capital	Economic viability negatively affected
	Restricted capital access	Few producers hinder, competitiveness & efficiency
	Non-availability of consumer credit	Potential market size decrease
	High initial costs for investments	Capital costs may also go up due to high risk perception
	Nil institutional Financial support	RET products hampered, Adversely effecting on competition and efficiency.
Institutional	Lack of information mechanisms	Lack of awareness among producers & consumers
	No legal/regulatory frameworks	RE producers encounter market, economic obstacles
	Vague financial incentives	Bureaucracy creates financial & economic hurdles
	Unstable macro - economics	Heightens risk & uncertainty for new investments, favoring products with shorter payback periods
	Conflicting stakeholder interests	Misaligned priorities lead to lobbying against RETs.
	Absence of research and development	May hinder technology adoption
	Lack of private sector involvement	Results in zero competition and inefficiency
	Lack of professional organizations	Producers' concerns not effectively communicated to policymakers

Continued on next page

Table 8 (Continued)

Barriers to Rate of Penetration from Different Barrier Categories

Barrier Category	**Barriers to RETs**	**Remarks**
Technical	Absence of standard codes certifications	Product quality & acceptance impacted; purchase & commercial risks, negative perceptions rise.
	Shortage of skills training	Potential barrier for producers
	Limited O&M facilities	May hinder acceptance of products.
	Entrepreneurship Scarcity	Can lead to limited competition & supply issues
	System limitations	Market potential remains unrealized for producers.
	Unreliable products.	Could cause decrease in market size
Social, Cultural & Behavioural	Low consumer acceptance	Dwindling of the Market
	Limited social support for RETs	Market expanse is affected
Other Barriers	Unfavorable government policies	Diminishes the confidence & escalates project costs
	Detrimental investment climate	Dilutes investor confidences
	High-risk perceptions	Escalates capital cost & financial incentives
	Unavailable infrastructure	Leads to poor RETs delivery due to lack of supporting infrastructure development e.g. Roads, grid connectivity.

Note. Outlines of various barriers to the penetration of renewable energy technologies, highlighting their causes and the resulting effects on the sector. *Source*: (Oryani, 2021; Sen & Ganguly, 2017).

At a broader level, table 8 categorizes obstacles in form of markets, Monetary, establishments, technological and socio-cultural dimensions, thereby offering a comprehensive overview of the challenges faced in RET implementation. Moving to a more detailed perspective, the table breaks down each barrier into specific consequences, providing insights into the intricacies of RET deployment. By thoroughly examining these barriers at multiple levels, stakeholders can gain a holistic understanding of the obstacles hindering the effective utilization of renewable energy and develop targeted strategies to address them.

Affordability is one of the obstacles that poses a significant challenge for solar investments at the household or mini grid level in Zambia. Table 9, outlines levels affordability of the energy tariffs at identified typical mini-grid sites at Sinda and Mpanta. The affordability levels are assessed based on average local household incomes and expenditure levels (Stritzke & Jain, 2021a).Computations presented in the country's currency, underscores the substantial detriments brought about by non-cost-reflective tariffs for these projects, indicating the necessity for increased consumption or further tariff reductions to make the system viable. Establishing an energy-affordability benchmark at a sub-regional level for rural areas in Sub-Saharan Africa (SSA) emerges as a crucial consideration for scaling up measures for the future mini-grid implementation strategies. Different authors have outlined challenges associated with solar mining operations in off-grid locations in rural Africa, highlighting different financing mechanisms, including pay-as-you-go models and other and supportive policies to make solar energy affordable for low-income households; additionally affordability is identified as a critical issue emanating from financial, technical, and social aspects and ultimately affects sustainability and scalability of solar in projects in off grid rural settings (Rolffs et al., 2015; Glemarec, 2012).

Table 9

Energy Tariff Affordability- Mpanta & Sinda MGs vs. Average UK Household

Characteristics	Sinda	Mpata	UK Household vs. Sinda /Mpata MG (£)
Daily output kWh	105	03	203
No. of customers	65	90	190
Disposable spending after fixed/food costs (30%0	800	50	2000
Disposable income for energy per month (50% of disposable income)	240	65	600
Affordable energy spending levels per day in ZMW	120	2.5	300
Required kWh/day based on outputs & connections*	4.00	0.75	10
Affordable tariff per kWh (ZMW) at Min competition**	1.62	0.07	1.07
Current MG OPEX per kWh in ZMW	2.48	0.57	9.53
	9.34	4	0.45

Note. Affordability comparisons for MG tariffs in Sinda & Mpanta (Zambia) with UK households,. MG -Mini-Grid, kWh- kilowatt-hour, & ZMW- Zambian Kwacha. *Source*: (Stritzke & Jain, 2021).

Challenges in PPP Programmes for Solar Investments

Investment improvement efforts for the solar sector in Zambia face significant hurdles, notably in the area of Public Private Partnerships (PPPs). PPPs have been widely promoted as an avenue for rallying capital, expertise, and efficiency from the private sector in support of public infrastructure and services. In Zambia, the solar energy sector represents a cordial area where PPPs could play a progressive role, particularly in bridging investment gaps, expanding access, and promoting renewable energy growth (African Development Bank (AfDB), 2022; International Renewable Energy Agency (IRENA), 2022). Nevertheless, the implementation of PPP arrangements in this sector has been met with substantial obstacles that limit their effectiveness.

Major deficiencies lie within the Public–Private Partnership Act (Government of the Republic of Zambia (GRZ), 2023), which has generated structural inefficiencies and eroded investor confidence. The lack of transparency and accountability in the negotiation and implementation of PPP contracts has raised concerns regarding equitable risk-sharing and the protection of long-term investment interests (World Bank, 2020a; Baker et al., 2021). Shortcomings in the Act, such as protracted approval procedures and overlapping institutional mandates, deter timely execution of projects; additionally, the lack of institutional and technical capacity within government-affiliated entities undermines their ability to negotiate, monitor, and enforce contractual obligations effectively (AfDB, 2022; Eberhard & Godinho, 2021).

Both public and private partners identify transparency, accountability, and protection of private sector interests as key aspects of successful PPP execution in Zambia. However, excessive government control over PPPs leaves financiers and private developers with minimal influence in the decision-making process (Muleya et al., 2020). The lack of protection for private sector interests manifests in uncertainties, policy inconsistencies, weak enforcement of contractual rights, and the absence of effective dispute resolution mechanisms (Odarno et al., 2020; Pegels & Altenburg, 2020). These shortcomings increase perceived risks, ultimately making Zambia's solar sector less attractive. In contrast, South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) demonstrates how strong regulatory frameworks and transparent procurement systems can mitigate such risks (Eberhard, A., & Naude, R. (2016).

The outlined deficiencies reduce PPPs' potential to serve as a reliable avenue for scaling solar energy investments in Zambia. Addressing these issues requires comprehensive reforms of the PPP Act, capacity-building within regulatory institutions, and the establishment of transparent and predictable frameworks that balance public roles with private sector security (African

Development Bank Group, 2022; Gardiner et al., 2015). Table 10 provides a detailed layout of the entities and their mandates under the Public-Private Partnership Act, along with the associated risks faced by these entities. In line with the obstacles encountered in the solar sector, it is evident that solar energy investments require robust approaches to attract capital effectively. To achieve this, Zambia needs strong legislation and regulatory frameworks to govern PPPs and facilitate effective investment incentives. Without such frameworks, partnerships between public and private actors remain strained, thereby hindering investment efforts. Worldwide, energy markets are confronting investment challenges in support of renewable energy initiatives especially with the advent of climate change (Hartley, 2013; Tshombe & Molokwane, 2016).

Overall, Public Private Partnership programmes designed to stimulate solar energy investments face significant structural, regulatory, and institutional challenges. Despite their potential to mobilise private financing, know-how, and proficiency, the flaws in PPP frameworks particularly relating to regulatory inadequacies, partial transparency, lengthy administrative processes, and inadequate institutional capacities weaken investor confidence. Public sector control, policy uncertainty, and weak protection of private sector interests further increase perceived investment risks thus reducing the attractiveness of PPPs as a viable tool for scaling solar energy development. Addressing these drawbacks requires strong legal and regulatory frameworks, enhanced institutional capacity, and transparent governance structures that balance public objectives with private sector security.

Table 10

Mandates and Public Private Partnership Bodies & Associated Risks

PPP Body in Act	Composition 0f The Body	Function 0f The Body	Risks Identified
PPP Unit	Undisclosed except Director; Not availed to public	• Promote PPPs • Identify project for Act • PPPs Tech Develop & Practice • Evaluate planned projects • Mentor project personnel • Stimulate PPP cognizance • Give go ahead to consultancies • Interrogate project suggestions • Review projects • Guide govt. on PPP actions	• PPP capability unknown • Unit lacks understanding to undertake tasks thus rely on consultations thereby diminishing investor sureness • Internal PPP unit should ably handle own projects
PPP Council	Finance Minister is the Chairmen, 4 ministers presidential appointees 4 members presidential appointees Permanent secretary (MoF)	• Formulate PPP policy for the Act • Approve or reject projects • Ensure transparency of PPP projects • Give directions to contracting authorities • Request technical assistance	• Composition may be incompetent • External consultation is detrimental • Presidential appointments upset balanced representation, making private sector exclusion unattractive for investor confidence.

Continued on next page

Table 10 (Continue)

Mandates and Public Private Partnership Bodies & Associated Risks

PPP Body in Act	Composition of The Body	Function of The Body	Risks Identified
PPP Technical Support	• Secretary to treasury as chair	• Advise the PPP council & unit on technical matters	• Member composition may be incompetent
	• 4 ministry permanent secretaries	• Recommend award of agreements	• External consultations weakens the body
	• Attorney general Rep.	• Evaluate & select project for award to council	Key organizations in private sector left out - architects, surveyors, planners etc.
	1Member each from EIZ, National council for construction, Environmental Council, Procurement authority & Economic association. 2 minister appointed members	• Recommend approval of projects	• Inadequate expertise to competently handle the mandate
		• Perform assignments from the council	Nil

Note. This table outlines the bodies involved in public-private partnership (PPP) agreements, along with their corresponding functions and associated risks. *Source*: (Muleya et al., 2020).

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Intricacies in Investments Frameworks

Solar energy investment incentives in Zambia constitutes a complex landscape, which presents challenges to main stakeholders such as ZESCO, the office responsible for Promoting investments in the private sector (OPPPI), and institutions in charge of facilitating financing such as the Development Bank of Zambia (DBZ) in terms of evaluating their effectiveness and attractiveness to investors. Notably, there is a significant inadequacy in incentivizing necessary renewable energy investments, prompting major energy producers to engage in negotiations for customized incentive packages with the Zambia Development Agency (Walimwipi, 2012b). The perceived importance of various incentives types varies among stakeholders. Large-scale investors have particularly benefited from government sponsored loan guarantees, facilitating easier access to finance and enabling upgrades in generation capacities for hydro, thermal, and solar projects. Meanwhile, project developers advocate for the successful finanlisation of negotiations on comprehensive incentive packages, particularly the Investment Promotion and Protection Agreement (IPPA) at a project-specific level (Reddy & Painuly, 2004). The establishment of the Development Bank of Zambia (DBZ) significantly adds to progress in renewable energy development as financiers of projects and as fund managers for United Nations Industrial Development Organization (UNIDO) supported financing; thereby playing a crucial role of facilitating financing for renewable energy undertakings and promoting growth in the sector (Walimwipi, 2012b). The energy division is a vital part of trade and industrial development in countries worldwide; nonetheless the uneven distribution and subsequent shortage of energy resources in certain geographical localities have led to heightened demand and increased energy costs. Consequently, there is a pressing need for sustainable solutions, with a shift towards renewable energies being paramount. Effective technology transfer, facilitated through funding tools such as Foreign Direct Investments (FDIs), is crucial for nations grappling with energy resource disparities. It is cardinal for recipient nations to guarantee that strategies confidently align with existing inducements to mitigate any undesirable potential impacts that FDIs may introduce to renewable energy investments (Kilicarslan, 2019).

In the bid to encourage private sector investments and support an investments environment without risks, strong oversight mechanisms and attractive inducements are essential. These efforts are crucial for mobilizing affordable funding for clean energy initiatives, thereby greatly contributing to the agenda to attain worldwide provision of reliable form of energy by 2030 (Cuamba et al., 2013). A notable strategy for advancing clean energy adoption, is the reliance on international policy frameworks that endevour to leverage the vast potential of solar power to enhance energy provision and access in African regions. These frameworks help to guide local policies in integrating solar PV technology into conventional energy systems, particularly through decentralized, off-grid solutions (Hussain et al., 2024). However, despite promising initiatives, the long-standing viability of off-grid solar solutions remain inadequately addressed. To bridge this gap, there is a need for targeted incentives to encourage community-based investments supported by innovation-focused programs. These programs should emphasize making solar PV technology relevant to local communities through collaborative research tailored to specific regional conditions and practical applications (Pillot et al., 2019).

In Zambia, domestic PV solar systems contribute substantially in the consumption of renewable energy. However, there exists a notable deficiency in deployment data concerning these systems, impeding informed planning by various stakeholders including policymakers and investors in the sector. Consequently, there is a pressing need to enhance data collection methods to obtain comprehensive insights into energy usage patterns. Furthermore, the absence of adequate infrastructure poses a significant challenge for independent producers seeking access to the national grid. Additionally poor information dissemination obscures the capacities and capabilities of the grid system, thereby adversely impacting renewable energy prospects of being incorporated into the main grid system. Ultimately, addressing these issues holds the possibility to attain substantial gains for households in terms of enhanced and sustained energy access (Ahlborg et al., 2015).

One of the primary barrier hindering the diffusion of renewable energy in Zambia originates from poor or non-comprehensive implementation of the laid out plans following the 2008 country energy policy direction for Renewable Energy Technologies (RETs). Despite subsequent motions proposed in the National Energy Policy of 2010 aimed at diversifying RE sources, the failure to adopt and implement these measures has led to inadequate funding, thereby impeding progress within the sector. To address this issue effectively, future policy directions should prioritize government support for Independent Power Producers (IPPs), particularly in delivering affordable energy to underserved households through the provision of appropriate incentives or subsidies (Kachapulula-Mudenda et al., 2018). Moreover, there exists a broader consensus as articulated by Gielen et al. (2019) that fast-tracking the changeover to renewable energy use worldwide could significantly improve energy provision in the coming decades. However, the current pace of transition falls short of meeting the benchmarks outlined in sustainable development goals such as the SDGs for 2030. To bridge this gap, there is a pressing need for improved financing mechanisms and financing incentives for generation capacities and infrastructure development. This entails the establishment of reliable, predictable, and informed policies that create transparent and risk-free investment environments. Despite the potential benefits of energy transitioning, Gielen et al. (2019) lament that many policymakers and analysts have yet to fully appreciate its significance, highlighting the need to raise awareness and fostering greater comprehension of this aspect.

Infrastructure Limitations and Technical Constraints. Lack of guidelines for grid integration is one of the salient obstacles facing Zambia, and other countries located south of the Sahara. This obstacles arises from the absence of clear procedures and requirement frameworks for grid integration. Without coherent assessments of energy technology requirements leads to difficulties in effectively integrating RE existing electrical systems. This absence of consistency deters the capability to leverage on potential contributions from alternative energies like solar to the desired overall energy combination. In the context of Southern African sub region, for example there is a significant lack of coherence in assessing the sustainability of energy technologies, thus governments face difficulties in establishing national policies pertaining to necessary technologies for effective grid integration capabilities (Musango & Brent, 2011). Technological factors have an important role in unlocking the abilities of renewable energy to contribute to the National energy basket, however the deployment of such technologies into the electrical grid necessitates clear guidelines and frameworks governing the interaction of stake holders in the sector at different levels (Haigh, 2023; Piana et al., 2018) states that often technical problems stem from shortage of expertise required to implementation of renewable energy projects, especially the complex utility scale installations and also due to Infrastructure capacity limitations and aging factor make which it costly and time-consuming due to the need to build or refurbish necessary infrastructure. Technically, variable Renewable Energies (VREs), such as solar power, pose specific integration challenges into main grids. These challenges arise from the fact that they cannot be hastily adjusted to meet changing demands, the restricted capacity to regulate production, and their inability to perform main frequency controls compared to orthodox power plants. In Zambia, leveraging hydropower plants for frequency regulation has been the preferred approach. However, integrating VREs requires additional measures such as use of power converters and frequency regulators to stabilize the grid (Habostad et al., 2021). In addition, unstipulated feed-in tariffs pose implementation challenges and do not help in stimulating this category of investments in Africa (Kruger & Eberhard, 2018). Notwithstanding, the electricity network in Zambia is s technically fitting for VRE incorporation using current hydropower installations, further examination relating to interfacing using power inverters to complement hydropower as a requirement in the implementation of net metering is cardinal (Habostad et al., 2021). Net metering allows consumers with installed solar PV for self-consumption to channel excess energy to the grid and be credited through bidirectional meters (George et al., 2019). In first world countries, small grid-connected systems are encouraged through availability of Feed-in Tariffs (FiT) and corresponding net-metering mechanisms which benefit produce/ consumers (prosumers), however in countries in the Sub-Saharan region, it is not the case and the situation is exacerbated by high upfront costs of solar technologies and limited government capacity to match technological advancements with human capital development, there is no stimulation in this direction (Amankwah-Amoah, 2015). Despite efforts to promote Renewable Energy through REFiT, challenges in the sector have persisted in the country due to unsuitability and incompatibility of existing infrastructure with conventional technologies (Piana et al., 2018). More specifically, technological implementation of smart grids faces technological barriers as existing infrastructure lags technological advancements, often leading to compatibility challenges (Mtokambali & Jun, 2014). Zambia has however made strides to adopt a mixture of Feed in Tariff and auctioning scheme under the program to scale up solar energy diffusion under the Scaling Solar Program, which focuses on auctions for fresh solar schemes (Piana et al., 2018).

Governance and Investment Incentive Dynamics.

Lack of reliable access to energy across Sub-Saharan Africa, including Zambia, is largely attributed to weak governance frameworks and limited policy mechanisms that guide financing and deployment of incentives in the renewable energy sector (Dagnachew et al., 2020; Yin & Liu 2025). In recent years, Zambia has demonstrated commendable political commitment to fostering an appealing investment climate for renewable energy. The country has benefited from external initiatives such as Get-Fit and the Scaling Solar program, both designed to facilitate the implementation of the Renewable Energy Feed-in Tariff (REFiT) strategy. These programs have created a more conducive environment for private investment through mechanisms such as premium payments per kilowatt-hour (kWh), guarantees against off-taker and political risks, and access to private financing at competitive rates (Cristian et al., 2018).

Despite these positive steps, Zambia still faces challenges in developing comprehensive legislation and regulatory frameworks that effectively support investment. This underscores the need for more targeted reforms to attract and sustain private participation in the solar sector. Renewable energy mini-grids in Zambia, for instance, continue to face sustainability challenges such as financial, social, and technical. Among these, financial sustainability remains most critical, encompassing both capital expenditure (CAPEX) during the initial investment stage and operational expenditure (OPEX) over the project’s lifespan. To ensure long-term viability, revenues must at least cover non-grant portions of these costs (Stritzke & Jain, 2021a).

Financing Structures and Incentive Mechanisms. Addressing these gaps requires innovative approaches that integrate financial, fiscal, and non-financial support mechanisms to attract sustainable investment. Zambia made notable progress in this regard, particularly during the decade leading up to 2012, where reforms were introduced to strengthen the business environment, expand private sector participation, and align energy sector investments with broader economic growth priorities such as mining and manufacturing (Walimwipi, 2012a)

Financing structures are especially important for recovering CAPEX. In Sub-Saharan Africa, common models include auction-based programs, where subsidies cover 60% to 80% of upfront costs, and results based funding (RBF), where developers are compensated based on the number of connections achieved, typically ranging from $350 to $500 per connection. Hybrid models combining subsidies and RBF have also been adopted to strengthen financial viability (Phillips et al., 2020a, 2020b).

To address high upfront costs for solar technologies, Zambia introduced tax exemptions on renewable energy imports, particularly solar photovoltaic (PV) equipment. Feed-in tariffs (FiTs) were also developed to incentivize production. To further increase private participation, electricity tariffs were raised by 25% to move toward cost-reflective pricing, while mini-grid projects in rural off-grid areas were granted a guaranteed tariff of $0.06 per kWh for 25 years (Bowa et al., 2017). Complementary mechanisms include the Rural Electrification Fund, government-backed loans, and capital support from the Rural Electrification Agency, all aimed at reducing risks and improving affordability.

Institutional Milestones and Policy Reforms. Milestones such as the establishment of the Office for Promoting Private Power Investment (OPPPI) in 1999 reflected the government's early efforts to place energy at the center of investment and development. The 2011 amendment to the Zambia Development Agency's schedule designated energy as a priority sector, making it eligible for structured incentives to stimulate investment inflows (Walimwipi, 2012b) Zambia's investment incentive framework has evolved significantly from its early roots in the Investment Act of 1993, which offered broad tax exemptions, capital allowances, and preferential corporate tax rates (Cornland et al., 2001). A landmark reform in 1998 by the Ministry of Energy and Water Development introduced fiscal support for independent power producers (IPPs), including concessions for transmission infrastructure to connect privately generated electricity to the national grid. This gradually transformed into a more flexible, project-based incentive system, with benefits varying by investment type, scale, and location. Larger-scale solar farms and rural off-grid projects were targeted with more attractive structures, balancing rural electrification with private sector profitability (Bayliss & Pollen, 2021).

Incentive Framework by Zambia Development Agency. Currently, the Zambia Development Agency (ZDA) administers a wide-ranging set of incentives for foreign and local investors, particularly in priority sectors such as energy, agriculture, manufacturing, and mining. These incentives include fiscal, financial, and non-monetary benefits such as tax exemptions, import duty waivers, and VAT deferment. For example, investors pledging at least US$500,000 in convertible currency qualify for multiple incentives, while those investing in Multi-Facility Economic Zones (MFEZs) or designated priority sectors may receive additional benefits such as corporate tax holidays and dividend tax exemptions (Zambia Development Agency [ZDA], 2022). ZDA also facilitates access to financing through government-backed loan guarantees and risk insurance, reducing uncertainties and fostering a favorable business environment. Large-scale investments exceeding US$10 million are eligible for broader benefits, including import duty waivers, VAT deferment, dividend tax exemptions, and corporate tax holidays (Walimwipi, 2012b). These measures extend beyond taxes to include technical support, land acquisition assistance, utilities facilitation, immigration processes, and licensing. Investors committing over US$10 million can even negotiate additional project-specific incentives directly with ZDA (UNCTAD, 2011).

Global Comparisons and Policy Gaps. Many countries worldwide acknowledge the importance of increasing renewable energy contributions to national energy portfolios. To promote integration, successful countries have adopted measures such as generation tax credits, compulsory production allocations, differentiated tariff schemes, and tradable certifications. However, many policies still lack explicit provisions to foster technological innovation in renewable energy. Ideally, innovation strategies should account for diverse local natural conditions influencing technology deployment. Addressing this gap could enhance policy effectiveness, encourage renewable energy patents tailored to regional contexts, and promote broader diffusion of technologies globally (Johnstone et al., 2010).

In conclusion, Zambia has a variety of incentives for investments intended to create a conducive investment atmosphere to attract renewable energy (RE) investments through reduction of investment costs and boosting the financial viability of RE energy projects. Key fiscal incentives in contention include corporate income tax holidays**,** accelerated depreciation allowances**,** and VAT and import duty exemptions on key renewable energy equipment such as solar panels, inverters, batteries, and other related installation summary, which significantly lower upfront capital costs for investors (Zambia Development Agency, n.d.; M&J Consultants, 2025). In addition, institutional incentives under the Zambia Development Agency (ZDA) Act provide concessions in form of duty-free importation of capital goods and investment protection guarantees, while non-fiscal incentives include efficient processing services, work permits support, and admittance to multi-facility economic zones for large-scale renewable projects (ZDA, 2022; Off-Grid Information Hub, n.d.) The outlined incentive frameworks aim to augment competitiveness in the sector and ultimately promote private-sector participation in Zambia's RE sector and particularly in solar energy deployment.

Table 11 provides an overview of Zambia’s financial, fiscal, and non-monetary incentives, highlighting regulations and subsidy schemes, while table 12 provides detailed description of some of the existing fiscal incentive for renewable energy investments by summarizing them by investment categories. Together, these illustrate the government’s commitment to sustainable energy development and private sector engagement. By offering tailored fiscal support, Zambia aims to reduce barriers, stimulate investment, and create an enabling environment for both domestic and foreign investors in the renewable energy sector (ZDA, 2022). Overall, Zambia’s solar sector reveals many of the broader challenges facing Sub-Saharan Africa, where structural, economic, and institutional obstacles continue to hinder progress. Recurrent issues such as limited technical expertise, insufficient policy constancy, affordability barriers, and investor indecisions have decelerated both utility-scale and decentralized solar adoption. While incremental reforms and incentive schemes have been introduced, their effectiveness remains irregular, with gaps in capacity building, financing accessibility, and regulatory consistency. Addressing these connected barriers is vital to unlocking the full potential of solar energy as a reliable contributor to Zambia’s energy mix and to attaining viable growth in the sector (Brunet et al., 2018).

Table 11

Overview of Investment Incentives for Renewable Energies in Zambia

Incentive Type	**Regulation**	**Scheme**	**Description**	**Type of Subsidy**
Financial Incentives	REA Act No. 20 of 2003	REA Fund	Fund to enhance rural electrification –Grant support	Targeted govt. spending
	-	Govt loan & guarantees	ZESCO attains guarantees for development	Subsidizing goods/ services
	Statutory Instrument 15 of 2011	REA capital Support	UP to 100% support for Hydro & Mini Grids	Govt. Loans & guarantees
	Framework & Package of incentives (FPI) 1998	OPPPI Insurance indemnification, risk sharing agreement	Risk sharing Agreement facility with potential projects	Govt. Insurance/ Indemnification
	FPI 1998	FPI for Hydro generation & Transmission Development	Overall document outlining investment	Various

Continued on next page

Table 11 (Continued)

Overview of Investment Incentives for Renewable Energy in Zambia

Incentive Type	Regulation	Scheme	Description	Type of Subsidy
Fiscal Incentives		Tax exemptions & reduced dividends.	Investment incentives in form of govt. forgone revenue is available & depends on investment levels, size and Type	Tax expenditure
		Tax exemptions & reduced import duty.		Exemptions from exercise/special taxes
		Tax exemptions & reduced VAT		Tax expenditure
		Corporate Taxes		Tax expenditure
Non-monetary Incentive facilitation		Technical support to access govt. resources, infrastructure & permits	OPPPI assists developers with permits and agreements, e.g., preferential access to Govt. assets	Subsidised goods/services

Continued on next page

Table 11 (Continued)

Overview of Investment Incentives for Renewable Energy in Zambia

Incentive Type	Regulation	Scheme	Description	Type of Subsidy
Other incentives: income /price support	FPI 1998	Power Purchase Agreements (PPAs)	PPAs incentive for generation at above market price rates. i.e., OPPPI negotiates PPAs (CUT, 2003)	Inflated market rates for producers
		Subsidised energy services	Good rates for consumers as an incentive to invest in other sectors	Regulated prices at below market rates

Note. This figure presents the various investment incentives for renewable energy in Zambia, outlining related schemes and subsidies available. *Source:* (UCTAD, 2011a; 2011b).

Table 12

*Fiscal Incentives for Investment Targets in Renewable Energy Sector (Zambia***)**

Aspect Attracting Incentives	**Description of Incentives Applied to Dividends and Taxes**
Dividends	15% withholding Tax on dividends; Tax rate on dividends is 0% for investments of US$10 million or US$500,000 in a priority sector for 5 years from initial dividends declaration.
Import Duty	Import duty raw materials, capital goods and specialized motor vehicles ranges from 0 to 40 % for first 5 years. Investments of US$10 million or US$500,000 in a priority sector, it is 0 %
VAT	VAT is levied at 16 %, except for the zero-rated goods / services. Investments of over US$10 million or US$500,000 in a priority sector are allowed to defer VAT. Other various investor categories also attract reduced VAT rates
General Corporate Tax	Corporate tax rate is set at 35% for first five years from first profits, with exceptions for investments over us$10 million or over us$500,000 in priority sectors. Reduced tax rates are in years 6 to 8, at only 50% of profits are taxable; in years 9 and 10, 75% of profits are taxable. Small or micro investors are exempt from for the first three years in urban areas and the first five years in rural areas.

Note. Table outlines various incentives Placed on dividends earned and taxes for investors with varying investment thresholds and locations. ZDA-Zambia Development Agency. *Source*: (Walimwipi, 2012)

Energy Access and Strategies for Scaling Solar in Zambia

Zambia's electricity generation capacity as of 2024, stood at approximately 3,871 MW**,** highlighting a minimal increase from 3,811 MW in 2023 (MOE, 2024). The composition of the energy mix is thus predominantly hydro based, with 84% of this installed capacity being from hydropower, followed by 9% coal, 5% heavy fuel oil, and 3% from solar energy (ZDA, 2024). Despite this installed capacity, Zambia faces significant challenges in meeting its electricity demand. As of July 31, 2024, the national peak demand was appraised to be at 2,400 MW, while the actual available power generation was only 1,040 MW, signifying a power deficit of 1,360 MW. In order to alleviate this shortage, the country imports about 410 MW from neighbouring countries, leading to a net shortfall of 950 MW (ZDA, 2024). Broadly speaking therefor, in order to effectively respond to these energy challenges, Zambia is actively making frantic efforts to diversify its energy mix. Notable developments include the commissioning of the Itimpi Solar Power Station in April 2024, which added 60 MW to the national grid, the Chisamba Solar Power Plant**,** a 100 MW facility commissioned in June 2025. Additionally, the Kafue Gorge Lower Hydroelectric Power Station, with a capacity of 750 MW, commenced operations in 2023 (ZDA, 2024).

The fact that Zambia is 84% hydropower dependent, it is prone to climate change effects such as poor rain patterns which drastically reduce electricity generation from hydro power plants, hence the necessity for a robust renewable energy-mix strategy to keep up with ever increasing energy demands (Imasiku, 2021). Additionally, it is unfortunate that Zambia has recorded governance weaknesses in the past in form of incomplete regulatory frameworks for the energy sector, lack of transparency, poor stakeholder comprehensiveness and non-responsive governance approach to energy access issues which consequently hinder electrification efforts (Stritzke et al., 2021). The launch of an action plan developed by the Health Coalition and the Off-Grid Taskforce to deliver reliable and inexpensive solar electricity to health centers with no access to the grid in accordance with the energy Vision 2030, stands out as a notable and positive effort undertaken by the government with assistance from UKAID and financing by the Africa Clean Energy Technical Assistance Facility & Power for All (ACE-TAF) (Hako, 2022). The initiative's aims was to increase Private Power Investments in energy for rural health centers between 2000 and 2015 during which Zambia documented an upsurge in electrification levels by 11 %. i.e., an increase of 17% in built-up areas and 1.6% in rural areas (Lyambai, 2018). Generally between 2000 and 2015 there was notable increase in grid power to the rural areas of about 4.4% and 7.4 % from solar power, culminating into 27.9% increase in energy access levels during the period which was largely attributed to the Public Private Partnership (PPP) Investments spearheaded by the Rural Electrification Authority (REA) (Mwanza et al., 2017; Lyambai ,2018). The increase in energy access resulted from 60 kWp from Solar Mini grids supplying about 50 households, 250 solar PV systems installed in learning institutions and traditional leader's dwellings including Four hundred under a pilot project for Energy Service Companies (ESCO) (Mwanza et al., 2017). The increase in availability of solar PV technologies in Zambia which are ever getting cheaper is a positive development considering governments initiatives, targets, and intentions outlined in the National Energy Policy to boost electricity availability from current 4% to 50% for remote locations and up to 90% for urban areas by 2030; this simply means that there is a requirement to accommodate an estimated increase in energy demands of up to 21.6TWh by 2030, which represents an increase of 4.4% annually, to be attained through a diversified energy mix comprising utility scale small and medium scale investments such as home PV systems (Eckhouse & Hirtenstein, 2016). To achieve aforementioned estimates in energy access growth the government needs to install at least

100MW of utility scale PV system and approximately 500,000 home solar systems throughout Zambia in the duration leading to 2030, a scenario requiring that the government devotes more efforts in attracting local and foreign investments by improving the investment environment i.e., through introducing feed-in-tariff; reducing the price rates for mini grid systems as low as USD 6cents/kWh to improve affordability and by introducing investment incentives to cushion initial costs of RETs (Bowa et al., 2017). According to Smith (2020), the coming on board of Infra Co Africa, Danish Investment Fund for Developing Countries (IFU) and EU-funded Electrification Financing Initiative (ElectriFI) to finance Africa GreenCo with US$15.5million in order to initiate a first renewable energy purchaser and service provider initiative in Zambia is a positive development as it will increase private sector energy investments and therefore improve off takers' creditworthiness. The initiative is such that Green Co will purchase energy from independent producers of green power and sale to public and private off-taker utilities, including markets in the Southern African Power Pool (SAPP), thereby creating an open, transparent and competitive environment, attractive for private sector investments (Sam, 2020). On a social cultural aspect of things, in order to improve solar utilisation in Zambia, people's attitudes and perceptions regarding solar energy solutions need to be improved through deliberate awareness programs on the benefits and trustworthiness of solar energy by government ministries such as ministry of Energy (MoE) and through private institutions concerned with alternative energy sources development in the country such as the Renewable Energy Association of Zambia including off-grid solar energy providers (Zulu et al., 2021)

Drivers and Barriers for Private Sector Participation

The energy sector is a very important part in the developmental plan hence the Zambian government has enedevoured to allocate more resource to the energy sector over the last recent years, albeit the effort has had forgoing notable challenges such as non-reflective tariffs and resulting low partaking from private investments. Additionally in order to increase Independent Power Producers (IPP) participation in the energy sector, the power sector reforms of 2018 were formulated to expand the energy combination so as to mitigate climate change triggered energy deficits (Policy Monitoring Research Center, 2022). Similarly, the Public Private Partnership (PPP) Act of 2009 is one other platform established to boost critical public infrastructures and associated energy provision services required for the country's development, however despite all these efforts Zambia has had challenges in attracting enough private sector investments under the PPP Act mostly due to framework deficiencies, bureaucracies, lack of transparency, accountability and poor risk sharing mechanisms to protect private developers and financiers, Additional challenges also emanate from PPP governing structures which were predominantly from the public sector hence introducing an inclination to protect public sector interests above those of the private sector (Muleya et al., 2020) . In Sub-Saharan Africa, a large proportion of remotely located communities cannot afford solar energy services. Additionally, there is poor energy infrastructure and distances between communities are significant, hence the markets for produced energy are equally typically small to medium-sized to correspond to communities in the vicinities. While these markets offer lucrative opportunities, they also carry high risks, such as market uncertainties and affordability issues, thereby making them less attractive to large scale or donor-backed programs. Despite this, such programs play a crucial role in providing small-scale energy solutions to low-income populations in developing countries hence the need to further improve their viabilities (Haselip et al., 2015). Notably low incomes and lack of affordable financial access to support such investments is a substantial barrier to the growth of SMEs, who are often upcoming businesses in the renewable energy industry (Haselip et al., 2015). Kruger et al. (2019) also elaborate on the challenges encountered as a result of government spearheaded site selection process during the first round of Zambia’s Scaling Solar progression; pointing out the fact that despite the program's potential to enhance solar energy utilization and utility scale solar PV auctions, various general and site specific risks are present and identifiable. They point out that the selection process applied in the Scaling Solar programme should have incorporated appropriate risk mitigation strategies after consultation with the private sector in order to address forgoing challenges effectively. Additionally with the advent of utility scale solar plants, notable challenges have persisted within the renewable energy sector plants in form of lengthy licensing processes for electricity generation, high poverty levels, lack of expertise, fragmented supply of renewable energy products, insufficient financing, limited knowledge on taxes and incentives and also lack of awareness as some of the significant challenges faced (ERB, 2020).

There has been notable increased engagement in public-private partnerships (PPP) by developing countries in order to boost energy access through stabilization of business and economic environments and offering investment incentives. However, challenges arising from bureaucratic processes and poor business environments, often caused by ineffective policies and procedures, hinder the realization of desired PPP schemes. Despite supportive factors, such as conducive environments for private sector exploitation, ensuring high returns on investments, and suitable risk factor allocations, challenges persist in attracting more investment in PPP projects.

Private sector participation in PPP projects have been noted to rely on three main driver clusters, namely the business environment, economic environment, and capacity of the public sector. A conducive business environment should foster reduced costs of doing business, while the economic environment should ensure high returns on investments. Additionally, the public sector's capacity is crucial for suitable risk factor allocations (Bisaro & Hinkel, 2018; Evdorides & Shoji, 2013;

Fleta-Asín & Muñoz, 2021). Similarly Incentives for private participation in PPPs fall into two main clusters groups, namely ‘Direct incentives’ and ‘Business environment incentives’, of which the former category include financial incentives, risk mitigations, government viability gap financing, concession loans and tax incentives. On the other hand, the business environment involves creating an enabling environment through fair allocation of risks and competitive bidding (Bisaro & Hinkel, 2018; Ilgenstein, 2022; Rezouki & Hassan, 2019).

Generally, the growing demand for energy throughout the world comes along with needs to pursue new energy technologies through consultation with public, private and research institutions in promoting and developing innovative renewable energies; however not much headway has been made in the country due to the challenges of deficiencies in human and institutional capacities, deficiencies in research and development, in financial and fiscal incentives, lack of awareness and insufficient donor support (Sovacool et al., 2018)

Solar PV Potential, and Growth

Significantly low levels of electrification were recorded before the establishment of the Rural Electrification Authority (REA) in 2006, during which rural electrification in Zambia relied solely on grid extension projects undertaken by ZESCO. These projects were slow and costly to accomplish under ZESCO as is exclusive responsibility. Consequently, with the recognition of favorable conditions for solar energy production in Zambia, characterized by high radiation levels estimated to be between 2100kWh and 2500 kWh/ per square meter respectively annually at an average of 5.5 kWh per square meter per day, authorities saw it feasible to integrate solar home systems under off-grid PV systems in the rural electrification initiatives (Bowa et al., 2017). This shift was aimed expediting electrification efforts to make them more cost-effective. Many sola installation projects have been undertaken and table 13 presents a summary of installed solar PV systems by 2017 outlining the targeted areas of electrification and coverage and power capacities (Mwanza et al. (2017).

Zambia, covering 752,614 square kilometers, holds substantial solar potential, with an estimated 1.59 million TWh annually on horizontal surfaces. Therefore utility-scale photovoltaic potential is about 392,701 TWh per year geographically, and 20,442 TWh per year technically.

Table 13

Solar PV Technology Diffusion Levels in Zambia

Description	PV Technology Status			
	MOE (Units)	REA (U)	ESC (U)	Capacity/ (U)
Schools	400	250		≥ 1kW
Households		500	199	> 1kW
Community centers		50	264	≤ 1kW
Chiefs Palaces		50		≥ 1kW
Mini Off Grids	-	1		= 60kW
Average total Installed Capacity				N ≤ 2MW

Note. REA = Rural Electrification Authority; MoE = Ministry of Energy; ESC = Energy Service Company; /U = per unit. *Source:* (Mwanza et al., 2017).

These estimations are attributed to large expanses of flat land conducive to Photovoltaic deployment coupled with high solar radiation, extended sunshine hours, and favorable temperatures (Mwanza et al., 2017). Table 14 and table 14 present details of solar energy potentials in Zambia outlining available areas, potentials and radiation parameters including Theoretical and Geographical energy potentials respectively.

Table 14

Solar Energy Potential in Zambia

Favourable Area	Average per Year	Energy Potential	Hours of Sunshine	Solar power density
(Km^2)	(KWh/m^2 d)	(KWh/ m^{2}a)	(Hrs/a)	(MW/k m^2)
186,121	5,78	2109.97	4403,12	55,6

Note. Outline of solar potential in terms of available area, sunshine hours, annual average energy and power density for solar energy in Zambia; *Source:* (Mwanza et al., 2017).

Table 15

Aspect of Solar Energy Potential in Zambia

Energy potential	Power (TW)	Energy (TWh/a)
Theoretical	360.645	1,587,964
Geographical	89.187	392,701
Technical	10.248	20,442

Note. Outline of solar energy potential in terms of theoretical, geographical and technical power and energy. *Source:* Mwanza et al., 2017).

Unfortunately some of the observations and documented evidence reveal that the implementation of solar infrastructure at household level in the country is significantly influenced by community attitudes towards new technologies. Negative perceptions, lack of trust, and subjective norms often hinder adoption, hence they require awareness measures to mitigate such attitudes in accordance with planned behavior theories (Zulu et al., 2022). Nonetheless it is evident that, the diffusion of solar energy, through mini-grids systems is pivotal in achieving access to affordable, reliable, sustainable, and modern energy for all in developing countries as outlined by the UN’s SDG 7 goals. However, mini-grid solar initiatives encounter various methodical, monetary, and community based sustainability challenges which unfortunately are often less detailed in existing literature due to the often applied narrow covering silo approach by the reviews. This ultimately underscores the necessity for comprehensive reviews of mini-grid solar diffusion efforts in sub-Saharan countries like Zambia and Uganda (Stritzke & Jain, 2021b). A notable challenge in Mini grid set ups is the mismatch between energy affordability and the set tariffs, which poses a threat to mini-grid sustainability and expansion of energy access. Ad-hoc planning based on affordability levels, financing options, and value-added activities is essential to address this challenge effectively. Additionally, despite numerous studies on mini-grid sustainability, financial data such as operating expenses (OPEX), capital expenses (CAPEX), revenues, and tariff models remain inadequately addressed in the literature (Stritzke & Jain, 2021b).

Solar energy investments at the utility scale level in Zambia has seen a significant upward trend following the initiation formulation of renewable energy mini-grid regulations by the Energy Regulation Board (ERB) in 2019. The regulations which were finalized in 2020 with support from the European Union (EU) through the Increased Access To Electricity And Renewable Energy (IAEREP) project, coincided with the government's adoption of the Electricity Act and Energy Regulation Act in 2020, along with the operationalization of net-metering regulations This regulatory momentum paved the way for the establishment of utility-scale solar power plants, such as the Bangweulu Power Company Limited in March 2019, with a capacity of 54.3 MW, and the Ngonye Power Company Limited (NPCL) in May 2019, with a capacity of 34 MWp. Both plants which are located at Lusaka's South Multi Facility Economic Zone entered into 25-year Power Purchase Agreements (PPAs) with ZESCO (ERB, 2020). These developments position Zambia favorably for participation in Renewable Energy (RE) auctions, providing a platform for gauging investment levels and fostering long-standing contracts between Independent Power Producers (IPPs) and buyers like ZESCO because accordingly, success in RE auctions is typically measured by cost-effectiveness of the investments and outcomes. In line with these benchmarks, the Scaling Solar programs were introduced, offering tailored packages of advisory services, standardized contracts, financing offers, guarantees, and insurance, facilitated by the World Bank. A comparative analysis of auction programs under various initiatives in three countries including the Scaling Solar program in Zambia, is presented in table 1, highlighting key insights into investment dynamics (Kruger & Eberhard, 2018; Fergusson et al., 2015).

Energy auctioning systems have gained popularity in Africa for tendering renewable energy projects to independent power producers, however findings indicate that they come with specific project risk implications. A comparative analysis between Zambia's approach, where the government took a leading role in selecting prospective sites for renewable energy investments under the Scaling Solar initiative, and South Africa's approach, where private developers lead in site selection, securing, and assessing investment sites prior to the bidding process, as done under the Africa's Renewable Energy Independent Power Producers Procurement Programme (REI4P), reveals notable differences. The outcomes suggest that the site selection process which is part of the overall procedure in theses process was led by government-thereby leading to high risk perceptions associated to technical and legal considerations (Kruger et al., 2019). Table 16 presents a tabulation outlining three Sub-Sahara Africa renewable energy auction programes displaying the Comparison among the three RE auction programs for Zambia, Uganda and South Africa according to the year of program initiation, their total installed capacities , gross domestic outputs, qualification requirements, site selection and Sellers'& Buyers obligations & liabilities etc.

Comparing energy auctioning systems between developed European countries like Germany and third-world nations in Sub-Saharan Africa, reveals nuanced findings. In Germany, a country which is pioneering in promoting renewable energy transition through initiatives like the Renewable Energies Act 2014 (Kruger, et al., 2018), auction promotion of renewable energy generation is based on determining optimal bidding strategies and their effects on resultant project values. Pay-as-bid and uniform pricing strategies, as well as single and multiple bids are notable crucial aspects. Interestingly, higher uncertainty regarding market clearing prices in Germany increases project values (Voss & Madlener, 2017). Other European countries similarly progressively employ competitive bidding tenders to allocate support payments to renewable energy market actors, with various design features impacting general and cost-effectiveness of the auctions. Factors like volume control, qualification requirements, and penalties influence successful project implementation, however they also carry associated risks. Balancing high implementation rates and minimized bidder risk may lead to higher bidding prices, a scenario which dispels any ideal plan for a good auction design (Gephart et al., 2017).

Auctioning has increasingly become a key avenue for procuring renewable energy in global markets, similar to European competitive tendering systems. Although United States, has no unified federal auction framework for utility-scale renewables, similar mechanisms are applied at state and utility levels through which power purchase agreements are awarded to the lowest bidders, operating alongside policy instruments such as Renewable Portfolio Standards and Solar Renewable Energy Certificate markets (Eberhard & Kruger, 2023). In India, reverse auctions is applied in RE procurement, allowing competitive bidding for solar and wind projects in exchange for PPAs, thereby driving cost efficiency (Alam, 2024). China has similarly transitioned from administrative tariffs to provincial competitive auctions, signaling a shift toward market-based tendering comparable to European practices (Zhang et al., 2025).

Table 16

Characteristics for 3 Sub-Saharan African Renewable Energy Auction Programs

	South Africa REIPPPP	**Uganda – Get-Fit Solar**	**Zambia-Scaling Solar 1**
Total Generation Capacity (MW; 2012)	44,559	779	1,888
Market Structure & Unbundling in Power sector	National utility with vertical integration and independent power producers (IPPs). Horizontal unbundling	Vertically unbundled with private generation and distribution concessions and IPPs.	National public utility with private transmission, Copperbelt supply, and IPPs
GDO US$ Million	314,572	27,529	21,154
Capacity Auctioned	6327 MW in total over 4 rounds; Multiple technologies	4 X 5MW PV Solar Plants	2 X 50 MW PV Solar Plants
Qualification Requirements	Single-stage RfQ/RfP with strict economic development criteria, including local content, ownership, job creation, and community investment.	2 stage RfQ/RfP; No local content requirement	2 stage RfQ/RfP; No local content requirement
Site Selection And Preparation	Location agnostic	Project to be sited within 3 km of the grid in priority areas.	Pre-selected site with ESIA by IDC and transmission line provided.

Continued on next page

Table 16 (Continued)

Main Characteristics for 3 Sub-Saharan African Renewable Energy Auction Programs

Winner Selection	70/30 price, economic growth assessment: Pay-as-Bid	70:30 price, Technical assessment: Pay-as-Bid	100% price evaluation: Pay-as-Bid
Contract currency & Financing	Local current(ZAR) bidder had to validate firm obligation equity and debt providers together	USD (Fit portion), Euro(Get-Fit Portion (premium payment) support notices from debt and equity providers	USD stapled concession financing, provided by IFC for portion debt
Sellers'& Buyers obligations & liabilities	20 Year PPA, fully indexed	20 Year PPA, only O&M portion indexed to US inflation rate	25 years PPA, Non-indexed
	Bid bonds double upon selection as preferred bidder (until FC).	Bid , construction and Performance (Cod) bonds	Bid performance (COD and decommissioning Bonds
		Letter of credit back stopped by World back PRG (Optional)	Optional letter of credit backed by World Bank PRG and loan guarantee.
	Implementation Agreement (Sovereign guarantee); Direct agreement (lender step in right)	Implementation Agreement (Sovereign guarantee); Direct agreement (lender step in right)	Government support agreement Direct agreement (lender step in right)

*Note***.** Comparative analysis of the three RE auction programs based on their initiation year: South Africa (2011); Uganda (2014); and Zambia (2015). *Source*: (Kruger & Eberhard, 2018)

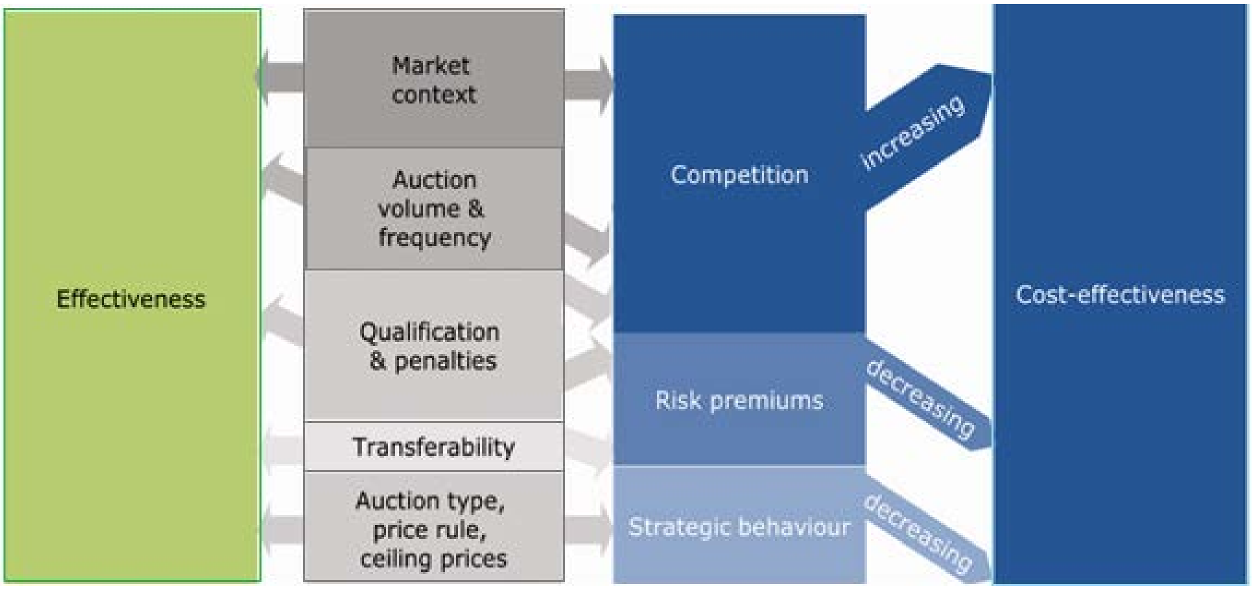
An analytical examination of renewable energy auctions in European countries such as Germany, France, and the Netherlands, compared with Sub-Saharan African countries including Zambia and South Africa, revealed notable insights using a compliance-focused assessment framework. Findings showed that South Africa achieved a 100% billable ratio, attributed to its stringent compliance measures, while European countries recorded only moderate billable ratios due to more lenient compliance requirements. The analysis further revealed that the duration of billable ratio periods was more closely linked to project size than to fixed timeframes, with South African projects being substantially larger, often 10 to 13 times bigger, and therefore associated with longer realization periods. Despite these differences, overall performance remained comparable across the regions. Additionally, when comparing average auction prices to technology-specific Levelized Cost of Energy (LCOE) estimates, results aligned with global averages. In South Africa, however, auction prices for photovoltaics (PV) fell by approximately 75%, despite initially being the highest among the countries studied (Kitzing et al., 2022).

In summary, renewable energy auctions in Sub-Saharan Africa, particularly in South Africa, demonstrated higher effectiveness due to robust compliance frameworks and larger project sizes, while European auctions showed moderate success under more lenient compliance conditions. Evidently, auction systems have a significant part to play in the diffusion of alternative energy sources, particularly solar energy because such systems encompass critical elements such as trust, institutional capacities, effective communication, and transparency. Their effectiveness lies in their simplicity and innovative design, which deliver remarkable results in effectiveness and mitigation of risks. Evidence from Zambia’s renewable energy investments indicates progressive trends in the impact of auction programs on driving renewable energy investment. The Scaling Solar development initiative is a good example of such impact where the initial assessment by the

International Finance Corporation of 20 solar markets in Africa which are promising, including Zambia, indicated non-viability due to limited market sizes, investments risks, high costs, and uncertainties. Figure 8 outlines the Renewable energy auctions nuances in factors that determine effectiveness and cost effectiveness of the cost shading light on nuanced comparison between European countries and sub Saharan countries.

Figure 8

RE Auctions Factors for Effectiveness and Cost Effectiveness



Note. Figure highlights the nuanced factors influencing the effectiveness & cost-effectiveness of renewable energy auctions, comparing outcomes in Europe and Africa. *Source*: (Gephart et al., 2017).

Zambia's solar energy investments have been significantly enhanced with the introduction of the Scaling Solar initiative, showcasing the success of such programs in promoting renewable energy development (Kitzing et al., 2022). Similarly, the GET-FiT program, launched to support the United Nations' efforts to stimulate renewable energy investments in lower and middle-income nations while addressing climate change, highlights the value of auction systems. These initiatives have successfully reduced risks and lowered costs for both public and private investors by leveraging well-structured international programs designed by organizations like the World Bank Group and Deutsche Bank Advisors (Kruger & Eberhard, 2019). Tables 17 and 18 provide detailed information on the projects implemented under the Scaling Solar program, including the roles and contributions of stakeholders in the winning bids. Additionally, these tables offer insights into the ownership structures and investor profiles of GET-FiT solar PV projects.

Table 17

Shareholding of Major Scaling Solar Projects in Zambia

Bangweulu Power Company Limited	Ngonye Power Company Limited
Neoen - 67%	Enel Green Power - 80%
First Solar - 13 %	IDC - 20%
IDC - 20%	

Note. Shareholders of the Scaling Solar program with the IDC retaining a minority (20%) stake in each project at full cost. *Source:* (Kruger & Eberhard, 2019).

Table 18

GET FiT Zambia Solar Project Details

Projects	**Bidders**	**Size**	**Price**
Bulemu East & West	Building Energy & Pele Green Energy	2x 20MWac	US$ 3.99 /KWh
Aurora Sola One & Two	Globeleq & Aurora Power Solutions	2x 20MWac	US$4.52/KWh
Garneton North & South	Innovent & CEC	2x 20MWac	US$4.80/KWh

Note. GET FiT Zambia solar project details showing the type of projects undertaken, size and bidding tariffs rate. Source: Kruger & Eberhard (2019).

Programmes for Scaling Solar Investments

Programs such as Scaling Solar and GET FiT have been at the center of Zambia's efforts to grow a robust renewable energy framework. These scaling solar initiatives not only augment the acceptance and utilization of sustainable energy but also encourage private sector participation. Through instruments like the Renewable Energy Feed-in Tariffs (REFiT) and net metering, these initiatives promote infrastructure improvements and create a conducive environment for Independent Power Producers (IPPs). In line with this, the Energy Regulation Board (ERB), supported by USAID Trade Hub Southern Africa, has played a pivotal role in standardizing licensing processes and establishing Power Purchase Agreements (ERB, 2014). Jointly, these undertakings represent significant advancement in creating an enabling environment for solar investments.

It is notable that, despite Zambia's 3,000 annual sunshine hours, household-level solar adoption remains very minimal with most of the renewable energy being allocated to essential services such as healthcare, education, and water supply and consequently, renewable energy accounts for only 22% of national electrification (Kachapulula-Mudenda et al., 2018). With a total installed generation capacity of 3,356.6 MW, and hydropower contributing 85% of the energy mix, diversification is critical in the light of Zambia's target to attain 500 MW of solar PV installations by 2023, but alas only 91 MW was installed, a scenario which underscores the sector's slow progress. Additionally limited electricity access, at just 40% nationally, further highlights the urgency of accelerating solar deployment (USAID, 2021).

Zambia's policy landscape reflects broader challenges faced by developing countries which are inefficiency of state utilities and reliance on hydropower. Effective diversification demands cost-reflective tariffs and stronger support for IPPs (Bayliss & Pollen, 2021). Currently, Zambia’s solar capacity stands at 0.1 kW per capita, which is far below developed-country levels at 1.0 –3.3 kW per capita (Zulu et al., 2021). Nevertheless, the country’s favorable solar irradiation status offers untapped opportunities for scaling solar energy generation (Quansah et al., 2016).

The government’s objective is to stimulate private-sector led solar growth by leveraging on financial, fiscal, and non-monetary incentives. Existing evaluations show that accessibility to incentives and affordability of solar services strongly influence investment performance. Evidence suggests that improving these measures has ability to enhance return on investment (ROI) in solar projects (Johnson et al., 2017). Furthermore, adopting the Technological Innovations Systems (TIS) extended framework provides a systematic approach to overcome institutional and structural barriers (Stritzke & Jain, 2021b). This framework is especially relevant in Zambian context, where systemic irregularities often hinder private investment.

Currently, Zambia’s renewable energy sector features diverse projects which include ten solar mini-grids, e.g., the Mpata Off-Grid System in Luapula Province totaling 60 kW, serving approximately 50 households, and the installation of 250 solar systems in schools and traditional palaces through the Rural Electrification Authority (REA). Pilot initiatives under Energy Service Companies (ESCOs) have added 400 solar systems to rural communities. At the utility scale, projects such as the 54 MW Bangweulu Solar Plant and 34 MW Ngonye Project in Lusaka’s Multi-Facility Economic Zone (MFEZ) exemplify successful Public-Private Partnerships (PPPs), Power Purchase Agreements(PPAs) and independent power producers (IPPs) in the energy sector (Mwanza et al., 2017; Stritzke, 2018; ERB, 2020). Despite the aforementioned initiatives that are promising, records indicate that solar energy diffusion remains modest relative to demand (Chabala et al., 2022).

In recent years, private solar investment in Zambia has been driven by four identifiable initiatives. The first being, the Scaling Solar Programme, spearheaded by the World Bank and the International Finance Corporation (IFC), which has positioned Zambia among the first Sub-Saharan African countries to fast-track utility-scale photovoltaic (PV) deployment (World Bank, 2019). Under this programme, the 54 MW Bangweulu solar plant supplies electricity to approximately 30,000 households and businesses, thereby reducing load pressure on ZESCO which is predominantly hydropower based grid. Second initiative is the Green Bonds for Solar Energy, a USD 200 million bond programme structured by Cygnus Capital, which has attracted increased participation from local investors. The advent in green financing markets is demonstrated by the launch of the first Green Bond programme by CEC Renewables, which issued the above mentioned US$200 million green bond in 2023 to finance solar energy infrastructure.. of which the impact report from this financing showcases the bond's position to support approximately 300 MW of renewable generation capacity and further exhibits how green bond mechanisms are able to effectively mobilise investment capital for clean energies in developing economies such as in Sub Saharan Africa (CEC Renewables Limited, 2024); Walusa, 2022). The third initiative is the expansion of domestic solar markets, demonstrated by projects such as the 33 MW Kitwe solar plant commissioned in 2023, signaling a growing trend in local investment prospects. Finally, it is the Pan African energy diversification initiatives which have aligned Zambia's efforts with continental stride to scale solar PV capacity to 30 GW by 2030 through international partnerships. Notably, the Masdar - ZESCO USD 2 billion agreement signed in 2023 aiming to co-develop large-scale solar projects, reflecting strong growing international confidence in Zambia's solar sector investments (Kruger & Eberhard, 2023). Collectively, these initiatives highlight Zambia's spirited efforts to address systemic barriers to unlock its substantial solar potential, through expanding solar investment opportunities for the diversification of the energy mix, and to ultimately reduce reliance on hydropower as a way of enhancing energy security.

It is worth noting that, while Zambia’s strategies for energy access and scaling solar illustrate both progress and persistent challenges, a broader understanding emerges when these dynamics are analytically compared with experiences from other Sub-Saharan African countries such as Kenya and South Africa.

Zambia’s Comparative Positioning in solar investments

In comparison with Kenya and South Africa, Zambia’s solar sector exhibits slower growth and more low-key incentive performance, likely linked to less mature investment environments. Comparative tabulations outline divergent solar sector pathways in Sub-Saharan Africa (SSA). Table 19 outlines the comparison of key aspects in solar sector investments. The regional comparison ultimately underscores Zambia’s relative position within SSA solar investment trends, providing lessons and gaps that inform the conceptual framework in integrating theoretical perspectives with Zambia’s contextual realities to guide the study’s empirical analysis.

Ultimately the literature review was undertaken with a focus to key thematic aspects, namely the theoretical framework befitting the study, energy status quo for Zambia, government and institutional frameworks, scaling and expansion strategies, investment incentives, barrier’s to solar adoption in form of policy, technological and socio economic aspects. Figure 9 presents a thematic map organising recurring themes from literature, highlighting relationships among concepts, policies, and factors that shape the study variables. It synthesizes literature into logical categories, clarifying gaps to justify the research, and visually structures the review to enhance understanding. Importantly, it also bridges the literature review to the conceptual framework.

Table 19

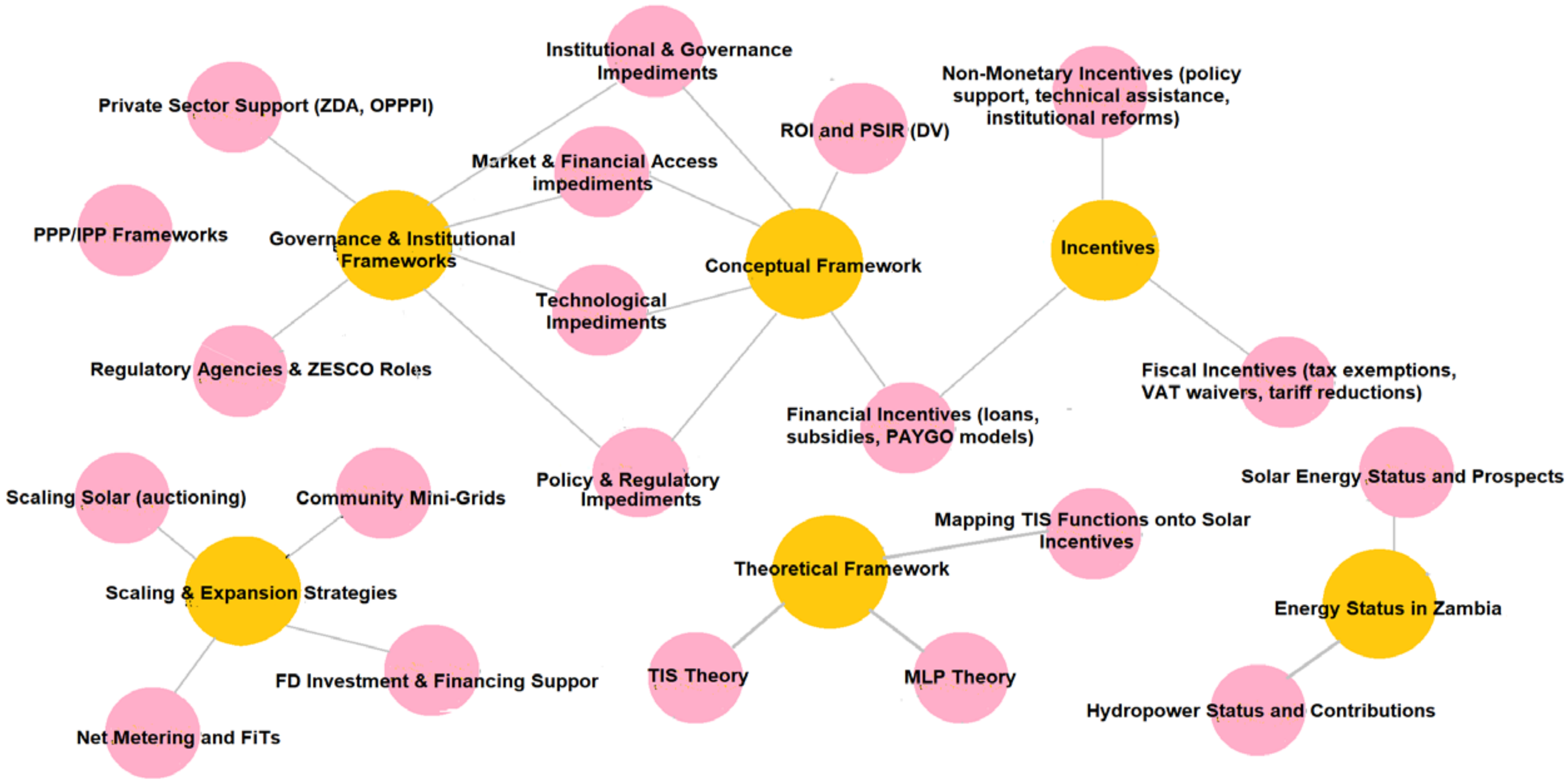
Solar Investment Incentives and Adoption Models in Sub- Saharan Africa

Aspect	Zambia	Kenya	South Africa
Financial incentives	Import duty and VAT exemptions largely favor utility-scale investors, while PAYGO models remain unviable in rural low income areas (World Bank, 2020b).	Tax & tariff reductions on solar equipment; PAYGO models widely adopted easing upfront costs; Available securities for off-grid growth (Taneja, 2018).	Accelerated depreciation, tax rebates, & RE loan guarantees for SME and rooftop solar adoption (Eberhard & Naude, 2017).
Regulatory / institutional support	Licensing & permits are cumbersome for SME; utility-scale projects benefit from ZESCO's sole off-taker role & import duty relief (REN21, 2022).	Efficient permitting; import duty relief; helpful frameworks boost mini - off-grid growth- mainly for SMEs (Gathua, 2021)	Strong PPP/IPPs framework; stable regulatory environment; robust PPAs & risk-reductions boost investor confidence (Mundonde & Makoni. 2025).
Adoption of models / execution	Utility-scale projects growing (Scaling Solar, CEC green bonds); SME's adoption stay limited due to affordability & financing barriers (Ministry of Green Economy & Environment, 2024).	Off-grid, PAYGO, community solar & mini-grids grow quickly; affordability mechanisms & NGO support drive inclusive adoption (Ochieng, 2019).	Rooftop solar & large-scale IPPs lead; private sector highly involved, sustained by incentives & regulatory tools (Meyer & Swilling, 2018).
Capacity growth / market impetus	Solar capacity is small; growth tied to donor/utility-led projects; with lagging SME adoption (Ziba & Phiri, 2021).	Significant off-grid growth; diversified solar contributing to energy mix; Active SMEs (Ondiek, 2020).	SSA leads in solar capacity additions; mature ecosystem with large installed base and consistent growth (Eberhard et al., 2021).

Note. Pay as you go –PAYGO; CEC - Copperbelt Energy Company; PPP-Public Private partnerships; IPP- Independent Power Producers; SME- Small and Medium Enterprises. *Source*: Author.

Figure 9

Literature Review Thematic Mapping of Key Elements in Solar Investments



Note: Thematic map for key themes - (Orange nodes) and sub-themes - (Pink nodes) as described in literature review for Zambia’s solar investment landscape. Dependent variable-DV; Private sector investment rate-PSIR; Return on Investments (RoI); FIT-Feed in Tariffs; PPP- Public private Partnerships; MLP- Multi Level Perspectives. *Source*:Author

Conceptual framework

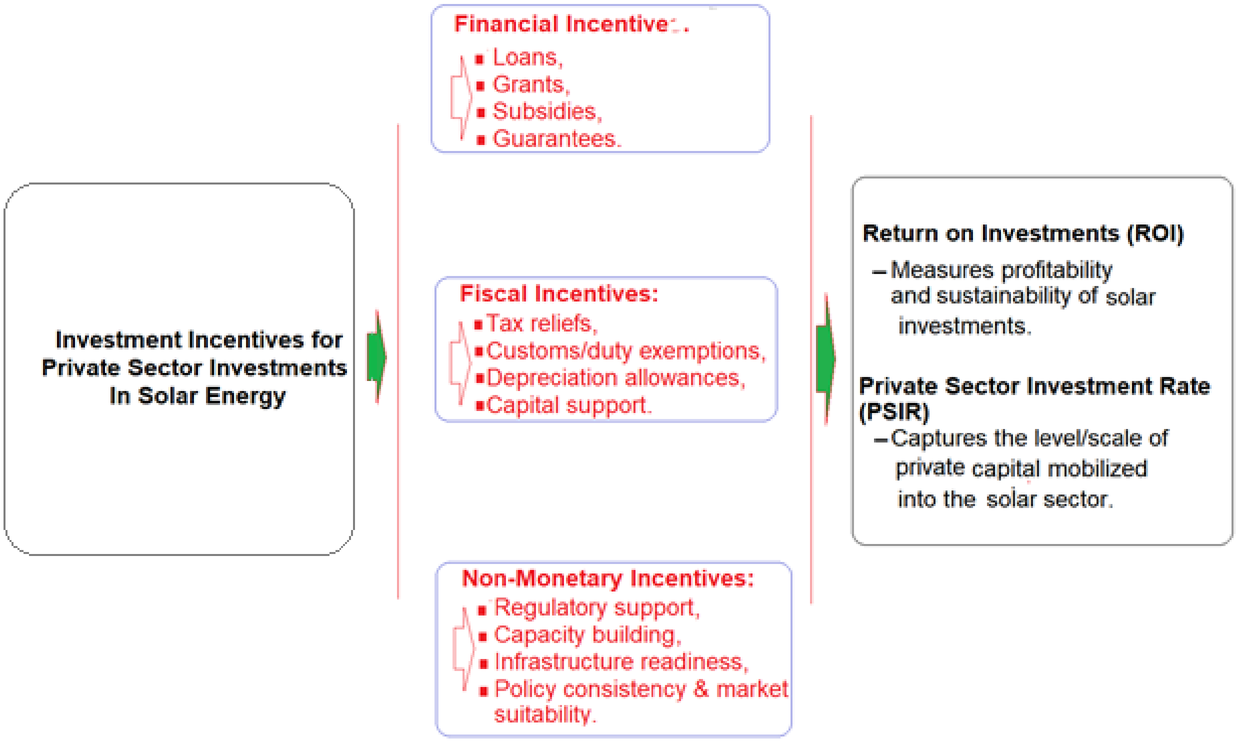
The conceptual framework of this study is designed to provide a structured lens through which the relationships between incentives and solar energy sector performance in Zambia are examined. Informed by the literature review, the framework is structured in three stages, as follows; Inputs Variable to Mechanisms and to Output Variable. It positions financial incentives which are loans, grants and subsidies, fiscal incentives which are tax reliefs, duty exemptions, depreciation allowances and capital support, and non-monetary incentives in form of regulatory support, capacity building, infrastructure, policy consistency and market suitability, as the independent variables influencing private-sector solar investments (Kwibisa, 2012; Werner, 2016). These variables are envisaged to play a critical role in reducing barriers to investments, improving investor confidence, and stimulating capital inflows into the sector. On the other hand, the dependent variables are drawn from indicators that measure growth and returns in the solar energy sector, including the Internal Rate of Return (IRR), Return on Investment (ROI), and investments rates levels linked to solar energy diffusion (Aburumman, 2023). These outcome indicators are appropriate measures of both financial performance and socio-economic benefits, making them suitable proxies for assessing the viability and sustainability of solar investments.

The relationship between the independent and dependent variables requires systematic testing because of the observed persistent underinvestment despite Zambia's vast solar potential, which suggests that existing incentive mechanisms are not well aligned to be adequately effective. By empirically examining these relationships, the study seeks to determine whether financial, fiscal, and non-monetary incentives significantly influence investment returns and sectoral growth. Establishing such correlations is essential for identifying which incentive structures are most impactful, thereby generating evidence-based insights to inform policy and attract private-sector participation.

Figure 10 illustrates the conceptual framework mapping the independent variables against the outcome indicators, offering a visual representation of the hypothesised relationships, thereby anchoring the study's hypotheses and ensuring that the research design systematically tests how each category of incentive contributes to investment outcomes, to ultimately address the broader problem of low solar investment despite high potential.

Figure 10

Conceptual Framework



Note: Outlined are steps in the research process and approach identifying Predictor and criterion variables and inter connections. *Source:* Author's Design

CHAPTER 3: RESEARCH METHOD

Chapter Overview

The research methods chapter outlines procedures which should be followed to ensure a credible, transparent, and replicable study. The term ‘Research methods’ refer to the planned set of sound steps, approaches, and instruments used to collect, analyse, and interpret data in a manner which best addresses identified research problem and ultimately to attain the objectives of a study. Therefore a good methodological framework is cardinal in attaining reliable results which are in essence a product of good research questions, data collection processes, analysis, and evaluation. This consistency reinforces scientific strictness of the study and ultimately upholds validity, reliability, and generalizability of findings (Willis, 2023).

A typical research methods chapter comprises a number of distinct aspects serving different purposes of supporting an organised interrogation of research questions; i.e., one key aspect is that the research approach and design outlines the overall methodological orientation such as the quantitative correlational research applied for this study, similarly it also addresses the structure of the plan to examine relationships among variables. The population and sampling procedures describing the target population and how participants are selected to ensure representativeness is also catered for. The research instruments or materials section details the tools used to gather data, to develop them, to appropriately structure then, and project theoretical alignment. The data collection procedures as the name implies**,** explains the processes followed in data collection, including timelines, platforms, ethical steps, and operational considerations. The validity and reliability section outlines strategies deployed to ensure accuracy, consistency, and trustworthiness of the measurement instrument. The pilot study procedures describe steps taken to pre-test and improve the instrument before full using it on the main study. Finally, the data analysis techniques section identifies the statistical methods used to examine associations, measure effects, and to test hypotheses (Creswell & Creswell, 2017; Kumar, 2018; Taherdoost, 2016; Lishinski 2016).

Collectively these distinct methods sub-sections ensure that the methodology is coherent, rigorous, and aligned with the research objectives. The subsequent section builds on this methodological foundation to outline the research approach and design, and to justify its suitability for this study.

Research Approach and Design

The Research Approach and Design section for this study outlines the overarching methodological framework that guided the study, describing how the research strategy, design choices, and data collection methods were selected to effectively address the research problem and research objectives. This section is vital because it establishes methodological consistency, ensures transparency, and validates the appropriateness of the selected method, thereby enhancing the reliability, validity, and replicability of the study. A well-structured design also ensures that the research process remains systematic, logical, and aligned with the intended analytical results.

This study adopted a quantitative cross-sectional research design to systematically examine the associations and predictive effects of financial, fiscal, and non-monetary incentives on private-sector solar investment performance in Zambia. As an explanatory study, its purpose was to determine the strength and direction of relationships between institutional incentives and key investment outcomes, including private sector investment rates and returns on investment (Asamoah, 2014; Curtis et al., 2016).

A probability-based sampling strategy was employed, specifically simple random sampling, to ensure representativeness of the diverse solar-sector population. The sampling frame comprised 315 participants across 55 solar-related organizations, comprising institutions involved in policy, regulation, financing, and project implementation. Eligible respondents were required to have at least two years of experience in solar investments and be aged between 18 and 62 years (Maheshwari, 2017; Acharya et al., 2013). Access to participants was facilitated through appropriate institutional gatekeepers to ensure ethical compliance (Nnebue, 2010).

Data collection was done through the use of structured questionnaires administered face-to-face to enhance response rates and improve data quality (Sadan, 2017). The survey instrument was developed based on theoretical alignment with the Technological Innovation Systems (TIS) framework, and its reliability and validity were rigorously assessed. Internal consistency was evaluated using Cronbach's Alpha, yielding acceptable values across constructs: financial incentives (Bujang et al., 2024; Taber, 2018). Content and face validity were ensured through expert reviews and pre-testing, while practical feasibility was confirmed via the pilot study tests (Acosta-Banda et al., 2021; Khanal & Chhetri, 2024). Data handling followed a structured workflow and r responses were collated in Microsoft Excel, randomization verified using the RAND function, and subsequent correlation and regression analyses conducted in IBM SPSS Version 21 to determine the direction, strength, and significance of relationships between incentive variables and performance outcomes. The quantitative correlational design allowed for objective, measurable, and generalizable findings, minimizing researcher bias and providing robust statistical evidence of associations between independent and dependent variables (Bryman & Bell, 2015).

The positivist paradigm guided the study, emphasizing empirical, testable, and replicable findings over subjective interpretation (Park et al 2020; William, 2024). While mixed-methods approaches offer broader insights, they were not suitable for this study's focus on measurable relationships between institutional incentives and solar investment outcomes due to increased complexity, resource requirements, and potential intrusiveness (Teherani et al., 2015; Zohrabi, 2013).

Overall, this research approach and design provided a coherent, systematic, and methodologically rigorous framework, aligning the study's purpose, sampling strategy, data collection instruments, and analytical procedures. This ensured credible, reliable, and generalisable findings capable of informing policy, practice, and future research on solar sector investment performance in Zambia (Martin & Bridgmon, 2012).

Population and Sampling

The study population consisted of stakeholders, i.e. persons engaged in Zambia's solar energy sector at various levels of the solar sector value chain ranging from financiers, implementers. Technical support institutions, regulators and those involved in trading and supply. In order attain an appropriate capture the sampling frame for the solar sector, a total of 75 solar related organizations were initially identified nationwide with a corresponding estimated sampling frame of 375 potential respondents at an average of five participants per organization. Out of this accessed sample frame from an average of five instruments distributed per organisation, 315 successfully responded to the questionnaire thereby yielding a sample frame of 315 eligible participants as a final sample frame for this study. With the aforementioned distribution of research instrument and the received responses, the response rate was 84%. The relatively average size of the yielded sampling frame reflected the developing nature of the solar industry in Zambia which is still diminutive, despite vast solar potential estimated at 392,701 TWh per year with 20,442 TWh per year being produced from large photovoltaic systems, the solar sector comprises of only a few utility scale installations, notably the Bangweulu (54.3 MW), Ngonye (34 MWp), Riverside (34 MWp), and Itimpi (60 MWp) (Chitandula et al., 2024; Mwanza et al., 2017; Payton, 2024).

Consistent with quantitative research principles requiring unbiased and representative samples (Maheshwari, 2017), the sampling frame incorporated diverse stakeholder categories, including public/government institutions, private sector entities, and international development partners involved in policy formulation, regulation, financing, implementation, and solar equipment provision. This approach ensured representation across major functional domains of the solar investment ecosystem (Grafström & Schelin, 2014). Eligible respondents were individuals aged 18 to 62, mentally sound, and possessing at least two years of experience in solar related work, thereby ensuring adequate knowledge to inform the study

From the established sampling frame of 315 respondents, to determine an appropriate sample size for this study, the 1967 formula by Yamane as shown in formula 1 for finite populations was applied (Adam, 2020); hence with a population of 315 accessed participants and a standard level of precision (e = 0.05) used, yielded a sample size of approximately 176 respondents. However, in order to enhance the accuracy, representativeness, and statistical power of the study, the level of precision was adjusted to 0.03**,** resulting in a larger sample size of 244 respondents**.** This adjustment was a measured resolution to reduce the allowable sampling error, considering the limited population size, high Variability in the Population and the anticipated non-Response or dropouts, thereby improving the reliability and validity of the findings while maintaining methodological consistency in line with standard practices in quantitative research. The final sample was selected using simple random sampling, executed through the RAND function in Microsoft Excel to guarantee equal selection probability and eliminate selection bias (Arifin, 2018).

$$n = \frac{N}{1+N(e)^2} \tag{1}$$

Where; n = sample size, N = population size, and e = margin of error (precision)

Accessing respondents was facilitated by institutional gatekeepers, after which participation continued only after informed consents from gate keepers and participants were obtained, ensuring compliance with ethical guidelines (Nnebue, 2010). The gatekeeper's letters to request access to participants are included on annex B. The resulting sample provided a robust and representative cross section of Zambia's solar investment landscape, supporting reliable quantitative analysis of the relationships between incentive structures and solar investment performance.

Materials/Instrumentation

Appropriate research instruments are vital in quantitative research because they are the primary tools used to methodically collect, measure, and record data that directly address the research questions and hypotheses. Therefore a well-designed research instrument ensures that the data gathered are correct, consistent, and usable**,** thereby ultimately enhancing the credibility of the study findings. Carefully selecting, developing, and validating research instruments reduces measurement error, aligns data collection with the conceptual framework, and supports robust analysis and correct conclusions (Sürücü & Maslakci, 2020). This section outlines materials and instrumentation applied in this study by explaining the 'what, how, and why 'of the tools used to collect data. It strives to shows that the applied instrument were appropriate, scientifically and theoretically grounded Valid and reliable, and also suitable for measuring the variables in the study

The study employs structured research instruments designed to measure the influence of financial, fiscal, and non-financial incentives on private-sector solar energy investments in Zambia. The development of these instruments was guided by concepts derived from the literature and aligned with the study's conceptual and theoretical frameworks, in this case, the Technology Innovation Systems (TIS) framework (Calder, 2021; Johnstone et al., 2010). These constructs identify salient classes of investment incentives such as financial, fiscal, and non-monetary acknowledged in previous empirical studies as essential factors in positive investment performance (Gavrea et al., 2011; Kachapulula-Mudenda et al., 2018).

Instrument Building

The research instrument was developed to operationalize variables outlined in the conceptual framework and to enable empirical investigation of relationships between incentives (independent variables) and private-sector investment performance (dependent variables). private-sector investment performance was categorise as Private sector investment rates (PSIR) and also as return on Investments(ROI) The instrument structure ensured that constructs could be quantified reliably and validly, consistent with positivist and quantitative research principles which underscore quantifiable and impartial assessments (Bryman & Bell, 2015; Duckett, 2021;Sharma, 2022). This approach enabled the statistical identification of predictor variables which are forms of institutional incentives and criterion variables which are investment outcomes (Asamoah, 2014; Chang, 2016; Thomas & Zubkov, 2023).

The literature review steered the identification of relevant dependent variables. i.e., investment performance indicators and also independent variables in form financial, fiscal, and non-financial incentives, thereby providing a strong basis for instrument development and ensuring consistency with theoretical framework for the study (Naepi, 2023; Patterson & Dawson, 2017;).

Description of research instrument

A structured questionnaire was used as the primary data collection instrument because of its suitability for quantitative measurement, consistency, replicability, and capacity to generate standardised data for inferential statistical analysis (Grove et al., 2012; Hagan, 2014). The questionnaire was organized into two main sections.

Section A of the research questionnaire. Section A of the questionnaire consisted demographic variables which captured respondents' background information, including age, sector of employment, work experience, disability status, and professional role. These variables enabled appropriate profiling of participants and supported the assessment of respondent eligibility for inclusion in the study.

Sections B, C and D of the research questionnaire captured investment incentive and outcome variables consisting question items to examine and measure relationship and effects of financial, fiscal, and non-monetary investment incentives on performance outcome. Responses were recorded using a five-point Likert scale ranging from 1 (e.g., strongly agree) to 5 (e.g., strongly disagree). The criterion variables measured in this section included perceived return on investment (ROI) and private-sector investment rates (PSIR), which facilitated the analysis of investment outcomes. The full version of the research instrument is included at annex G to this thesis

The initial version of the questionnaire contained 23 items, comprising 4 demographic items and 19 incentive-related items; however, after the refinement process to improve clarity and relevance, the final instrument retained 16 items, comprising 4 demographic items and 12 incentive-related items, of which the Private Sector Investment Rate (PSIR) variable is specified as an endogenous variable. As outlined at annex G. The questionnaire design adhered to the Total Survey Error (TSE) paradigm, which emphasizes accuracy, minimized bias, and the credibility of collected data (Lyberg & Weisberg, 2016). Closed-ended, structured questions were employed to support efficient coding, enhance comparability, and ensure suitability for correlation and regression analyses.

Instrument Adaptation and Validation

Instrument adaptation and validation involves systematic tailoring of an existing or newly developed data-collection tool to ensure it accurately measures the constructs of interest within a specific research. This process includes refining questionnaire items, evaluating applicability and clarity, and approving that each item aligns with the study's conceptual framework and operational definitions. Validation processes such as knowledgeable appraisal, pilot testing, and reliability analysis are vital for founding, face validity, internal consistency etc, thereby ensuring that the instrument being adapted produces trustworthy, precise, and replicable findings. Undertaking thorough adaptation and validation reinforces the methodology and of the study and improves confidence in the interpretations from collected data (Cruchinho et al., 2024).

Instrument development for this study was informed by established survey questionnaire formats. The questionnaire was specifically adapted elements from a previously validated instrument used in a study on strategic management and organizational growth in Nigeria's manufacturing Industry in Anambra State (Muogbo, 2013), which was then modified to fit the context of examining growth in solar energy investments in Zambia. Validity considerations undertaken in the identification and adaptation of the research instrument included content validity which was ensured by grounding questionnaire items in the literature and aligning them with constructs identified in the theoretical frameworks (Heale & Twycross, 2015). Similarly Construct validity was supported through operationalization of variables based on empirical evidence and theoretical alignment with solar incentive studies (Fotio et al., 2022; Šimović & Žaja, 2010). Face validity was enhanced through clarity refinements, relevance checks, and item restructuring during pilot testing and expert review stages. Finally, reliability focused on ensuring consistent measurement of constructs, with internal consistency assessed through comparisons of observed and actual variances (Hossan et al., 2025).

Role of the Research Instrument

The research instrument to for this study was designed to capture respondents' experiences with investment incentives in Zambia's solar energy sector through the demographic section; to evaluate the role of financial, fiscal, and non-financial incentives such as grants, tax holidays, concessional loans, investment concessions, and corporate tax waivers(Gavrea et al., 2011; Šimović & Žaja, 2010); to methodically gauge relationships between incentives and private-sector investment outcomes through inferential statistical methods, in this case correlation and regression analyses (Apuke, 2017; Mustafa & Malik, 2023; Sadan, 2017). Furthermore. The quantitative research approach is ideal in supporting objective measurement, identification of patterns and associations which are vital in understanding drivers to solar energy sector investments, which unfortunately, currently indicate low levels estimated at 0.1 kW per capita compared to 1.0 to 3.3 kW per capita in wealthier countries (Zulu et al., 2021). The instrument therefore, is a vital material resource for examining the nature and strength of investment incentives on investment outcomes.

Ultimately, the outlined materials and research tools were developed in direct response to factors identified in the literature, such as barriers to fiscal and financial incentive deployment and gaps in private-sector participation (Mwanza et al., 2017; Patterson & Dawson, 2017). The quantitative instrument thus provided a systematic basis for comparing observed investment trends with underlying incentive structures and supported the study's goal of assessing incentives influence on solar sector performance in Zambia.

Pilot Study

The pilot study was conducted to ensure that the research instrument was clear, reliable, and suitable for application in the main research study. Pilot testing is essential because it helps to identify ambiguities, refine questionnaire items, assess feasibility of procedures, and detect potential sources of error before large-scale data collection (Brooks et al., 2016; Doody & Doody, 2015). It also improves measurement accuracy by determining whether items effectively capture the intended constructs while minimizing irrelevant or unintended influences (Toraman et al., 2022).

The purpose of a pilot study can be summed up in a summarised way in three major categories as follows; to assess clarity, relevance, and usability of the questionnaire in the main study; to evaluate the feasibility of accessing respondents and administering the survey; to establish preliminary evidence of reliability and validity of the measurement tool (Acosta-Banda et al., 2021; Khanal & Chhetri, 2024). These steps for a pilot study ensure that the instrument applied reliable and accurate for quantitative data needed for the correlational analysis of solar investment incentives.

***Pilot Sample Size Determination*.**

The pilot sample size was determined using established procedural guidelines, which recommend including approximately 10 to 30% of the target population or a minimum of 24 to 36 participants to support meaningful pilot testing (Arifin, 2018; Johanson & Brooks, 2010). Given an initial estimated study population of 315 respondents drawn from approximately 55 solar organisations, and after accounting for anticipated non-response and potential access constraints, an adjusted pilot sample size of 25 respondents was arrived and was considered practical, statistically appropriate, and consistent with recommended standard size for pilot studies (Julious, 2005; Montgomery, 2025). In estimating the pilot study sample size using a prescribed procedure, adjustments to the confidence level, confidence interval, and estimated population proportion were done to ensure suitability of the pilot sample proportionate to the pre-estimated size of the solar sector, particularly in the context of low private sector solar investment involvement. The mathematical expression for pilot size estimation is shown in formula 2. In this study rule-of-thumb percentages of 10 to 30% of the main sample are applied to guide determination of pilot study size as a practical approximation,

$$N\text{-pilot} = 0.10 \text{ to } 0.30\ (N\text{-main}) \qquad (2)$$

Where N-pilot = pilot sample size and N-main = planned main study sample size.

Notwithstanding in estimating pilot sample size, other mathematical expressions or formulas from statistical principles that include the estimation of variance, effect size, or reducing Type I and Type II errors which more accurately ensure the pilot study is large enough to detect major issues are applied.

Pilot Reliability Validity/ Instrument Refinements.

Instrument refinement began with expert and supervisor feedback, which improved clarity, relevance, and alignment of questionnaire items with the study's conceptual framework and theoretical foundation, which in this study is anchored on, the Technological Innovation Systems (TIS) framework. This feedback ensured face and content validity by confirming that the items appeared to measure the intended constructs and that the content adequately represented incentive-related dimensions (Heale & Twycross, 2015). Additional refinements incorporated pilot respondents' feedback to enhance usability and consistent of the questionnaire

Several forms of validity were addressed during the pilot stage, namely Face validity was established by confirming that each questionnaire item appeared to measure the intended construct and reflected relevant incentive dimensions. Content validity was strengthened through expert review by specialists in energy, technology, and business, ensuring alignment with theoretical constructs and study objectives. Internal validity was supported by refining item wording, minimizing bias, and ensuring that questionnaire items captured relationships between incentives and investment outcomes (Heale & Twycross, 2015). External validity was to be reinforced through random sampling methods for the research sample selection, enabling generalisability of findings to the broader solar sector population (Tin & Bui, 2024). Together, these processes ensured that the research instrument was theoretically aligned, contextually appropriate, and empirically sound.

The pilot study tested the usability of the data collection platforms, measured response rate, and evaluated operational practicality. It also examined item discrimination, response variability, and consistency across questionnaire sections (Toraman et al., 2022). The findings enabled the removal of irrelevant items, clarification of ambiguous wording, and improved operationalization of variables. This structured refinement process ensured that the research tool was robust enough for deployment in the main study. Whilst most of the test in the pilot study were non-statistical tests, the test for Internal consistency reliability was statistically tested using the Cronbach's Alpha executed through SPSS software, to determine whether questionnaire items within each construct measured the same underlying latent variable (Bujang et al., 2024). Cronbach's alpha measures internal consistency of a scale which directly speaks to the validity of the instrument. Formula 3 is a standard mathematical expression for Cronbach alpha value. Correspondingly Table 20 presents a summary of the Cronbach's alpha results, including item refinements and the final overall reliability coefficient, which indicates preliminary yet acceptable internal consistency for scale testing. Additional steps in Cronbach alpha test are shown at annex K. to this document

$$\alpha = \frac{k}{k-1}\ (1 - \frac{\sum_{i=1}^{k}\ \sigma_i^2}{\sigma_t^2}) \tag{3}$$

Where. *k* = number of items in the scale; *σ_i^2* = variance of item i; *σ_T^2* = total variance of the summed scale (composite score)

Table 20

Pilot and Final Cronbach Alpha Test Results

Independent Variables	**No. of Items**	**Cronbach's α (Pilot)**	**Cronbach's α (Final)**	**Remarks**
Financial	5	0.62	0.73	Refined
Fiscal	4	0.64	0.71	Refined
Non -Monetary	6	0.68	0.75	Refined
Collectively	10	-	0.72	Accepted

Note. The combined set of items across constructs. *Source*: IBM SPSS Outputs

In this study the overall reliability of the instrument was Cronbach's alpha = 0.72, for 10 items, exceeding the minimum acceptable threshold. Other Sub-scale reliabilities were; financial incentives (Alpha level = 0.73), fiscal incentives (Alpha level = 0.71), and non-monetary incentives (Alpha level = 0.75). Although initial values for some constructs fell below acceptable limits, subsequent refinement of ambiguous questions and removing irrelevant items resulted in improved consistency(Taber, 2018),. These adjustments raised the final overall Cronbach's alpha to a satisfactory level (Alpha level = 0.72), demonstrating reliability of the instrument to measure intended constructs. Construct validity was reinforced by aligning questionnaire dimensions with the conceptual framework and themes identified in the literature.

Overall, the pilot study provided a rigorous foundation for the main research. It ensured that the questionnaire was clear, reliable, valid, and practicable, for accurate measurement of financial, fiscal, and non-monetary incentives affecting private-sector solar energy investments in Zambia. The structured steps in developing the pilot study which including expert review, sample based testing, validity assessment, and reliability evaluation ensured the instruments ‘capability to produce credible and generalisable findings for the main study.

Operational Definition of Variables

Appropriate research instruments are vital in quantitative research because they are the primary tools used to methodically collect, measure, and record data directly addressing the research questions and hypotheses. A well-designed research instrument therefore ensures that data gathered are correct, consistent and usable**,** thereby ultimately enhancing the credibility of the study findings. Carefully selecting, developing, and validating research instruments reduces measurement error, aligns data collection with the conceptual framework, and supports robust analysis and correct conclusions.

The operational definitions of this study involved converting financial, fiscal, and non-monetary incentives constructs into measurable parameters related to solar energy investments. Financial incentives are defined as mechanisms that improve access to financial benefits, such as loans, to offset initial investment and operational costs. These also included direct financial indicators, such as investment rates. Fiscal incentives referred to tax-related measures like credits, exemptions, breaks, or rebates aimed at reducing the tax burden on solar energy initiatives. Non-monetary incentives included regulatory support, policy frameworks to ensure stability, capacity-building initiatives, infrastructure development, and mechanisms to establish stable markets and mitigate variability. These definitions provided a structured framework for quantifying each type of incentive for analysis in the study (Zhang et al., 2023).This process required that primary constructs are operationalised into measurable variables, enabling the testing of study hypotheses.

Quantitative statistical analysis techniques in form of correlations and regression helped to ascertain the significance of observed differences and relationships between variables (Volchok, 2020). Primary constructs relevant to this study are those linked to the support systems for private sector investments. The study focuses these constructs in private sector investments and examines hypothesized relationships between investment incentives categorized as financial, fiscal, monetary, and non-monetary including their level of influence on solar energy investment outcomes. Financial incentives were defined as the availability of institutional financing options, such as loans and grants. Fiscal incentives were characterized by tax benefits, including waivers, exemptions, and concessions on customs duties, corporate taxes, or other investment-related taxes. The dependent variables reflected performance indicators such as private-sector investment levels, ROI (Return on Investment), service delivery (e.g., the amount of energy delivered in kWh), and infrastructure development. Service delivery was operationalized as the level of energy provided, while ROI was measured as the profits earned above the initial investment costs (Zamfir et al., 2016).This study focuses on variables related to solar sector investment incentives in Zambia, which are categorized into three main groups: financial incentives, fiscal incentives, and non-monetary fiscal incentives. These categories are designed to address research questions that explore the influence of these incentives on private-sector solar energy investments in the country. Therefore the operationalization of these incentives involves transforming them into practical, measurable components that support solar energy projects. Financial incentives are defined as monetary support mechanisms, such as grants and loans, provided to investors in the solar sector. These initiatives directly mitigate the costs associated with solar installations and operational activities by offering tangible financial benefits.

Fiscal incentives, in contrast, encompass tax-related measures such as breaks, exemptions, or rebates. These incentives aim to reduce the tax burden on solar investments or encourage renewable energy production without directly providing monetary benefits (Zhang et al., 2023). Additionally, non-monetary fiscal incentives include regulatory frameworks, infrastructure development, and market support systems that create a stable environment for solar energy investments (Abolhosseini & Heshmati, 2014; Lee, 2021).

In this study, the independent variables are the operationalised constructs of financial, fiscal, and non-monetary incentives. These variables influence the dependent variable, which represents the performance outcomes of private-sector solar investments. Performance is assessed through key indicators such as returns on investments (ROI), which measure financial success. It also includes productivity, reflected in the increased output capacity of solar installations (kWp), and employment levels, determined by the number of jobs created (Zamfir et al., 2016). By defining and quantifying these constructs, the study ensures a robust outline for analyzing the impact of incentives on solar energy investments. This structured approach enables the effective testing of hypotheses and achieves the study's primary goal of evaluating how these incentives drive performance outcomes in Zambia’s solar energy sector.

A broad spectrum of quantitative analysis techniques were employed in this study which included significance tests such as t-tests, f-tests, z-tests, chi-square tests, and regression analysis. These methods helped to determine significance of detected variances, the nature of associations among variables and the impacts on outcome performance variables (Volchok, 2020). Some of the tests computed were T-tests to assess the significance of observed differences between the means of two groups, thereby distinguishing between random, chance and systematic differences (Coman et al., 2013). Another test indicator was the value of the confidence intervals obtained, which determined whether to reject the null hypothesis. If the range fell outside the predicted interval, the null hypothesis was rejected; otherwise, it was not (Heslop & Roberts, 2012). The z-tests, on the other hand, compare sample means to population means, allowing for comparisons across distributions through the calculation of z-scores (Li & Zhang, 2022). Similarly, Chi-square tests were used to compare observed results with expected outcomes to determine whether the differences were due to chance or reflected a true relationship between variables (Franke et al., 2012). In a similar vein, regression analysis was applied to determine the associations between variables, helping to describe, estimate, predict, or control outcomes. Overall, these quantitative analysis techniques were critical in assessing the validity of the research process, in identifying meaningful relationships between variables and the predictive power in the outcome variables (Ali & Younas, 2021).The primary constructs for the study were directly related to incentives systems for private sector investments in the solar energy sector and also in line with hypothesized relationships affects between identified investment incentives and investment levels. These constructs focus on three main categories of investment incentives: financial, fiscal, and non-monetary fiscal incentives. They form the basis for developing research assumptions, based on the premise that the type and extent of incentive support are key factors influencing solar energy investments in Zambia. Specifically, the study is guided by two main assumptions: 1) Low investment levels in Zambia's solar energy sector are primarily due to the inadequate availability of financial incentives, and 2) The low performance levels of solar firms in terms of service output are linked to the nature of fiscal and non-monetary fiscal incentives available to firms in the sector.

The dependent variables in this study represent performance outcome levels in private solar energy investments. These include returns on investment (ROI), service delivery, infrastructure development, and human resource development. Specifically, service delivery is measured by the energy produced in kilowatt-hours (kWh), ROI is quantified as the monetary profits generated from investments, infrastructure development is assessed by the installed solar capacity in kilowatt-peak (kWp), and human resource development measured by growth in number of workers over the course of a unit year. These definitions are informed by established methodologies (Srinivasu & Rao, 2013).

The operationalization of these variables is influenced by similar studies. For example, a case study on the poultry industry in Tennessee explored the impact of energy incentives, grants, and other programs on the viability of solar photovoltaic (PV) systems. The study found that improving incentives was necessary for making solar PV adoption financially viable; in a related study reviewing solar PV incentives and policies across several countries, including Turkey, it was found that effective policies were essential for promoting solar PV installations. This research emphasized the need for well-defined policies, with variables like installed solar capacity measured in kWh or kWp. Financial incentives, such as grants or loans for PV installations, were operationalized as monetary amounts relative to installation costs, serving as growth indicators for the solar sector (Kılıç & Kekezoğlu, 2022; Lee et al., 2016).

This study used descriptive statistics to organize and present basic information about variables in the dataset, and inferential methods were applied to draw deductions which could be generalized to the wider population coverage (Alem, 2020). To test hypotheses and establish statistical significance, t-tests, z-tests, f-tests, and chi-square tests were applied. These tests helped determine whether observed differences between groups were statistically significant or due to chance (Coman et al., 2013; Franke et al., 2012). The Statistical Package for the Social Sciences (SPSS) was applied to analyse the collected data through correlations and regression computations were undertaken to comprehend relationships between variables and predictive power on outcomes (Ali & Younas, 2021).

Ultimately operational definitions of variables are conversions of financial, fiscal and non-monetary incentives ‘constructs into practical measures that support investment mechanisms (Zhang et al., 2023). Research constructs are abstract concepts that represent phenomena which cannot be measured directly, such as attitudes, perceptions, or investment confidence. In quantitative research, constructs provide the theoretical foundation for identifying what is to be studied and guide the selection of measurable variables that serve as their empirical indicators. Through operationalisation, these constructs are translated into observable and quantifiable variables using clearly defined measurement items, scales, and procedures. This process ensures consistency in measurement, enhances reliability and validity, and enables statistical analysis by linking theoretical concepts to empirical data in a systematic and replicable manner (Bhattacherjee, 2012).

For this study, primary constructs are support mechanisms for private solar investments and they address hypothesised relationships between investment incentives and investment levels in Zambia’s solar energy sector. The study focuses on financial, fiscal, and non-monetary incentives, assuming that the solar energy investment landscape in Zambia is heavily influenced by the types and levels of support provided to the sector. Additionally operationalization entails defining variables such as financing availability, access to loans and grants, tax holidays, excise duty waivers, and regulatory, infrastructure, market, and policy stability support systems as independent variables. The dependent variables include performance outcomes in solar energy investments, such as ROI and private sector investment rates. Correlation and regression analyses were used to examine relationships with and effects on outcome variables (Ali & Younas, 2021; Coman et al., 2013; Franke et al., 2012; Volchok, 2020).

Table 21 presents a structured summary of the study variables outlining the key constructs, associated variables and indicators, measurement scales, data collection methods, and data analysis techniques employed in the research. The table outlines in detail the independent variables relating to financial incentives, fiscal incentives, and non-monetary incentives by identifying their respective indicators used to assess incentive accessibility, adequacy and effectiveness within the solar energy sector. It also includes solar sector investment rates as the dependent variable, capturing measures related to investment scale, growth, and performance. Overall, the table clarifies how each construct was operationalised and systematically measured, ensuring coherence between the study objectives, data collection instruments, and analytical procedures.

Table 21

Operational Definition of Variables

Constructs	**Variables**	**Indicators**	**Measurement**	**Scale**	**Data Collection**	**Data Analysis**
Financial incentives Vs. Solar sector investments	- Loans - Grants	- Loan offers - Grants offers	Financing; - Grants - Loans	Ratio	Survey Questionnaire	-Correlation -Regression
Fiscal incentives Vs. Solar sector investments	Benefits from: -Tax exemptions -Tax waivers -Duty waiver -Customs waiver	-Available tax incentives -Accessible tax incentives	Financing; -Tax returns, -Tax exemptions waivers	Ratio	Survey Questionnaire	-Correlation - Regression
Non-monetary Incentives	-Regulatory Support, -Capacity-building -Infrastructure Support, -Market Access, -Policy Stability	- Available service support -Accessible services support -Available service support	-Response time -Resolution efficiency -satisfaction rates	Ratio	Survey Questionnaire	-Correlation - Regression
Solar Sector investment Rates	Levels of: -Infrastructure -Human resource -Service delivery -RoI	-Development of: Infrastructure -Human resource -Service delivery - - - Profitability	Output capacities - kWp - kWh - RoI	Ratio	Survey Questionnaire	- Correlation - Regression

Note: Research constructs, variables indicators, data instruments and methods of analysis employed. Methodologies outlined in IMF Government Finance Statistics Manual 2021. *Source:* (Hair et al., 2019)

Construct/Variable 1: Financial Incentives

As earlier outlined in the operationlisation of variables section, constructs and variables are cardinal in any research study as they provide practical means of gauging relationships and effect but also ultimately help to build a framework for explaining and analysing the phenomena under examination. This study enedevoured to address financial, fiscal and non- monetary incentives in solar sector investments in Zambia and as such, the formulation of appropriate research constructs and variables were cardinal in shaping the research strategy and guiding the collection of records and analysis (Calder, 2021). The first variable under this study is directly linked to the first construct sating that; ‘Suitability of financial incentives in the solar energy sector or lack of it has significant influence on performance levels in private sector investments in solar energy. Consequently the identified variable pertains to the level of availability and accessibility of financial loans and grants for private solar investors which is crucial in assessing the impact of financial incentives on investment decisions in the Zambian solar energy sector. With this variable measurement, the extent to which private solar investors could access financial support mechanisms such as loans and grants to facilitate their investment activities was done. The level of measurement for this variable was is in Likert scale, ranging f from 0 to 5. This scale allowed for accurate quantification of the variable, where 0 represents non-availability or accessibility of financial support, and 100 represents complete availability and accessibility. The scale also allowed for comparisons between different levels of availability and accessibility, enabling researchers to gauge the degree to which financial incentives influence investment decisions (Gunter, 2013). To measure this variable, respondents are presented with structured survey questionnaires consisting a series of questions relating to the availability and accessibility of financial loans and grants for solar energy projects. The questionnaire were designed to capture respondents' perceptions regarding available financial support mechanisms for the solar sector on which responses were gauged on a scale from 0% to 100%, or from 0 to 5; with 0 indicating no availability/accessibility and 100 indicating highest availability/accessibility. The questionnaires were disseminated face to face to participants in public and private solar sector stakeholder organisations in Zambia. The survey items were specifically designed capture responses related to the suitability and accessibility of financial loans and grants (Sadan, 2017).

Collected data from survey responses were compiled using Ms Excel and analysed through SPSS statistical tool which was used to compute means, medians, and modes of responses, thereby providing a complete portrayal of the level of availability and accessibility of financial loans and grants, including taxes exemptions and waivers. Additionally, SPSS was applied to execute the analysis of variable association and predictive power in the outcome variables. The application of Correlation/ Regression analyses helped the study to describe the nature in terms of direction and robustness of the associations between suitability of available financial support mechanisms in form of incentives and investment levels in the solar sector (Bryman & Cramer, 2012).

Generally, the level of availability and accessibility of financial loans and grants serves as a key variable in assessing effects arising from financial incentives on investment decisions in the Zambian solar energy sector. By measuring this variable on a Likert scale and analyzing it using statistical techniques, the research revealed valuable insights into the effects of financial incentives in promoting investment in solar energy.

Construct/Variable 2: Fiscal incentives

The second variable was related to the second construct arising from to the second research question focusing on fiscal incentives which represented tax related benefits. The interrogation of this incentive focused on the nature, suitability, or lack of it, in the solar energy sector. Specifically, this variable measures the level of suitability of available fiscal incentives, including tax exempts, waivers on excise duty, other investment taxes, including corporate taxes which significantly influence the accomplishments levels from private sector investments in solar sector.

Research constructs relating to, fiscal incentives are conceptualised in terms of their accessibility, suitability and intensity, reflecting how easily investors can obtain these incentives and the extent of financial relief they provide. To operationalise this construct, accessibility and incentive values were gauged on a Likert scale ranging from 5 t o0, where a score of 5 indicates high accessibility or the maximum level of fiscal incentives' intensity and a score 1 denotes very low accessibility,. This approach enables the systematic quantification of fiscal incentives, allowing for consistent measurement and meaningful statistical analysis of their influence on investment outcomes .The Likert scale measurement allows for quantification of abstract concepts like stakeholder perceptions by assigning them specific numerical values in a clearly rank order and technically equal interval measurement and comparison of different levels of incentives thereby ensuring the attainment of quantitative data when used and ultimately confirming construct validity of identified variables (Ali, 2020; Batterton & Hale, 2017). Furthermore, Likert scales provides numerous advantages in quantitative research in comparison with other types of measurement scales making them particularly appropriate for survey-based studies. Unlike nominal or ordinal categorical scales that only classify responses or outline rank order, a Likert scale provides ordinal data response categories with equal intervals, allowing scholars to treat the resulting scores as approximating continuous data which is suitable for many statistical analyses. This aspect of Likert scales improves comparisons and interpretations thereby enabling the calculation of means, variances, and correlation coefficients. Likert scales are also easy for respondents to comprehend and complete thereby helping to improve response rates to survey questionnaires and reduces measurement error. If applied in structured format Likert scale appropriately supports standardisation across bulky samples, enabling steadfast aggregation and replication. Additionally, Likert scales are able to gauge the strength of attitudes or opinions, providing more insightful information than simple binary or yes/no enquiries. Collectively, the aforementioned properties position Likert scales as efficient, robust, and fit for parametric and non-parametric statistical procedures usually applied in quantitative research such as regression, t-tests, factor analysis (Jebb et al., 2021)

The research questionnaire used to measure this variable was a structured survey type through which respondents were presented with questions related to the appropriateness of tax-related fiscal incentives for renewable energies (Roopa, & Rani, 2012). Participants were requested to provide responses on a scale from 0% to 100% or from 1 to 5, to indicate the perceived level of accessibility and suitability of these incentives. For example, participants were asked about the extent to which they can access tax exemptions, excise duty waivers, investment tax exemptions, and corporate taxes for solar energy projects; additionally they were asked to indicate the values of these incentives in terms of percentage of numbers. Data for these variables was therefore collected through structured questionnaires disseminated face to face and to respondents in public and private solar energy sector due to observed non-response from the electronic platform. The prompted the adoption of face dissemination of questionnaires through appropriate gate keepers. The enquiries in the survey questionnaire were designed to gather participants' perceptions on the suitability of fiscal incentives for the solar sector investors (Roopa, & Rani, 2012).

Following the collection of data, participants’ feedback was gathered and examined with Statistical Package for the Social Sciences (SPSS). Through the application of the SPSS Statistical software, means, medians, and modes of responses were computed, summarizing the accessibility and appropriateness of non-financial fiscal incentives. Additionally, SPSS facilitated regression and relationship analyses to assess the connections between this variable as an independent factor and the performance-based dependent variables in the study. During the analysis phase, the study was able to attain correlation results for relationships between the available/suitable non-financial fiscal incentives and investment levels in the solar investments through the use of SPSS analytical tool (Kafle, 2019). These correlation and regression analyses were key in establishing the extent to which non-financial fiscal incentives influence private sector investments in solar energy (Almquist et al., 2020b)

A research instrument applied, was a structured survey questionnaire which was used to gather appropriate information to evaluate the fiscal incentive variable by asking respondents to answer questions about the accessibility and suitability of fiscal incentives in the solar energy sector. Respondents selected their answers using a scale of 0% to 100% or 1 to 5 to indicate their perceived levels of accessibility and suitability. For example, participants were asked to estimate the level of access to tax benefits such as excise duty waivers, investment tax exemptions, and corporate tax reductions in their solar energy projects. They were also required to provide the value of these incentives as a percentage. Consequently data sources for this variable were survey information collected through structured questionnaires disseminated face to face to participants in public and independent solar power sector investors. The questions in the survey questionnaire were designed to capture respondents' perceptions of the accessibility and suitability of non-financial fiscal incentives for the solar sector investors. The research process was such that, after collection of survey responses, data was compiled into data on MS Excel and analyzed using SPSS Statistical tool was used to compute the means, medians, and modes of collected, presenting a pattern layout of the level of accessibility and suitability of non-financial fiscal incentives. The SPSS analytical tool enabled the undertaking of correlation and regression computation procedures for associations among independent variables and performance-tied variables in the study (Almquist et al., 2020b).Through this analysis tool, the research was able to outline the significance and orientation of the relationship between fiscal incentives variables with investment levels in the solar department. This analysis was key in establishing the extent to which non-financial fiscal incentives influence private sector investments in solar energy

Construct/Variable 3: Non-monetary Fiscal incentives

The third variable of the study, related to the third research construct focusing on non-monetary fiscal incentives, pertains to the nature, suitability, or lack of non-monetary fiscal incentives, specifically, measuring level of accessibility and suitability of non-monetary fiscal incentives, including regulatory support mechanisms, capacity-building systems, infrastructure readiness, market access support and, policy stability in solar investments. The operationalisation, data collection instrument and measurement scales for this construct variable is similar to the previously defined processes and methods for fiscal incentives

Construct/Variable 4: Solar sector Performance outcomes

The fourth construct in this study represents the dependent variables, which capture investment outcome and performance indicators in the solar energy sector under the influence of financial, fiscal, and non-monetary incentives. These outcomes reflect the extent to which institutional support mechanisms contribute to sector growth and are assessed through indicators such as asset growth (infrastructure expansion), improvements in service delivery capacity, and return on investment (ROI)**.** Collectively, these indicators reflect overall expansion and performance of solar energy investments (Oswald et al., 2011).

Performance levels were measured using a five-point Likert scale, where a score of 1 indicates minimal or no development and a score of 5 indicates extensive development. Data were collected using a structured questionnaire comprising items designed to capture changes in investment outcomes over time in relation to financial, fiscal, and non-monetary incentives. For example, respondents were asked: “How has your organisation’s investment in solar energy changed over the past five years?” with response options ranging from 1 = little or no improvement to 5 = significant increase. Another example item is one requiring respondents to rate changes in solar generation capacity using percentage-based categories, such as “On a scale from 20% to 100%, how would you rate the increase in your organisation’s solar energy generating capacity over the past year?”. Constructs relating to solar sector performance outcomes in the study are private sector investment rates and return on investment outlined in subsequent sections.

Private Sector Investment rates. Private sector investment rates, as the dependent variable in this research, represent the level and growth of private capital committed to the solar energy sector and reflect the resulting expansion of energy provision. This variable captures how effectively investments translate into sectoral performance and service delivery. It is operationalised using indicators such as the amount of energy delivered, responsiveness to service requests, and customer satisfaction levels, which together provide a practical measure of investment outcomes and market participation in the solar energy sector (Aimesheva, 2016). Accordingly the measurement scale used was a Likert scale ranging from 1 to 5, where 1 indicates low service delivery and 5 indicates high service delivery. The primary tool for the collection of research information was a questionnaire structured in such a way as to effectively assess performance outcomes levels in the solar energy sector. The research tool included standardised questions, such as; "Using a scale from 20% to 100%, how would you rate your satisfaction with the energy delivery service from your solar energy provider?"

Return on Investments ROI Variable. The variable measures financial returns gained from investments in the solar energy sector which includes indicators such as profits generated, cost savings or revenue growth (Dadd & Hinton, 2023). Similarly, the measurement scale used was also a Likert scale ranging from 20% to 100% and as earlier indicated, the tool for data gathering was an organized survey, with items designed to assess ROI. Example question for the variable is: "What percentage increase in profits has your organization achieved from solar energy investments in the past year?"

These variables were collected and gauged using a structured survey questionnaire disseminated to respondents through a face to face or web based electronic platforms to interrogate solar sector investments. The survey items were designed to capture data on the performance indicators and were analysed through correlation and regression analysis methods (Ali, 2020; Aini et al., 2018). A practical example of an application of such a research instrument is in the employee engagement survey to examine job satisfaction of employees called "A study of employee engagement, job satisfaction and employee retention of Michigan CRNAs," in which the nature of variables collected allowed for work trends identification, areas of concern, and improved formulation of relevant policies (Carnahan, 2013).

Study Procedures and Ethical Considerations

Ethical principles were strictly observed to ensure that the study adhered to international standards and local regulatory requirements. At the national level in Zambia, research clearance for engineering- and energy-related studies was obtained from the Engineering Institution of Zambia (EIZ), which oversees ethical and development-aligned research practices (Thompson et al., 2025). Other national bodies, such as the National Institute for Scientific and Industrial Research (NISIR) and the University of Zambia's Directorate of Research and Graduate Studies, were not applicable as they primarily oversee internal or collaborative research.

At the organisational level, gatekeeper permissions were secured from targeted institutions in the solar sector. Gatekeepers endorsed consent forms authorising access to staff and permitting the distribution of survey instruments. This ensured compliance with institutional protocols and facilitated the identification of eligible participants.

At the individual level, participants were provided with written informed consent forms explaining the purpose, procedures, expected time commitment, voluntary nature of participation, right to withdraw, and assurance of anonymity and confidentiality (Nnebue, 2010; Rowley, 2014).

Participants were informed that they could decline to answer any questions they found intrusive or uncomfortable, and that all collected data would be securely stored, anonymised, and reported only in aggregated form. These measures minimized potential physical, psychological, or social risks, ensuring compliance with ethical standards of beneficence and non-maleficence (Burr & Leslie, 2023; Varkey, 2021).

Study Procedures

The research adopted quantitative methods, using structured questionnaires with closed-ended questions to collect data on financial, fiscal, and non-monetary incentives in the solar energy sector. Eligible participants were identified from financiers, regulators, policy implementers, traders, and private investors, with a pilot study conducted on 25 respondents to refine the survey and ensure clarity, relevance, and reliability (Brooks et al., 2016). Data collection and dissemination initially involved both electronic, and face to face dissemination; however due to low response rates during the pilot study for online questionnaires, the main study utilized face-to-face distribution to enhance response rates and reduce non-response bias. The questionnaires included a mandatory informed consent section and provided details about the participants' rights, including voluntary participation and confidentiality. The informed consent form for participants is exhibited at annex A to this study.

Sampling was achieved through Simple Random Sampling (SRS) from a homogeneous frame of 315 participants, yielding a final sample of 244 respondents (Sarker & Al-Muaalemi, 2022). Collected data were coded, stored securely, and managed using SPSS and Excel to ensure accuracy, consistency, and traceability. Consequently all procedures were conducted in line with methodological and ethical standards to ensure replicability and reliability of the research findings (Mathiyazhagan & Nandan, 2010).

Ethical Assurances

Ethical assurance refers to the strategies employed to protect participants' rights, dignity, and welfare throughout the research process. The study followed key ethical principles including; Informed consent**:** Participants were fully briefed on the study's purpose, procedures, risks, benefits, voluntary nature, and confidentiality safeguards. They were reminded of their right to withdraw at any time without consequence (Vanclay et al., 2013; Dahal, 2024). Respect and dignity where data collection was conducted professionally, with sensitivity to participants' time, privacy, and work responsibilities. Confidentiality and anonymity where data were anonymised using codes, securely stored, and accessed only by the research team to prevent identification of individuals or institutions (Artal & Rubenfeld, 2017; Hwang, 2023) Minimising risks, in which the survey posed minimal risk, limited to answering questions on structured questionnaires, avoiding sensitive or intrusive content and Research permissions for **e**thical clearance was obtained from Engineering Institution of Zambia (EIZ**)** in the absence of a fully operational national ethics committee, still under formation at ministry level and institutional permissions were secured from gatekeepers to ensure adherence to organisational and professional standards. The local research approval from EIZ is included at annex C to this study.

The study also emphasized transparency and trust by providing participants with full disclosure of the study's objectives, procedures, potential risks and benefits, and the intended use of collected data. Ethical assurance was reinforced by educating participants about their rights, protecting their welfare, and maintaining data integrity. Generally, the study upheld ethical standards at national, institutional, and individual levels, ensuring reliability, credibility, and ethical integrity in data collection, processing, and analysis (Frambach et al., 2013; Gao et al., 2016; Sargeant, 2012; Skinner et al., 2023).

Data Collection and Analysis

This study collected quantitative primary data using a structured questionnaire designed to measure the effects of financial, fiscal, and non-monetary incentives on private-sector solar investment performance in Zambia. The target research audience comprised actors across the solar value chain i.e., financiers, equipment suppliers, energy regulators, transmission and distribution utilities, policymakers, and private solar investors. Eligible respondents were aged 18 to 65, of sound mind, of any gender, and had a minimum of two years' experience in the solar sector. Access to organisations and respondents was obtained through gatekeeper permissions, and individual informed consent was secured from each participant before data collection to ensure ethical compliance.

Data collection procedures

To minimise non-response and maximise completion rates, questionnaires were distributed face-to-face. Physical administration allowed the researcher to support respondents during completion and to ensure secure return of each instrument this. This was after electronic online distribution was attempted contributing to informing the design choice of which low pilot response rates led to a decision to priorities in-person distribution for the main study (Etikan et al., 2016; Marczyk et al., 2010). Secondary sources scholarly journals, professional publications and policy reports were used to contextualise primary data.

Sampling followed a systematic process. A homogeneous sampling frame of 315 eligible solar-sector professionals drawn from pre-identified organisations was established; from this frame a simple random sample of 244 respondents was selected using the RAND function in Excel to ensure representativeness and replicability. This approach strengthened generalisability of results (Etikan et al., 2016; Marczyk et al., 2010).

Data preparation

In quantitative research studies such as this one, data preparation is an underpinning stage that ensures raw data are converted into good quality, analysable form before undertaking any statistical tests**.** This process includes systematic cleaning, management of absent variables, verification of consistency, correction of inaccuracies, and appropriate coding which is meant to prevent the yielding of misleading results, to reduce bias, and to enhance the validity and reliability of findings. Without such good preparation, even intricate analytical procedures can result into inaccurate conclusions because the quality of analysis is fundamentally restricted to the quality of the data used. Appropriate data preparation also improves reproducibility and credibility of the study, thereby strengthening the contribution of the research to the concerned field (Sharifnia et al., 2025).

Data preparation for this study was done in accordance to standard stages of checking, editing, coding and transformation (Kent, 2015). Completed questionnaires were checked for completeness and consistency; missing pages and late returns were handled according to pre-defined rules. Editing addressed logical anomalies, range checks and response-set issues. Variables were pre-coded numerically where possible and entered into datasets or a codebook for future decoding. Data matrices were created in Excel and exported to SPSS for analysis. These steps ensured data integrity and facilitated reliable statistical processing (Pallant, 2020).

Data Analysis Techniques

In quantitative research and other research approaches, the choice of data analysis techniques is cardinal**,** as these techniques provide the means through which raw numerical data are transformed into meaningful evidence that informs conclusions and supports the testing of hypotheses. Such techniques include descriptive and inferential statistics, such as regression analysis and hypothesis testing, which are employed in this study, as well as multivariate methods that enable researchers to identify patterns, measure relationships between variables, and generate valid, generalisable inferences. The application of appropriate analytical techniques ultimately enhances the validity, reliability, and scientific rigour of the study. Conversely, the use of inappropriate or weak analytical techniques can undermine even accurately collected data, leading to misleading and difficult-to-interpret findings, thereby diminishing their credibility and contribution to the body of knowledge. Proper application and justification of data analysis techniques ensure clarity and transparency in the research process, which are essential for academic scrutiny and replication. This emphasis on rigorous analysis aligns with the central role data analysis occupies within the complexity of contemporary research methodology (Aguinis et al., 2018).

This study employed quantitative data analysis techniques consistent with the structured questionnaire design, which used closed-ended questions to generate measurable responses. These closed-ended items allowed the researcher to quantify participant perceptions of financial, fiscal, and non-monetary incentives and analyse their relationships with private-sector solar investment outcomes (Saunders et al., 2019). Before conducting statistical analyses, all completed questionnaires were collated and systematically coded, ensuring that each response category was assigned an appropriate numerical value. This coding process was essential for maintaining data accuracy, enabling structured analysis, and ensuring the credibility of the dataset (Pallant, 2020).

To evaluate the distributional properties of the collected data, Q-Q plots (Quantile–Quantile plots) were generated to assess the normality of key variables. Normality testing is a fundamental prerequisite for many parametric statistical techniques, as it confirms whether variables follow the assumptions required for correlation and regression analysis (Carvalho et al., 2023). The results of these Q-Q plots assisted in determining the suitability of the subsequent analytical procedures.

Following data preparation and normality checks, the study used IBM SPSS Statistics to perform correlation and regression analyses. Correlation analysis was conducted to determine the strength and direction of relationships between the incentive variables and investment performance metrics. Regression analysis was then applied to assess the predictive effects of financial, fiscal, and non-monetary incentives on investment outcomes, allowing the study to identify significant determinants of solar sector investment. The use of SPSS was vital because the software provides reliable statistical outputs, flexible modelling options, and automated diagnostic tools that enhance the accuracy, replicability, and robustness of quantitative research (Pallant, 2020).Generally, these analytical procedures ensured that the study’s findings were grounded in strict statistical processes, enabling meaningful interpretation of the relationships and predictive impacts of independent variables on dependent variables.

The collection of data and consequent analysis is a fundamental constituent of any study, aimed at quantifying research variables and establishing actual associations between independent and dependent variables in accordance with formulated study questions. As earlier outlined the study utilised a quantitative survey questionnaire corresponding to a quantitative research approach to inquire and generate objective responses suitable for quantitative data analysis (Curtis et al., 2016; Taheri et al., 2015). The main goal of this section is therefore to outline a thorough operationalization of research constructs into measurable variable data, particularly for the purpose of establishing the relationship between investment incentives and performance outcomes in private sector solar investments (Emmerich, et al., 2016; Rao & Reddy, 2013). To effectively evaluate scaling measures for the solar sector, the study focused on collecting quantitative data pertaining to investment incentives for the solar energy investments, comprising financial, fiscal non-monetary incentives. Research constructs relating to financial incentives were divided into grants and loans and were gauged on a ration type of scale in research questionnaires examining availability, accessibility and suitability of these incentives. Similarly fiscal non-financial incentives were category in form of exemptions, delays or waivers on corporate tax, duty tax and other concessional investment waivers related to solar sector investments, were correlated to levels of performance outcomes in the solar sector.

The undertaking of the data analysis involved several steps, including checking, editing, and coding processes, before applying statistical techniques such as bivariate Pearson correlation and linear regression. Similarly the testing of the hypothesis helped to evaluate the plausibility of research hypotheses. Null hypotheses were established to provide a basis for comparison, with a significance level set at $p \leq 0.05$. The process to test formulated hypothesis involved defining clear null and alternative hypotheses, planning and executing the analysis, and examining the results to determine whether findings fail to reject the null hypotheses or indeed they reject the null hypotheses. Independent variables derived from financial and fiscal incentives were assessed alongside dependent variables related to private sector investments and returns on investments in the solar sector. The study analysis aimed to deliver valued understandings regarding the effectiveness of incentives in promoting solar energy sector investments.

To ensure both validity i.e., confirming that the measurement tool accurately assesses the intended behavior or quality and reliability, which reflects the instrument's consistency across different environments (Sürücü & Maslakci, 2020), appropriate research methods were applied to analyse relationships between key variables. The determination and evaluations arising from associations between independent and dependent variable were achieved through the application of a statistical tool called the Statistical Package for the Social Sciences (SPSS) which was utilised to compute correlation coefficients (r) and regression coefficients (beta) from the collected data (Kafle, 2019).

The study employed SPSS statistical software to conduct correlation analyses on selected variable pairs, with the sample Pearson correlation coefficient (r) used to assess the strength and direction of linear relationships within the data (Meyers et al., 2016). In addition, regression analysis was performed to examine the effect of the independent variables on the outcome variables, allowing assessment of the magnitude and direction of influence between predictors and investment performance outcomes (Hair et al., 2019). The study further employed a hypothesis-testing design using Pearson's correlation coefficient (r) with a two-tailed significance test. All statistical decisions were made at a predetermined significance level of $\alpha = 0.05$ with the null hypothesis (H0) positing that no statistically significant relationship existed between the variables, such that the population correlation coefficient equaled zero. When the computed *p*-value was greater than or equal to 0.05 ($p \geq 0.05$), it indicated insufficient statistical evidence to support a relationship between the variables, and the null hypothesis was not rejected. Conversely, when the p-value was less than 0.05 ($p < 0.05$), results indicated a statistically significant relationship between variables, leading to rejection of the null hypothesis (Field, 2018).

As outlined above for hypothesis testing, the null hypothesis (H0) represents the absence of any correlation in the findings, while the alternative hypothesis (H1) represents the presence or a level of relationship between variable regardless of direction. The correlation coefficient (*r*) can indicate a positive correlation (+*r*), meaning both variables increase or decrease together. Alternatively, a negative correlation (-*r*) implies an inverse relationship, where one variable increases as the other decreases, or vice versa. (Obilor & Amadi, 2018). Formulas 4 and 5 represent the mathematical computation of the correlation coefficient for a sample relating to two variables x and y (r_{xy}); and correlation coefficient of a broader population between two variables x and y (ρ_{xy}) respectively (Pal & Bharati, 2019).

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum y_i - \bar{y})^2}} \tag{4}$$

Where r_{xy} is correlation coefficient for variables, where x_i are x variables in a sample; y_i are y variables in a sample; is r_{xy} is correlation coefficient for variables, where x_i are x variables in a sample; y_i are y variables in a sample; $\bar{x}$ is average of values of x in sample; $\bar{y}$ is the average of values of *y* in sample.

Similarly formula (6) is for linear multiple regression with one dependent variable (Y) and multiple independent variables (X_1, X_2…Xn).

$$\rho_{x,y} = \frac{E[(X-\mu_X)(Y-\mu_Y)}{\sigma_X \sigma_Y} \qquad (5)$$

Where, numerator represents covariance of variables while σ*X* and σ*Y* are standard deviations of *X* and *Y* respectively. E is the expectation and μ*X* and μ*Y* are means of *X* and *Y* as variables. Note that: $-1 \leq \rho X,Y \leq +1$ and is always symmetrical, i.e., $\rho X,Y = \rho Y,X$

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \in \qquad (6)$$

Where Y is the dependent variable (outcome), β0 is the Intercept (constant term), *β1, β2,…,βn* are coefficients of the independent variables (*X1*, *X2* … *Xn*).While ϵ is the error term (For unexplained variation).

This study is non-experimental with no control variables involved but rather it is correlational, and as such it inherently exhibited lower level of internal validity which often arises due to the absence of the manipulative variables in the analysis procedures (Price et al., 2015). As earlier mentioned, private sector investment rates are treated as the dependent variable, representing the growth and effectiveness of private capital participation in the solar energy sector and the resulting expansion of energy provision. Consequently to ensure the validity of findings associated with this outcome variable, particular attention was extended to external and temporal validity. External validity was addressed during the data collection and analysis stages by clearly defining the target population and ensuring accurate operationalisation of the variables. Eligible respondents were drawn exclusively from recognised solar sector institutions, and access was facilitated through appropriate gatekeepers to ensure relevance and authenticity of responses. In addition, a simple random sampling technique was applied to obtain a representative sample, thereby enhancing the generalisability of the results. Temporal validity was maintained by anchoring the study within a defined time frame and comparing the findings with evidence from contemporary empirical studies, ensuring that the observed investment patterns reflected current sector conditions. Collectively, these measures support robust interpretation of private investment rates and allow for credible inferences and well-grounded recommendations for future research. (Flake et al., 2017).

Instrument description and validation

A concise description and cautious adaptation of the research instrument are indispensable in ensuring that data collected are valid, reliable, and aligned with the study objectives. A research instrument provides a primary avenue through which constructs in abstract form are operationalised and gauged, and its credibility is directly reflected in the quality precision and interpretation of research results. It therefore follows that applying a properly designed or previously validated instrument guarantees methodological rigor. Additionally appropriate adaptation of the instrument in terms of its context, cultural, or sectoral modification ensures effective applicability to an identified of targeted field of study without compromising field-specific indicators or properties. Similarly accurate documentation of the instrument’s source, adaptation process, and justification reinforces its transparency and replicability confirming its theoretical and empirical grounding (Arafat et al., 2016). The outline of the research instrument in exhibited at annexes D and H, while the research instrument adaptation is included at annex E

For this study the research instrument was adopted from a research study titled; ‘Impact of Strategic Management on Organizational Growth of manufacturing industry in Anambra state (Muogbo, 2013), and adapted to appropriately interpret theoretical constructs for this study into measurable variables and directly corresponding to this study’s research questions and hypotheses (Aithal & Aithal, 2020; Saaiq, 2024). It comprised two sections, with section ‘A’ capturing demographics (sector, role, age, work experience) and section B measuring perceptions of financial, fiscal and non-monetary incentives and outcome variables in form of return on investment and private-sector investment rate. Items were gauged on a five-point Likert scale to provide orderly ranking and technically assumed uniform intervals in responses. The instrument initially contained 23 items (4 demographic, 19 incentive related items) and was refined to 14 items (4 demographic, 10 incentive related items) following expert review and pilot testing to remove redundancies and improve clarity (Grove et al., 2012; Muogbo, 2013).

Content validity was established through expert peer reviewed by specialists in academia, energy and economics who assessed construct coverage and recommended wording changes. Face validity was tested via a pilot survey of 25 respondents, which led to adjustments that improved clarity and logical flow. These validation steps informed a robust instrument for the correlational analysis that followed (Brooks et al., 2016).

Response Rate

In survey based quantitative research studies such as one at hand, the response rate which **is** defined as the proportion of completed and usable responses to the research instrument relative to the number of participants accessed is a critical gauge of the quality of data and ultimately the credibility of the study. Adequate or acceptable response rates reduce the risk of non-response bias, enhance the statistical power, and improve the representativeness and generalisability of findings. In various social science and applied policy research, response rates of 60% or above are normally considered acceptable, while rates above 80% are regarded as strong (Booker et al., 2021) In this study, a total of 75 eligible solar sector institutions were initially identified and accessed from which 375 potential participants were accessed through gatekeepers at an average of five to six respondents per organisation. Of these, 315 participants returned completed research instruments, yielding an 84% response rate, which exceeds commonly accepted thresholds and therefore strengthening the reliability and validity of the empirical results. Furthermore, in line with the statistically determined sample size requirements, 244 participants were selected from the valid responses using Simple Random Sampling, implemented through the Excel RAND function, to ensure equal probability of selection and minimise sampling bias in subsequent analyses.

Summary

This chapter presented a comprehensive overview of the research methodology employed to examine the effects of financial, fiscal, and non-monetary incentives on private-sector solar investment in Zambia. The study adopted a quantitative correlational research design, which facilitated the examination of relationships between institutional support mechanisms and investment performance levels in the solar sector. Both primary and secondary data were utilised, with primary data collected using a structured questionnaire and secondary data drawn from scholarly journals, professional publications, and policy reports to provide contextual depth.

The target population comprised stakeholders across the solar energy value chain, including financiers, equipment suppliers, energy regulators, transmission and distribution utilities, policymakers, and private investors. Eligible respondents were required to be aged 18 to

65, mentally sound, of any gender, and have at least two years of experience in the solar sector. Access to organisations and respondents was secured through gatekeeper permissions**,** while individual informed consent ensured voluntary participation, confidentiality, and ethical compliance.

A systematic sampling approach was employed, where a homogeneous sample frame of 315 eligible participants was accessed and a final sample of 244 respondents was randomly selected using Simple Random Sampling (SRS) to ensure representativeness and generalisability. To maximise response rates and minimise non-responsiveness, questionnaires were primarily distributed physically and face-to-face, with support provided to participants where necessary. The response rate of the study denoting the proportion of completed, usable and returned responses relative to participants accessed enabled the determination of data quality and study credibility as it signified reduced non-responsiveness and enhanced representativeness and statistical power. This study, responses were obtained from a large pool of accessed participants, resulting in a high response rate (84%)**,** which exceeds commonly accepted thresholds and thus strengthening the reliability and validity of the research findings, with a statistically determined subsample subsequently selected using simple random sampling to minimise bias.

The study emphasised content validity and reliability of the research instrument. Content validity was achieved through expert peer review by academics and practitioners in energy economics, who refined item wording, removed redundancies, and confirmed construct coverage. Face validity was assessed via a pilot study involving 25 respondents, which guided adjustments to improve clarity and logical flow of questionnaire items. The reliability coefficients attained through Cronbach’s alpha tests, assured reliability of the study ensuring that the instrument yielded consistent and repeatable results when applied in main study. This process ensured the development of a reliable and valid instrument suitable for correlational and inferential quantitative analysis.

Collected data were systematically prepared, checked, edited, coded, and transformed into interpretable datasets using SPSS and Excel**.** The structured questionnaire employed a Likert scale to capture key variables, including the availability, accessibility, and suitability of financial, fiscal, and non-monetary incentives, and their impact on private sector investment outcomes. Data analysis involved descriptive statistics**,** Pearson correlation**,** and linear regression to establish the strength, direction, and predictive relationships among variables. Hypothesis testing was conducted at a significance level of 0.05, with clearly defined null and alternative hypotheses guiding the interpretation of results.

Ethical considerations were integral to the study. Ethical clearance was obtained from the **host** university's Research Ethics Committee (UREC) and from the Engineering Institution of Zambia (EIZ)**,** given that the national ethics committee was not yet fully operational. Participants and organisational gatekeepers were provided with detailed informed consent forms outlining study purpose, participation rights, potential risks, benefits, voluntary participation, and confidentiality measures. Ethical assurances were further upheld by maintaining anonymity, securing data, minimizing risks, and promoting participants' autonomy, aligning with principles of beneficence, non-maleficence, justice, and respect for self-determination (Burr & Leslie, 2023; Vanclay et al., 2013; Varkey, 2021). Additionally, quality assurance was prioritised through standardisation of data collection procedures, competency of research team members, and adherence to methodological rigor (Gao et al., 2016; Sargeant, 2012).

Overall, the chapter demonstrates that the research employed a methodologically robust, ethically compliant, and systematic approach to collect, manage, and analyse data. The combination of rigorous sampling, valid and reliable instruments, structured data collection, and advanced statistical analysis ensured that the study produced credible, generalisable, and reproducible findings on the relationship between investment incentives and performance outcomes in Zambia’s solar energy sector.

CHAPTER 4: FINDINGS

The Findings Chapter presents the main findings of a study and is one of the most critical components of a research, as it directly reports the empirical evidence generated from the collected data. This chapter outlines the patterns, relationships, and statistical outcomes that emerge from the analysis, allowing the reader to understand what data divulged in relation to the research questions and hypotheses. By presenting results objectively, albeit without interpretation or biasing, the chapter provides a factual basis upon which subsequent deliberations, comparisons with theory, and conclusions are anchored. Its importance lies in demonstrating the credibility, thoroughness, and transparency of the research process thereby demonstrating how evidence supports or defies anticipated outcomes.

The findings chapter begins by presenting a detailed account of the process prior to actual data analysis which was done in line with, the study's overarching objectives. Specifically, the evaluations focus on relationships between institutional incentives designed to support investments in solar energy, namely financial, fiscal, and non-monetary incentives and key performance outcome variables, thereby assessing their overall impact on investment performance within the solar energy sector. This section also present summaries of rigorous processes of ensuring trustworthiness, reliability and validity, pilot study in relations to data collection and operationalisation of variable with the aim of attaining robust results.

This evaluation is grounded in the understanding that Zambia's developmental agenda relies heavily on the availability of sustainable energy. The study examines financial incentives that are directly related to financial input in the sola sector or though observations directly reflecting financial input such as the investments financing access levels and also the private sector investments rates. Similarly fiscal incentives represents tax related investment inducements such as excise duty, corporate tax exemptions or deferments, including tax based investment concessions as outlined in the country’s energy Plan for 2030 (Bowa et al., 2017). The justification behind this inquiry is the proposition that Zambia’s development in the renewable energy department is hampered by an inefficiencies in the public utility energy systems that necessitates additional generation capacity, particularly from private sector solar investments (Bayliss & Pollen, 2021). Key objective of the study was therefore to interrogate the effectiveness of financial, fiscal and non-monetary incentives, considered as independent variables (IV), in promoting private sector investments within Zambia's solar sector. These incentives were evaluated in relation to key performance indicators such as assets, and service delivery; including return on investment (ROI) which are the study's dependent variables (DV). The findings chapter is systematically organized to encompass key research aspects, including research questions, objectives, methods, collection of data, and analysis. To achieve the set research goals, the study conducted a thorough analysis of financial, fiscal and non-monetary incentives available for the country’s solar energy sector. This analysis covered government backed loans or grants as well as donor cooperating partners inducement in form of financing, implementation or technical assistance. Fiscal inducements also covered refunds or exemptions on dividends, import duties, general corporate tax, and value-added tax (VAT).

Three questions were formulated for this study, aligned with the study’s problem statement purpose and objectives, with a focuses on the suitability of financial, fiscal and non-monetary incentives for solar sector investments in Zambia. The goals of the study intended to assess the suitability of financial, fiscal and non-monetary incentives which included existing availability and accessibility of these incentives and also their impact on private solar sector investments in alignment with the respective research questions. This structured layout is designed to offer an all-encompassing framework for analyzing the influence of monetary and non-monetary fiscal incentives and also highlighting importance of these incentives in promoting investments for independent energy investments in the country.

In line with the research method of choice, the research questions and objectives were strategically formulated to effectively guide the research process. The quantitative correlation approach in conjunction with suitable tools for collecting and subsequent analysis of quantitative data were amalgamated to deliver reliable results (Curtis et al., 2016).The collection of measurable data aimed to establish correlations between predictor and outcome variables, with specific details on the design of the data gathering instrument. Literature references identify gaps in administering investment incentives, employing a deductive inferential statistical approach to generalize results to the broader population (Soiferman, 2010; Hammer, 2017). The computation of complex statistical data analysis procedures was undertaken with the help of SPSS analysis software (McCormick, & Salcedo, 2017).

The importance of trustworthiness in the study's results is emphasized, ensuring reliability and validity (Roberts & Priest, 2006). The objectivity and effectiveness of the research instrument, including target populations, participant numbers, and methods to refine the instrument, are outlined (Hazzi & Maldaon, 2015). Data collection is presented as a critical part of the research process, aligned with correlation analysis to scrutinize the impacts of investment incentives on performance outcomes and the application of questionnaire surveys to collect large data sets for generalisation of results is highlighted. Additionally in this section the sample frame and targeted organisations which provided eligible participants, including the nature of their operations are outlined in detail. The Likert scale used in the research instrument and its suitability for gathering relevant variables related to investment incentives in the solar sector are discussed. To ensure validity and reliability of measurements, the study employed a validated and tested research instrument and followed procedures designed to establish internal consistency through the Cronbach alpha tests and also in order to ensure fair participation, generalisability and replicability of findings, appropriate sampling steps such as random sampling were employed were to ultimately ensure external validity of the study (Sharma, 2017).

The pilot study participants and its importance in pre-testing the research tool to determine the clarity of items and consistency of responses, and to eliminate errors before the main study, are outlined (Hilton, 2017). The preparation of raw data and coding methods used, which involved use of SPSS and Excel analytical software’s, are described. Salient computations involved in the analyses, i.e., correlation analysis and regression analysis to determine, respective coefficients, and tests, Z-scores, p-values, means, standard deviations, and Cronbach's alpha to quantify internal consistency, were thoroughly outlined (Lee, 2016).To concisely recap key points, the findings chapter systematically addresses key research aspects, including research questions, objectives, methods, data collection, and analysis. The study analyses financial, fiscal and non-monetary incentives in Zambia's solar sector, which include government and donor-backed loans, grants, tax exemptions, deferment or reductions. Three research questions and corresponding objectives were developed to assess accessibility, and suitability of these incentives and their impact on private solar sector investments. The research employed a quantitative correlation approach using SPSS analysis tool to establish associations between independent and dependent variables, aiming to attain generalised findings and address gaps in the administration of investment incentives (Hammer, 2017; Soiferman, 2010;).

Trustworthiness of Data

To ensure trustworthiness in the study, several measures were implemented i.e., credibility was realized through strict data gathering and examination to accurately represent participants' perspectives (Tavakol & Dennick, 2011; Shenton, 2004) transferability was secured by contextualizing findings for relevance in similar settings; and dependability was maintained through consistent, replicable research processes alongside thorough documentation of methods and procedures. Confirmability was established by minimizing bias and employing objective, hypothesis-driven statistical methods using SPSS, grounding the findings in empirical evidence (Anney, 2014). Additionally, data preparation involved coding and sampling with SPSS and Excel, applying statistical techniques to ensure robust and reliable results (Lee, 2016). Coding data processes for this study, done through the RAND excel function are shown at annexed I and L.

The trustworthiness of data is essential in credible studies and as such an all-inclusive approach was adopted to avert possible hitches to the attainment of validity of findings that may arise during data handling from the collection stage through to the interpretation of results. In a quantitative correlational study, trustworthiness involves implementing quality control measures, with credibility being a key factor. Credibility denotes assurance of the truthfulness of the research findings, specifically whether the results are accurate and correct as intended. To achieve credibility amidst the processes and procedures of determining associations and effects of financial, fiscal and non-monetary incentives on performance indicators in the solar sector, data coding was employed to ensure anonymity and confidentiality. Consistency in data was maintained by targeting the appropriate research population within the solar energy sector, which included workers and stakeholders such as implementers, financiers, policymakers, regulators, and individuals involved in the purchase and supply chain of solar products. The physical distribution and collection of questionnaires facilitated the involvement of eligible participants and most importantly improved the response rate (Lavitas et al., 2021). Systematic coding of the data was performed to maintain accuracy by assigning unique identifier numbers to each questionnaire response. Collation of data into systematic format attained with the help of Excel sheet software and was further randomly sampled to select a final research sample through the use of the software's random selection function t ultimately enable precise data analysis (Skinner et al., 2023).

Instrument reliability was achieved by using established measurement instruments, which for this study was the quantitative survey questionnaire, subjected to reliability tests such as Cronbach’s Alpha (Taherdoost, 2016). The research instrument used in this study was adopted from a research study titled. ‘Impact of Strategic Management on Organizational Growth of manufacturing industry in Anambra state (Muogbo, 2013), which was consequently adapted for use on this study. A pilot study was also undertaken to test the legitimacy of the questionnaire and also how dependable it is for the research, ensuring that the questions accurately measured the intended variables (Hazzi & Maldaon, 2015). Q-Q plots were employed to check normality assumptions necessary for correlational analysis, thereby enhancing the credibility of the results (Yang & Berdine, 2021).

Transferability, which denotes the degree to which the study’s results can be effectively employed to other contexts, was ensured through a thorough outline of the methods section. This included identifying the correct sample frame, eligibility of participants, including their roles in solar sector organisations in order to, to allow for possible comparisons with other contexts. This also allowed for methodological transparency (Drisko, 2025). A detailed context description of stakeholders in the solar sector was provided, including definitions of focus variables to be interrogated emanating from financial and fiscal-non financial incentives' constructs as independent variables against the corresponding performance outcomes measures

Dependability was ensured through a study procedure which is logically outlined, observable, and documented, was attained through thorough documentation of data collection methods, sampling procedures, and data analysis (Roy et al., 2025). Finally, confirmability, another important aspect of credible research, was ensured through adherence to objectivity included in procedures and processes of quantitative methods, which prevented researcher bias, allowing the research process and findings to be shaped by the respondents. Hypothesis testing through SPSS statistical methods ensured that the findings were based on empirical evidence Confirmability was further enhanced by identifying and addressing limitations encountered during the study process which included apathy from participants from small and medium enterprises, bureaucratic tendencies in utility-scale organizations, including within donor and government institutions (Wagar, 2014). These challenges slowed the research process and increased costs, but persistence from the research team helped mitigate the situation. By addressing the aforementioned aspects of trustworthiness, this study provides robust and credible insights into private sector solar investment initiatives.

The design of the questionnaire was crucial in ensuring the trustworthiness of the data, particularly in effectively interrogating appropriate variables linked to financial, fiscal and none monetary incentives for private investments in solar (Kyngäs et al., 2020). Consistency and relevancy of results, reflecting the true nature of the measured concept meant that the reliability of the research and also the validity of the study where ably upheld. This was achieved by employing a rigorously designed questionnaire tailored to effectively investigate investment incentive variables in relation to outcome performance variables (Lleo et al., 2021). The trustworthiness of the data for this research was therefore enhanced by meticulously designing research tools to appropriately measure intended metrics, by appropriately operationalisng variables investment variables pertaining to financial fiscal and non-monetary incentives; including dependent variables associated with performance levels, in form of returns on investments, and levels of resulting investments. Research constructs were operationalized through a Likert scale to gauge levels of accessibility and suitability of existing investment incentives, including performance levels in the solar sector. This careful design ensured that the observed correlations accurately reflected the true relationships between these variables. The detected correlations between the predictor and outcome variables signified internal validity, considering that in correlational quantitative research, internal validity represents the degree or level to which the correlation results accurately portray the relationship between the tested variables (Dunbar-Jacob, 2012).

The study, having adopted a quantitative correlational approach, emphasised the crucial aspect of checking for linearity between variables to guarantee that the expectations underlying the numerical tests were met. This was achieved through plotting histograms using SPSS analytical software to check the normality of data. A histogram is a graph which presents the distribution of statistical data, used to visually inspect the normality through the shape of data distribution. In this study, histograms were essential for verifying the normality of variables, ensuring that the assumptions underlying statistical tests were satisfied. By plotting histograms, the study checked for normality in data distribution. Key features, such as the uniformity of bins and the shape on both sides of the graph, were examined to determine the suitability of data for correlation and regression analysis. The range of coverage and central tendency were also assessed to determine the central value of the mode, where clusters of data points occur. This visual presentation allowed the verification of how symmetrical or skewed the data was, consequently informing the appropriateness of correlation and regression analyses in the study. Histograms are bar graphs that represent the frequency distribution of data to assess normality, with data divided into equal interval bins, and the frequency of data points within each bin plotted. For normally distributed data, the histogram exhibits a bell-shaped curve, where most data points cluster around the mean, with frequencies tapering off symmetrically towards the tails. Deviations from this bell-shaped pattern, such as skewness or the presence of multiple peaks, indicate departures from normality (Hudson, 2015). Thus, the normal distribution of data was established through histograms and Quantile-Quantile (Q-Q) plots to ultimately ensure that statistical tests pass the validity criteria, particularly the correlation and regression analyses undertaken in this study (Park et al., 2020).

Q-Q plots provide a more detailed examination of normality by comparing quantiles of the sample data against normal theoretical distributions, plotted on the X and Y axes respectively. Normally distributed data aligns approximately diagonally in a straight line. Deviations from this line suggest departures from normality, such as skewness if points tend to curve away from the line or kurtosis if they tend to cluster at the ends (Loy et al., 2016). While histograms give a broad overview of the data distribution, Q-Q plots provide a more precise check for normality by highlighting where the data diverges from a normal distribution. Together, they helped this study to ascertain the normality assumption to guide appropriate data transformations or statistical methods to apply (Field, 2013).

A notable quantitative correlational analysis action crucial for the validity of statistical tests is the verification of the independence of observations, in which the value of a data point is not influenced by another, thus ensuring unique information about the variables under study in each observation (Osborne & Waters, 2019). To achieve this, the study endeavored to collect data with minimal dependencies, i.e., through simple random sampling (SRS), to give equal participation chances for participants, thereby reducing the likelihood of bias or influence between data points. Ultimately, SRS helped prevent systematic relationships between observations. Additionally, data collection was controlled to ensure that the participants did not influence each other during the data collection process, maintaining independence. Scatterplots were also examined for residual patterns suggesting dependence. Finally, for this study, independence was ensured through rigorous data handling using clear data entry protocols, addressing missing data, and outlier management to prevent unintended correlations. Strict data management procedures and appropriate statistical tests helped this study to verify that data points are independent, thus enhancing the validity of statistical inferences and trustworthiness of research findings (Adeyemi, 2024; Field, 2013).

The study endeavored to establish reliability of the constructs by subjecting them to Cronbach’s alpha tests, which is essential in ensuring internal consistency in a quantitative correlational study. Cronbach's alpha tests were used to determine the level at which a set of variables consistently measure the same core construct. The test is critical in validating questionnaires and scales to ensure that items under a test yield the same results under constant conditions. Cronbach's alpha is calculated by correlating all items on the same scale with every other item, then averaging these correlations. The resulting coefficient ranges from 0, which indicates low or no internal consistency, to 1, indicating the highest level of internal consistency. For this study a Cronbach's alpha reliability test of 0.65 was attained as indicated in the results table on Appendix H. the result was approximately equal to acceptable threshold of 0.70, suggesting that the questionnaire was relatively consistent and items correlated well and required minor or no review on the scale (Hajjar, 2018). This computation for a pilot study was done using SPSS, with results suggesting a considerably favorable alpha coefficient (α) of approximately 0.65 to 0.70 for tests examining effects of financial and fiscal incentives on performance outcomes in the solar sector.

Reliability and Validity of Data

Ensuring the reliability and validity of measurement instruments is essential for the credible operationalisation of research constructs and the generation of dependable quantitative findings. In this study, a structured questionnaire employing a Likert-type scale was used to measure both independent and dependent variables. The scale provided ordered response categories with assumed equal intervals, enabling consistent measurement and the application of a wide range of statistical analyses (Rokeman, 2024).

The Likert scale facilitated the quantification of abstract constructs by translating perceptions of financial incentives and performance outcomes into numerical values. This allowed for systematic measurement of variables such as access to grants, loans, and tax exemptions, as well as indicators of performance including return on investment and service delivery levels. These attributes supported construct validity by ensuring alignment between the theoretical concepts and their empirical measures.

Nevertheless, potential limitations associated with Likert-type scales, such as central tendency bias, respondent response patterns, and assumptions regarding interval-level measurements were carefully considered. To mitigate these risks and enhance measurement reliability, the questionnaire was carefully designed, pre-tested through a pilot study, and accompanied by clear instructions to respondents. These measures were implemented to minimise measurement error and improve consistency and accuracy of responses, thereby strengthening the overall reliability and validity of the study's data (Jebb et al., 2021; Khalid et al., 2012).

Internal Validity

Internal validity is the level to which the findings reflected in a study are attributable to the variables tested without influences form confounding variables, was a critical focus of this research. Key steps included systematically establishing relationships between independent variables, such as financial incentives in the solar sector, and dependent variables like Return on Investment (RoI) and service delivery. Additionally, correlations were explored between fiscal non-financial incentives, such as tax waivers and exemptions, and performance outcomes. These relationships were analysed using the SPSS statistical tool's tests particularly the Pearson correlation coefficient test and linear regression, in order to validate associations between key research variables and to bolster confidence in the study's findings (Kafle, 2019).

To minimize methodological errors and improve internal validity, several measures were implemented. Since the study was not conducted in a controlled setting, the survey questionnaire was carefully refined. This process involved third-party proofreading and pilot testing, which acted as quality control steps to remove unclear or irrelevant questions (Price et al., 2015; Patino & Ferreira, 2018). These efforts ensured that the questionnaire design was precise, thereby strengthening its content and face validity.

Random sampling was employed to guarantee that all eligible participant had equal opportunity to be incorporated into the research. This method ensured that the sample attained was representative to a broader population, thereby ensuring that the study was generalizable to other situations. The questionnaire was meticulously designed to address variables of interest comprehensively, covering the accessibility of financial and fiscal incentives and the investment environment resulting from the advent of various forms of Power Purchase Agreements and also partnerships between public and private institutions in the solar sector industry. Research questions for each individual incentives were deliberately crafted to appropriately interrogate these incentives. Accordingly the inclusion of fiscal and non-monetary incentives, which included duty exemptions, tax waivers, and investment policies, regulations and markets, were included to thoroughly analyze their impact on solar sector investments. This addition strengthened the overall depth and reliability of the research.

The reliability of the research questionnaire for the study was evaluated by Cronbach’s Alpha tests to ensure consistency. Typically, a high Cronbach’s Alpha value, usually above 0.7, signifies that items within a same scale consistently measure the same constructs without any confounding influences. To further enhance validity, previously validated questionnaires were employed including a pilot study to ensure accuracy and relevance of measures. Assumptions tests were done to ascertain suitability of data for correlational analysis, utilizing SPSS diagnostic tools such as scatterplots and histograms. The aforementioned actions are important for attainment of internal validity of the study (Bonett & Wright, 2015; Dunbar-Jacob, 2018).

External Validity

Ensuring external validity was crucial in this study to make the findings applicable to a broader population. To achieve this, the research population was strategically selected to include diverse stakeholders in the solar energy sector i.e., non-governmental financiers, implementers, equipment traders in purchasing and supply, government regulators, and policymakers. By recruiting participants with relevant knowledge and experience in solar sector investments, the study aimed to produce findings that are relevant and applicable to the wider context of solar energy initiatives. To further improve the generalizability of the outcomes, a representative sample was attained through simple random sampling facilitated by Excel sheet software. This method ensured all eligible participants reached had an equal opportunity of selection, thereby enhancing the representativeness of the sample. The involvement of gatekeepers in targeted institutions also helped to enhance verification of appropriate and eligibility participants, further strengthening the validity of the data collected.

Temporal validity was another aspect considered to support external validity. By according a suitable time duration to the study progression and comparatively evaluating the findings with existing research, the study maintained a realistic context of findings before drawing conclusions and suggesting future research directions (Flake et al., 2017). This approach ensured that the study's results were not only relevant at the time of the research but also maintained their applicability over time. Statistically, external validity was supported through the significance of the p-value as inferred from the r-value, indicating that the results were generalizable to the target population. The use of robust statistical techniques in SPSS, along with effective sampling methods and a rigorous study design, further contributed to the attainment of validities in the correlational analyses conducted in this research (Jopling, 2019; Rovai et al., 2013).

Responsiveness and Response rate

The study used online platforms like Google Forms to distribute the questionnaire, recognizing their efficiency in saving time and costs during data collection. However, non-responsiveness to online platforms in the pilot study stage was a limitation; hence in order to avert nonresponse bias, the data collection method was changed to physical or face-to-face distribution and collections of the questionnaires. Despite being time-consuming and costly this approach yielded above acceptable level of response rate as outlined in the research methods chapter and referenced to in the subsequent results section as well, while the case summary presents participant's responsiveness to the research tool questions as outlined in table 21. The follow up dissemination and collection approach in the main study done face to face through institutional gatekeepers, helped to avert non-responsiveness (Brick & Tourangeau, 2017). The careful planning and execution of the study's methodology, along with strategic steps to address validity and reliability concerns, enhanced the study's trustworthiness and credibility (Hossan et al., 2025).

Operationalisation of Variables and Analysis

In quantitative research, operational definitions of variables guides how they are measured or quantified, providing clear criteria to ensure uniformity and replicability in future studies. These definitions translate abstract concepts into measurable constructs, enabling researchers to collect and analyze data systematically (Onen, 2016). In this study on financial incentives for solar energy investments, "financial incentives" were operationally defined as the amount of grants, loans, and tax credits received by solar companies. Similarly, fiscal non-financial incentives in the context of solar sector investments were defined as government-provided benefits that do not involve direct cash transactions but offer financial relief or advantages, such as tax exemptions, import duty waivers for solar equipment, corporate tax holidays, and accelerated depreciation schemes allowing faster deductions of solar investment costs to lower taxable incomes in the short term. These fiscal incentives reduce operational costs and enhance the financial viability of solar investment projects (Mthembu, 2018; Qadir, 2021). Operationalisation of constructs is an important step in quantitative research because it ensures that abstract descriptive concepts are transformed into quantifiable variables, making sure that that all variables are interpreted and measured consistently. This process improves the reliability of the study which directly relates **to** the extent to which measurements are consistently done and are replicable under comparable setting. It also ensures validity of findings, which directly relates to how accurately the measurements cover intended constructs. Accurate operational descriptions avert uncertainties and errors in the measurements, thereby also improving confidence that observed relationships between variables reflect true associations and not artifacts of bad designs. Appropriate operationalisation therefore strengthens internal validity through alignment of measurements with theoretical constructs to ultimately solidify meaningful analysis and credible research results (Bhandari, 2022)

Results

The presentation of the research results is systematically orgainised to align with specific research questions and corresponding hypotheses of the study, while focusing on the associations between investment incentives and performance outcomes in Zambia's private sector investments in solar energy. This section is structured with initial presentation of descriptive statistics, followed by inferential statistical analyses, and ending with evaluation of research results in relation to the study objectives. Descriptive statistics provide a clear outline of patterns for demography and data distribution.

In this section collected data is numerically summarise in a logical and meaningful way, clearly establish central tendencies such as means, medians, and modes, as well as the variability of variables of interest in form of financial, fiscal and non-monetary incentive variables. Summaries are tabulated to easily depict demographic distribution and response frequencies from study participants. Demographic analyses is important as it provides basis for effective interpretation of results (Ray & Fellow, 2020).

In Addition to descriptive statistics, the section delves into inferential statistical analyses to test the hypotheses and establish correlations between the independent variables (financial and fiscal and non-monetary incentives) and the dependent variables in form of private sector investment rates (PSIR) as well as return on investments (ROI). The Pearson correlation and regression analyses results, were performed using SPSS, to validate the relationships between these variables. Finally hypotheses tests relating to the findings are presented to clearly outline statistical significance of the tests. This structured approach to presenting the results ensures a comprehensive and systematic dissemination of the study’s findings, providing valuable insights for policymakers and actors in the solar sector to undertake informed investment decisions.

Case processing summaries are crucial in quantitative research as they provide a detailed account of data integrity and participants' responsiveness to survey questionnaires. Table 22 presents the case processing summary for this study, which outlines the results on valid, missing, and total cases, both in number and percentage form. Remarkably, the tabulation indicates no missing cases, achieving 100% validity and participation in responding to the questionnaire. This complete responsiveness from participants signifies robust engagement with the research questions, particularly concerning variables relating to investment incentives in the solar energy sector and their impact on solar sector investments in Zambia. The absence of missing data ensures that the findings are based on a comprehensive dataset, enhancing the validity and reliability of the study's conclusions. By documenting full participation, the case processing summary underscores the effectiveness of the data collection process and the reliability of the insights drawn from the analysis, thereby providing a solid foundation for understanding the dynamics of investment incentives and their influence on the solar energy sector in Zambia.

In a nutshell, the findings segment represents a structured and comprehensive presentation of the study's results, ensuring clarity and coherence in outlining key research points by incorporating both descriptive and inferential statistics, to offer a balanced touch to data explanation. Through descriptive **s**tatistic**s** data is summarised using means, frequencies, standard deviations, or percentages. These provide a clear overview of tendencies and distributions in collected data thereby aiding in attaining fundamental understanding of date before evaluations and conclusions are made. Additionally Inferential statistics, not only do they help to summarise but also introduce analysis methods such as regression analysis, hypothesis testing, and correlation assessments to identify patterns in associations of variables. Ultimately the outcome is that generalisability of findings to a larger population is attained thereby improving the **s**tudy’s legitimacy and dependability**.**

Table 22

Case Processing Summary for Participants' Responsiveness

Responsiveness Per Question	Cases					
	Valid		Missing		Total	
	N =244	Percent =100	N	%	N	Percent
1		100.0%	0	0.0%	244	100.0%
2		100.0%	0	0.0%	244	100.0%
3		100.0%	0	0.0%	244	100.0%
4		100.0%	0	0.0%	244	100.0%
5		100.0%	0	0.0%	244	100.0%
6		100.0%	0	0.0%	244	100.0%
7		100.0%	0	0.0%	244	100.0%
8		100.0%	0	0.0%	244	100.0%

Note. Table presents the case processing summaries for participants' responsiveness, indicating 100% responsiveness to questionnaire questions. *Source*: IBM SPSS 21 Statistical outputs.

The frequency presentation in table 23 presents the demographic statistical frequencies of gender, age group, educational background, and work experience of respondents. These frequencies are provided for all participants in the research sample, allowing for a logical presentation of subsequent results. Descriptive data tabulation helps in structuring the study analysis in a clear and orderly manner. The case processing summary for demographics is presented in terms of both numbers and percentages, highlighting gender, education level, work experience, and age group. The table shows that 73.8% of the research sample were male, while 26.2% were female.

Table 23

Demographic Statistical Frequencies

		Frequency	%	Valid %	Cumulative %
Gender	Male	180	73.8	73.8	73.8
	Female	64	26.2	26.2	100.0
	Total	244	100.0	100.0	
Age Group	22 to 30	43	17.6	17.6	17.6
	31 to 40 years	159	65.2	65.2	82.8
	41 to 50 years	35	14.3	14.3	97.1
	51 to 60 years	7	2.9	2.9	100.0
	Total	244	100.0	100.0	
Highest level of Education	Trade Certificate	12	4.9	4.9	4.9
	College Diploma	95	38.9	38.9	43.9
	Bachelor's Degree	104	42.6	42.6	86.5
	Master's Degree	29	11.9	11.9	98.4
	PhD	4	1.6	1.6	100.0
	Total	244	100.0	100.0	
Work experience in RE.Org	1 to 2 years	33	13.5	13.5	13.5
	3 to4 years	95	38.9	38.9	52.5
	5 to 6 years	74	30.3	30.3	82.8
	Above 6 years	42	17.2	17.2	100.0
	Total	244	100.0	100.0	

Note. Demographics and affiliation with Renewable Energy Organisations. *Source:* SPSS Statistical outputs.

The response rate for the study hereby referenced to, is thoroughly described in the methodology chapter, where the study recorded 84% response rate from 315 completed responses obtained from 375 participants accessed across 75 solar-sector institutions. This response level exceeds accepted thresholds and supports the reliability and representativeness of the data. From the valid responses, 244 participants were selected using Simple Random Sampling (Excel RAND function) in line with the pre-determined sample size for subsequent analyses. Tabulation of sample selection is outline at annex J to this document.

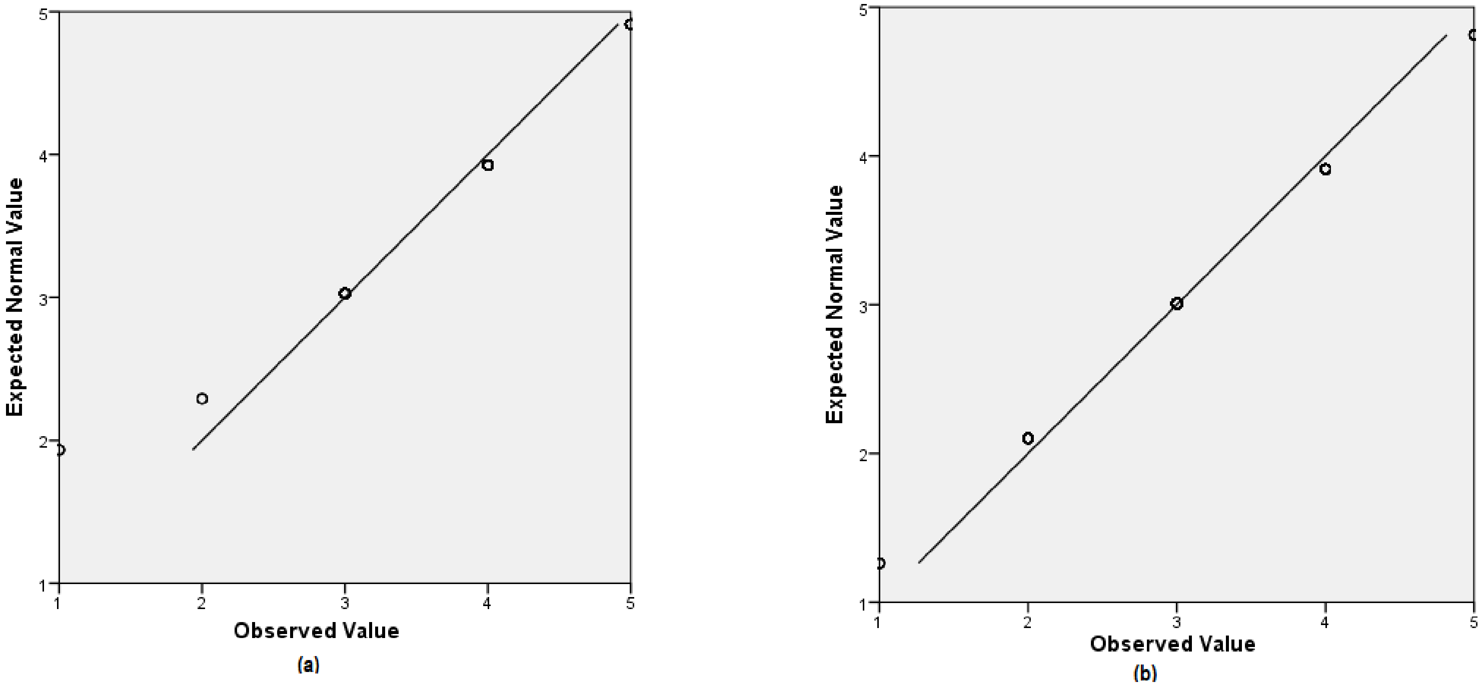
To assess the distributional characteristics of obtained data, Quantile-Quantile (Q-Q plots) were employed. These plots compare the quantiles of the sample data against those of a theoretical normal distribution, allowing a visual assessment of whether the data adhere to normal distributions. Points lying approximately along the diagonal reference line at forty five degrees angle indicate that the data closely follow the anticipated distribution, while deviations reveal skewness, heavy tails, or outliers. Evaluating normality using these plots is essential because numerous parametric statistical tests assume normally distributed data and where there are any significant departures data transformation may be necessitated or the use of non-parametric approaches applied. Therefore the use of these plots ensures transparent reporting and reinforces the credibility and reliability of the subsequent results analyses (Shatz, 2024).

For this study therefore, the plots provided a clear, rigorous, and visual method for assessing the normality of continuous data, a key assumption for most of the advanced statistical techniques such as Pearson correlation, regression modelling, and ANOVA applied in this study. Unlike numerical tests alone, Q-Q plots allow the researcher to directly assess how closely the empirical data align with a theoretical normal distribution across the entire range of values, revealing delicate aspects such as skewness, kurtosis, or tail abnormalities that statistical tests may overlook. The visually diagnosis of distributional behaviour makes them cardinal in formal normality tests. (Andersen & Dennison, 2018).

Q-Q plots were generated for all continuous variables to assess the normality of their distributions. The Q-Q plot for the financial incentives access level (FIAL), private sector investment rates, (PSIR), Suitability of fiscal incentive (SFI), Effect of fiscal incentives on investments(EFI), initial cost of investment incentives (ICSI) and affordability of solar services (ASS) and protection and promotion of Power Purchase agreement (PPAs), Bankability of Power purchase agreement (B-IPPAs), return on Investment (ROI) and location, value and type of investment based incentives (LVTI) incentives variable are shown in figures 11 to 14. The finding were that all the data points aligned closely with the theoretical normality lines, indicating an approximately normal distribution. Minor deviations were noted in the upper or lower tail, suggesting slight positive skewness; however, they were not substantial enough to indicate a violation of normality. Q-Q plots confirmed that normality assumptions were sufficiently met, to use parametric techniques in analysis, i.e., Pearson correlation and linear regression.

Figure 11

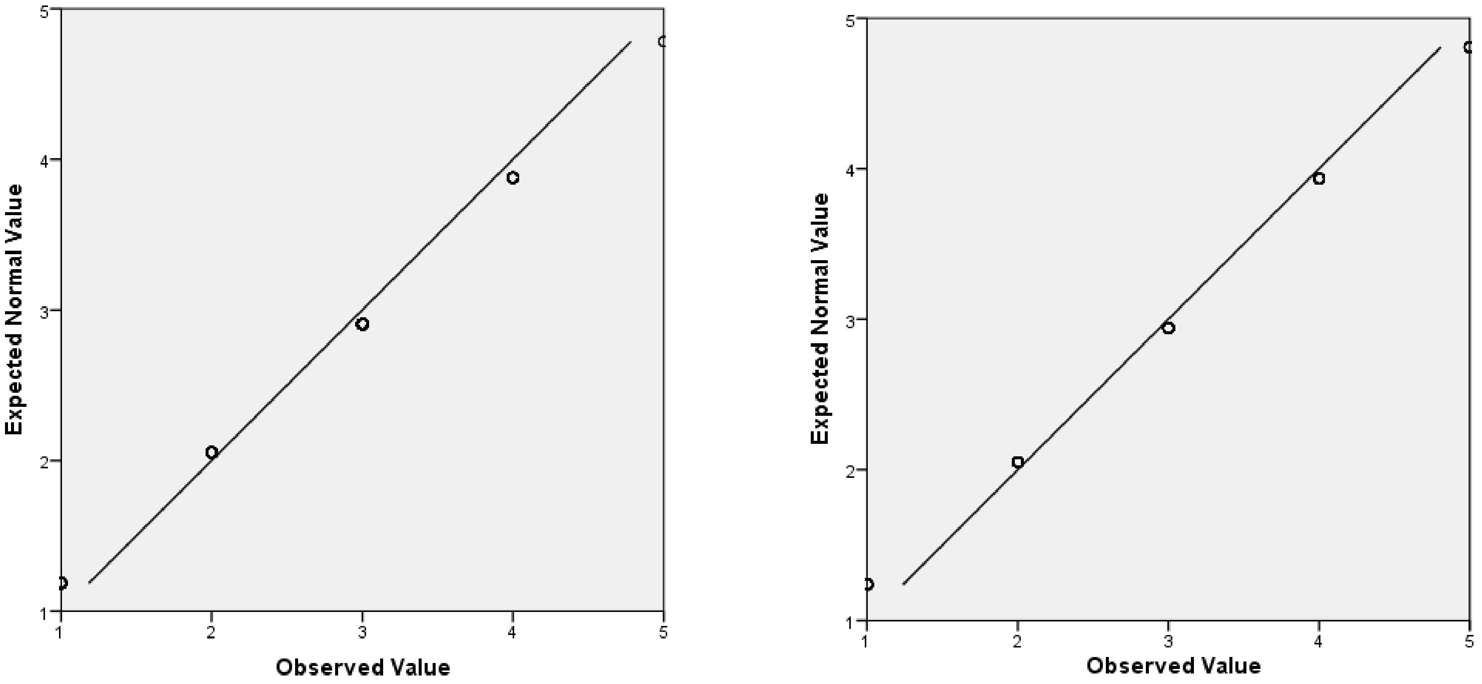
Normal Q-Q Plot for FIAL and PSIR



Note. The Q-Q plots for both FIAL and PSIR aligned closely with the theoretical normal distribution line. *Source*: IBM SPSS outputs

Figure 12

Normal Q-Q Plot for SFI and EFI (fiscal Incentives)

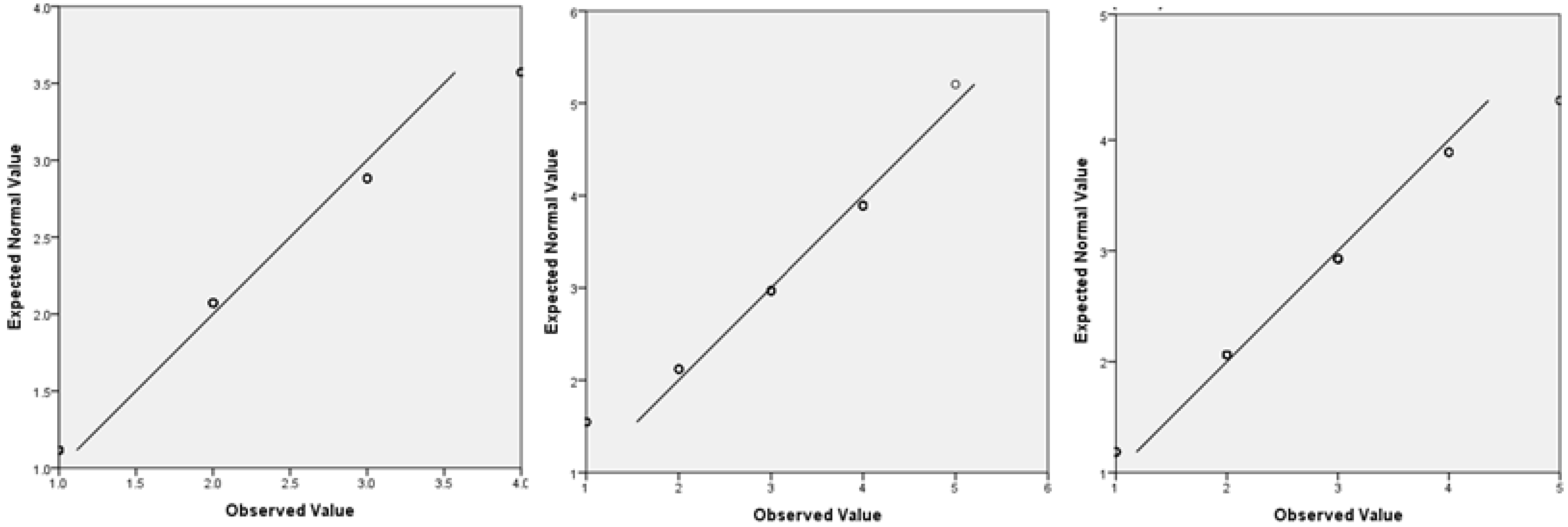


(a) (b)

Note. The Q-Q plots for both SFI and EFI (fiscal incentives) aligned closely with the theoretical normal distribution line. *Source*: IBM SPSS outputs

Figure 13

Normal Q-Q Plot for ICSI, ASS and APPAs respectively

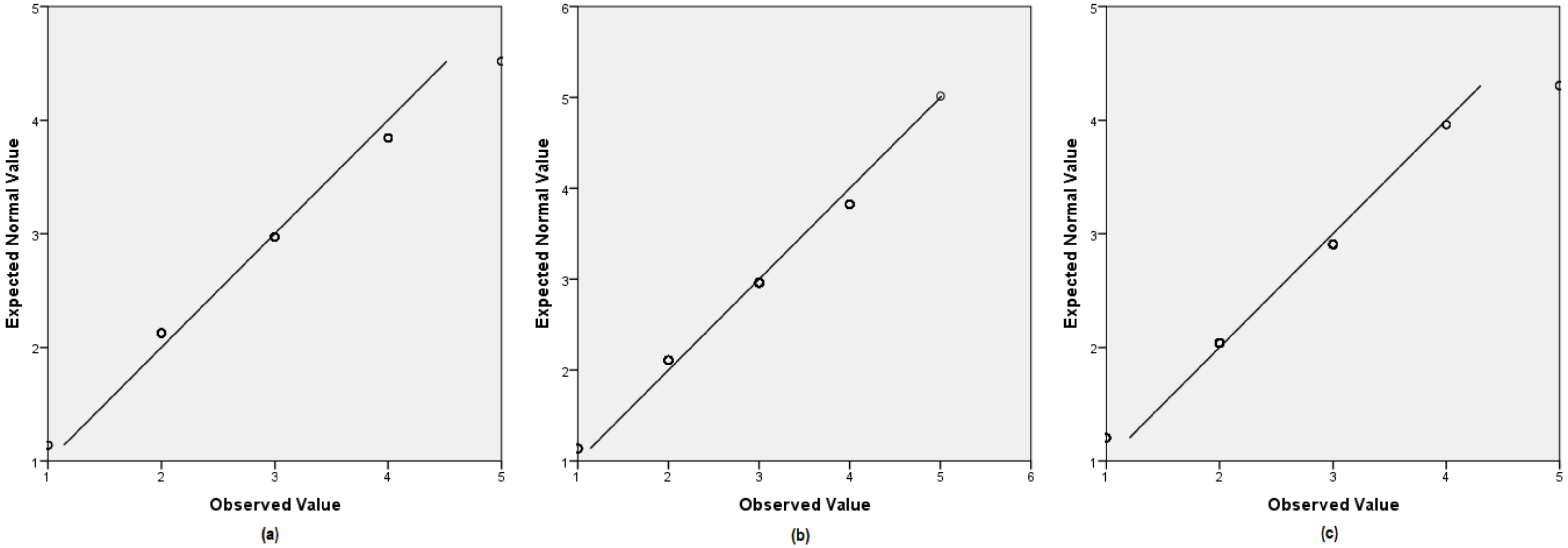


(a) (b) (c)

Note. The Q-Q plots for initial cost of Solar investments – ICSI, Affordability of solar Services - ASS and investment power purchase agreements- IPPAs respectively; indicating close alignment with the normal distribution line. *Source:* IBM SPSS outputs

Figure 14

Normal Q-Q Plot for B- IPPAs, ROI and LVTI Respectively



Note. The Q-Q plots B- IPPAs (a) and ROI (b) and LVTI (c) respectively aligned closely with the theoretical normal distribution line. Source: IBM SPSS output

The results in this section are presented in direct alignment with the study's research questions and hypotheses, following a clear and systematic structure. The primary aim of the study was to examine the relationships between various investment incentives i.e., financial, fiscal, and non-monetary and solar sector investment performance outcomes. The independent variables include financial measures such as the initial cost of solar investments (ICSI), financial incentive access levels (FIAL), and the affordability of solar services (ASS). Fiscal incentives focus on tax-related measures, including the suitability of fiscal incentives (SFI) and their effects on investment performance. Non-monetary incentives examined include value-location-type-based incentives (LVTI), improvements in the investment environment for independent power producers over the past five years (IEnv-IPPs-5Y), the bankability of power purchase agreements (B-PPAs-IPPs), and the effects of promotion and protection measures for IPPs (IPPAs). The outcome variables assessed in relation to these incentives are Private Sector Investment Rates in the solar sector (PSIR) and Return on Investment (ROI).

Table 24 presents descriptives statistics of the participants 'responses to questions in the survey questionnaire relating to the listed incentives of interest. The presentation of Key descriptive statistics in a clear format helps to provide a concise and informative overview of data being analysed (Mishra, 2019). In the subsequent sections results are presented in line with formulated hypotheses for each of the identified incentive groups, namely financial fiscal and non-monetary.

Table 24

Descriptive Statistics on Study Variables

N =244	Minimum = 1.00		Maximum	Mean	Std. Deviation
		PSIR	5.00	3.11	.870
		ICSI	4.00	1.99	1.99
		ROI	5.00	2.7172	.82024
		SFI	5.00	2.37	.927
		EFI	5.00	2.70	.992
		ASS	5.00	3.09	3.09
		FIAL	5.00	3.92	3.92
		B-PPAs-IPPs	5.00	2.7951	.69612
		LVTI	5.00	2.38	.779
		IEnv-IPPs-5Y	5.00	2.5656	.78029
		IPPAs	5.00	2.4713	.76120
		Valid N (listwise)			

Note. The table presents descriptive statistics for responses to questions related to fiscal, financial, and non-monetary variables. *Source:* IBM SPSS outputs

Financial Incentives and Return on Investments: Hypothesis 1

In line with Research Question 1 and its corresponding null hypothesis, this study examines the effect of financial incentives (the independent variable) on performance outcomes, measured in terms of return on investment (ROI) from solar sector investments (the dependent variable). The null hypothesis (H01) states that financial incentives have no statistically significant effect on performance outcomes in private solar sector investments in Zambia.

Within the financial incentives category, correlation analyses were conducted to examine the relationships among financial incentives access levels (FIAL), private sector investment rates (PSIR), and return on investment (ROI). As shown in Table 25, the correlation between FIAL and ROI was weak and statistically non-significant, while the relationship between PSIR and ROI similarly exhibited a weak, non-significant positive association. These findings indicate that neither financial incentives nor policy-related investment support approaches demonstrate a meaningful linear relationship with ROI in Zambia’s solar energy sector. Overall, the findings reveal that the current structure and delivery of financial and policy support incentives exert minimal observable influence on investment returns, underscoring the need for strengthened, more effectively targeted incentive mechanisms to enhance ROI.

Table 25

Correlation of Financial Incentives Variables with ROI

Variables	**ROI**	
FIAL	*r* = .047	*p* = .067
PSIR	*r* = .462	*p* = .297

Note. R-correlation coefficient; p-significance level (2-tailed). N = 244, FIAL = Financial incentives Access Levels; PSIR = Private sector investments rates; ROI = Return on Investments. *Source*: IBM SPSS outputs

Multiple regression analysis was further conducted to further assess the predictive effect of Financial Incentives Access Levels (FIAL) and Private Sector Investment Rates (PSIR) on return on investment (ROI). The results are presented in tables 26, 27, and 28, corresponding to the model Summary, analysis of variance, and multiple regression analysis tests. The model summary indicated that the independent variables explained an extremely small proportion of variance in ROI, with R squared = .005, meaning that only 0.5% of the variation in investment returns is accounted for by financial incentives and private-sector investment activity. The Analysis of Variance (ANOVA) results showed that the overall regression model was not statistically significant, demonstrating that the combination of FIAL and PSIR did not significantly predict ROI. The regression coefficients also confirmed non-significant effects for both predictors, indicating that neither financial incentives nor policy support for financing mechanisms exerted a meaningful influence on investment returns in Zambia's solar energy sector.

Table 26

Model Summary Analysis of Variance for Financial Incentives

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.074	.005	-.003	.82141

Note. Predictive effect of financial incentives on return on investment (ROI); R Square = proportion of variance explained; Adjusted R Square = model complexity. *Source*: IBM SPSS outputs

Table 27

Analysis of Variance of Financial Incentives in ROI

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.883	2	.442	.655	.521[a]
	Residual	162.604	241	.675		
	Total	163.488	243			

Note. Non-significant model; a = non-significant at $p < 0.05$. FIAL = Financial incentives; PSIR = Private sector investment Rates. *Source*: IBM SPSS outputs

Table 28

Regression of Financial Incentives in Relation To ROI

Model		**Unst. Coeff**		**Std. Coeff**		
		B	**Std. Error**	**Beta**	**t**	**Sig.**
1	Constant	2.436	.267		9.139	.000^a
	FIAL	.028	.060	.031	.468	.640
	PSIR	.055	.063	.059	.876	.382

Note. Statistically non-significant results for FIAL and PSIR. B = unstandardized coefficient; Beta = standardized coefficient; t = t-test statistic; p = significance (2-tailed). *Source* IMS SPSS Outputs

Further analyses were conducted to examine the individual contribution of each independent variable, namely Financial Incentives Access Levels (FIAL) and Private Sector Investment Rates (PSIR) to return on investment (ROI) as an outcome variable. For the FIAL variable (H01), the regression results showed non-significant effect on ROI (B = .028, t = .468, p = .640). Based on this outcome, the test failed to reject the null hypothesis (H01) hence correspondingly, the alternative hypothesis was not supported. This entails that accessibility to financial incentives do not meaningfully predict returns on solar investments in Zambia. Similarly, the analysis for PSIR, (H02) also revealed non-significant effect on ROI (B = .055, t = -.876, p = .382). Suggesting non-significant effect on the outcome variable.

Overall hypothesis decisions were guided by the obtained *p*-values and the overall predictive performance of the model, as summarised in table 29. Both financial incentive variables

(FIAL and PSIR) produced p-values above the 0.05 significance threshold, indicating that any observed differences in ROI were likely due to chance. Consequently, none of the variables demonstrated a statistically meaningful influence on investment returns, and all corresponding null hypotheses were retained (Andrade, 2019).

Table 29

Regression of Financial Incentives with Return on Investment

Factor	*B*	*t*	*p*	Hypothesis (H01)	Decision
FIAL	.028	.468	.640	(H01-i)	Failure to reject
PSIR	.055	.876	.382	(H01-ii)	Failure to reject

Note. Hypothesis tests H01, and H02 for FIAL and PSIR relating to ROI. Both were non-significant (*p* > .05).*Source*: IMB SPSS Outputs

Fiscal Incentives and Private Investments: Hypothesis 2

In relation to Research Question 2, which examines the association between fiscal incentives and private sector investment rates in Zambia's solar sector, this study assessed the suitability and influence of fiscal incentives as the independent variables and private sector investment performance as the dependent variable. Accordingly, the null hypothesis (H_{02}) posits that fiscal incentives do not have a statistically significant effect on the performance of private solar sector investments in Zambia. To test this hypothesis, correlation analyses were conducted to examine the relationships between the suitability of fiscal incentives (SFI) and the effects of fiscal incentives (EFI) as independent variables and private sector investment rates in the solar sector as the outcome variable. The fiscal incentives evaluated included tax-based incentives, subsidies, duty reliefs, customs incentives, and capital support measures.

The correlation analysis showed a statistically significant yet weak positive relationship between fiscal incentive and private-sector solar investment performance, $r(242) = .169$, $p = .008$. This indicates that fiscal measures such as tax reductions, subsidies, customs duty relief, and capital support are modestly associated with improved investment outcomes in Zambia's solar energy sector.Conversely, economic financing incentives (EFI) demonstrated a weak and statistically non-significant relationship with investment performance, $r(242) = .120$, $p = .062$, indicating limited direct impact under existing conditions. The results are summarized in Table 30.

Table 30

Correlation between Fiscal Incentives and Outcome Variable (PSIR)

Predictors	PSIR	
SFI	$r = .169^{**}$	$p = .008$
EFI	$r = .120$	$p = .062$

Note. Predictors: SFI = Suitability of Fiscal Incentives; EFI = Effect of fiscal incentives; p = significance (2-tailed); N = 244). SFI is statistically significant ($p < .05$); EFI is statistically non-significant ($p > .05$). *Source:* IBM SPSS Outputs

In addition to the correlation analysis, regression tests were conducted for fiscal incentives to evaluate the predictive influence of fiscal incentives on private-sector solar investment performance. The analysis focused on two key variables: the Suitability of Fiscal Incentives (SFI) and the Effects of Fiscal Incentives (EFI), both assessed in relation to private sector investment rates in the solar energy sector. The outcomes of this regression analysis are presented in tables 31, 32, and 33, which detail the model summary, the analysis of variance, and the multiple regression for the fiscal incentive variables, respectively.

Table 31

Model Summary of Fiscal Incentives' Effect on PSIR

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.174	.030	.022	.860

Note. Predictors: EFI = Effect of fiscal incentive on solar investments in Zambia; SFI = Suitability of fiscal incentive for private sector investments; PSIR= Private sector investment rates. *Source* IMB SPSS outputs

Table 32

Analysis of Variance Suitability and Effects of Fiscal Incentives Vs PSIR

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	5.577	2	2,789	3.766	.025[a]
Residual	178.435	241	.740		
Total	184.012	243			

Note. a = significant effect, Predictors: Private sector solar investments rating in Zambia, EFI = Effect of Fiscal incentives, SFI = Suitability of fiscal incentive for private sector investments. *Source:* IBM SPSS outputs

Table 33

Regression for Suitability and Effects of Fiscal Incentives Vs PSIR

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	Std. Error	Beta		
1	(Constant)	2.671	.178		14.996	.000
	SFI	.136	.068	.145	1.995	.047
	EFI	.044	.064	.050	.687	.493

Note. Dependent Variable: Private sector solar investments rating in Zambia; SFI = Suitability of fiscal incentive for private sector investments; EFI = Effect of Fiscal incentives;: Source: IBM SPSS Outputs

The analysis revealed different relationships between the independent and outcome variables. While the suitability of fiscal incentives showed a statistically significant but weak association with private-sector investment rates, the effects of fiscal incentives variable demonstrated a non-significant relationship with the same outcome. Nonetheless, the overall regression model for the fiscal incentive variables significantly predicted private-sector solar investment rates in Zambia, $F(1, 242) = 3.766$, $p = .025$. This indicates that, although the predictive effect is modest, fiscal incentives collectively have a statistically significant influence on private-sector solar investment performance, explaining approximately 3% of the variance in the outcome variable.

Hypothesis tests conducted to assess the individual effects of fiscal incentive variables, are presented in table 34**.** The hypothesis decisions were based on results for fiscal incentives variables which showed varied significances and negative association with the outcome variable, leading to effective rejection of the null hypothesis H02 (i) Indicating sufficient statistical evidence to support the alternative hypothesis, and confirming that the observed results were not due to random variation. In contrast, hypothesis testing for EFI variable demonstrated a non-significant and weak association with PSIR resulting in a failure to reject the null hypothesis H02 (ii) or correspondingly providing insufficient support for the alternative hypothesis. Summary of the aforementioned hypothesis test decisions are outlined in table 34. Collectively, these findings point to an overall significant influence on private sector investment rates.

Table 34

Hypothesis tests for Fiscal Incentives with Private Sector Investment Rates

Factor	B	t	p	Hypothesis (Ha 1)	Decision
SFI	.136	1.995	.008	(H02-i)	Rejected
EFI	.044	.687	.062	(H02-ii)	Failure to Reject

Note. Hypothesis tests H02 (i), and H02 (ii) for SFI and EFI relating to PSIR. *Source:* IMB SPSS Outputs

Non-Monetary Incentives and Investment Rates: Hypothesis 3

The third research hypothesis aligns with the third research question, which investigates the relationship between non-monetary incentives and two key performance outcomes in Zambia's solar energy sector: private-sector investment rates (PSIR) and return on investment (ROI). The analysis is therefore organised into two categories. The first category evaluates the influence of Initial Cost for Solar Investments (ICSI), Affordability of Solar Services (ASS), and Location–Value-Type-based Incentives (LVTI) on Private-Sector Investment Rates (PSIR).

The second category examines improvements in the investment environment for Independent Power Producers over the last five years (IEnv-IPPs-5Y), the bankability of Power Purchase Agreements for IPPs (B-PPAs-IPPs), and the effects of Investment Promotion and Protection Agreements (IPPAs) in relation to return on investment (ROI). In line with the guiding research question, the corresponding null hypothesis (H03) states that non-monetary incentives have no statistically significant effect on private-sector solar investments in Zambia. Accordingly, the analysis assessed whether changes in the investment environment, contractual bankability, and investment protection mechanisms influence investment performance outcomes in the solar energy sector. For tests relating to Initial Cost for Solar Investments (ICSI), Affordability of Solar Services (ASS), and Location-Value-Type based Incentives (LVTI), the results, summarised in table 35, indicate that both ICSI and ASS exhibited positive but weak correlations with PSIR, and these associations were statistically significant. In contrast, the correlation between LVTI and PSIR was weak and statistically non-significant, indicating that location, value, and type based incentives do not demonstrate a meaningful relationship with private-sector investment rates in Zambia's solar energy sector.

In addition to the correlation analyses undertake prior, linear regression tests were conducted to determine both the direction of the relationships and the predictive power of the predictor variables on the criterion variable. Specifically, regressions for Initial Cost for Solar Investments (ICSI), Affordability of Solar Services (ASS), and Location-Value-Type based Incentives (LVTI) were performed with Private-Sector Investment Rates in the solar energy sector as the outcome variable. The corresponding results are presented in tables 36, 37, and 38, which show the model summary, analysis of variance (ANOVA), and regression coefficients, respectively. The findings show that the independent variables significantly predicted private-sector solar investment rates in Zambia, $F(3, 240) = 7.653$, $p < .001$. This indicates that the three factors under examination exert a statistically significant effect on private-sector investment in solar energy in Zambia, although they account for only 8.7% of the variance in the outcome variable.

Table 35

Correlation of Non-Monetary Incentives with Private Sector Investment Rates

PREDICTORS	PSIR	
ICSI	$r = .166^{*}$	$p = .009$
ASS	$r = .204^{**}$	$p = .001$
LVTI	$r = .060$	$p = .354$

Note. ICSI = Initial Cost for Solar Investments; ASS = Affordability of Solar Services; LVTI = Location, Value and Type based Incentives; r = correlation coefficient; *p* = significance. *p* < .05*; *p* < .01**. *Source*: IBM-SPSS Outputs

Table 36

Model Summary for Non-Monetary Incentives and PSIR

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.295	.087	.076	.837

Note. Predictors: LVTI = Location, Value, and Type based incentives; ICSI = Initial cost of solar investments; ASS = Affordability for Solar Services. Criterion: PSIR= Private Sector Investment rates. *Source*: IBM-SPSS Outputs.

Table 37

Analysis of Variance -Non-Monetary Incentives with PSIR

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	16.067	3	5.356	7.653	.000
Residual	167.946	240	.700		
Total	184.012	243			

Note. Predictors: LVTI = Location-Value-Type based Incentives; ICSI =Initial Cost of Solar Investments; ASS = Affordability of Solar Services. *Source*: IBM SPSS Outputs

Table 38

Regression for Non-Monetary Incentives Model with PSIR

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.719	.315		5.457	.000
	ICIS	.219	.064	.217	3.444	.001
	ASS	.274	.073	.239	47	.000
	LVTI	.046	.070	.041	.656	.513

Note. Predictors ICIS = initial cost of solar investments; ASS = Affordability of Solar Services; LVTI To evaluate the=‘location-Value-Type’ investments. *Source*: IBM SPSS Outputs

Individual effects of each predictor variable on private-sector solar investment rates, regression coefficient tests were conducted in which predictor variables examined were Initial Cost for Solar Investment (ICSI), Affordability of Solar Services (ASS), and Location, Value, and Type-Based Incentives (LVTI). The results provide insight into the extent to which each factor influences the outcome variable.

The findings for ICSI showed a significant positive effect on private-sector solar investment rates (*B* = .219, *t* = 3.444, *p* < .001). This result reject the null hypothesis HO3 (a-i) indicating sufficient statistical evidence to conclude that a significant relationship, difference, or effect exists in line with the proposed alternative hypothesis and suggesting that initial investment costs have a significant influence private-sector investment rates in solar energy.

Similarly, ASS exhibited a significant positive effect on private-sector investment rates (*B* = .274, *t* = 4.700, *p* = .001), effectively rejecting the null hypothesis H03 (a-ii) hence supporting the proposed alternative hypothesis and confirming that affordability of solar services positively affects private-sector investment levels. In contrast, LVTI demonstrated a non-significant effect on private-sector solar investment rates (*B* = .046, *t* = .656, *p* = .513). This result failed to reject the respective null hypothesis H03 (a-iii), indicating insufficient statistical evidence to support the proposed alternative hypothesis, and confirming that the observed results may be due to random variation. Ultimate this results suggested that LVTI does not exert a substantial influence on private-sector investment rates in Zambia.

Overall, the coefficient tests established that ICSI and ASS individually have significant positive effects on private-sector solar investment rates, while LVTI does not. These findings, presented in table 39 offer important insights into the role of non-monetary incentives in fostering private-sector investment in Zambia’s solar sector.

Table 39

Regression Results for Non-Monetary Incentives with PSIR

Factors	B	t	p - value	Hypotheses: Ha3(a)	Decision
ICSI	.219	3.444	.000*	H03 (a-i)	Rejected
ASS	.274	47	.001	H03 (a-ii)	Rejected
LVTI	.046	.656	.513	H03 (a-iii)	Failure to Reject

Note. Predictors: ICSI = Initial Cost of Solar Investments; ASS = Affordability of Solar Services; LVTI = Location, Value and Type based incentives. Criterion: PSIR = Private Sector Investment Rates. *Source*: IBM SPSS Outputs

Applying the same analytical approach, correlation tests were conducted for a second category of non-monetary incentives to examine the degree of relationships between selected variables, namely Bankability of Power Purchase Agreements for Independent Power Producers (B-PPAs-IPPs), Investment Promotion and Protection Agreements for Independent Power Producers (IPPAs), and Investment Environment for IPPs in last Five Years (IEnv-IPPs-5Y) with Return on Investment (ROI) as the criterion variable.

The correlation analysis results between the bankability of Power Purchase Agreements for Independent Power Producers (B-PPAs-IPPs) and return on investment (ROI) revealed a weak, positive, and statistically non-significant association, *r*(242) = .078, *p* = .223. Accordingly, the null hypothesis H03 (b-i) was not rejected, indicating insufficient statistical evidence to support the alternative hypothesis. This outcome suggests that the observed association may be attributable to random variation rather than a systematic effect. In practical terms, the results indicate that improvements in the bankability of power purchase agreements do not demonstrate a statistically significant influence on returns from private-sector solar energy investments.

Further correlation analyses were conducted to examine the relationship between Investment Promotion and Protection Agreements for Independent Power Producers (IPPAs) and ROI. The results indicated a statistically significant positive correlation, $r(242) = .175$, $p = .006$. Consequently, the null hypothesis H03 (b-ii) was rejected, providing sufficient statistical evidence to support the existence of a significant association between the variables, as suggested by the alternative hypothesis. These findings suggest that IPPAs exert a statistically significant influence on returns from investments in the solar energy sector.

Additionally, the relationship between improvements in the investment environment for IPPs over the last five years (IEnv-IPPs-5Y) and ROI was examined. The analysis revealed a statistically significant but weak positive correlation, $r(242) = .212$, $p = .001$. As a result, the null hypothesis H03 (b-iii) was rejected, indicating the presence of a statistically significant relationship. However, the level of the association suggests that, despite statistical significance, the practical effect on investment returns remains limited.

The general overview presented in table 40, for the correlation results for the second category of non-monetary incentives reveal varied outcomes. While Investment Promotion and Protection Agreements for independent power producers (IPPAs) and Investment Environment for IPPs in the Last Five Years (IEnv-IPPs-5Y) exhibited significant positive correlations with Return on Investment (ROI)**,** their effects were relatively weak, suggesting limited practical influence despite statistical significance. Conversely, the Bankability of Power Purchase Agreements for independent power producers showed no significant relationship with ROI, implying that

B-PPAs-IPPs individually may not substantially drive investment returns. The findings highlight the fact that collective impact of the above listed non-monetary incentives variables on financial performance in Zambia's solar energy sector remains modest.

Table 40

Correlation between Non-Monetary Incentive and Return on Investments (ROI)

Predictor Variables	**Criterion Variable - ROI**	
	r	*p*
B-PPAs-IPPs	.078	.223
IPPAs	$.175^{**}$	.006
IEnv- IPP_S -5Y	$.212^{**}$	.001

Note. r = Pearson correlation coefficient; *p* = significance (2-tailed). N = 244. *p < .05****; p** < .01***; Predictors =B-PPAs-IPPs; IPPAs; IEnv-PP_S-5Y. *Source*: IBM SPSS Outputs

In addition to the correlation analyses, a multiple linear regression was conducted to examine the predictive relationship between non-monetary incentives and return on investment (ROI) in Zambia's solar energy sector. The results are outlined in tables 41, 42, and 43, in form of model summary, analysis of variance (ANOVA), and regression coefficients, respectively.

The regression model was statistically significant, indicating that the combined influence of the independent variables, namely Bankability of Power Purchase Agreements (B-PPAs-IPPs), Investment Promotion and Protection Agreements for independent power producers (IPPAs), and Investment Environment for IPPs over the last five years (IEnv-IPPs-5Y) significantly predicted return on investments (ROI) in private solar energy investments in Zambia, $F(3, 240) = 4.741$, $p = .003$. The model yielded an R square value of .056, suggesting that approximately 5.6% of the variance in ROI is explained by the set of non-monetary incentive variables.

Table 41

Model Summary for Non-Monetary Incentives

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.237[a]	.056	.044	80193

Note. Predictors**:** IEnv-IPP's-5Y, B-PPAs-PPPs and IPPAs**.** 5.6% variance in ROI is explained by the combined non-monetary incentives. *Source*: IBM SPSS Outputs

Table 42

Analysis of Variance Model for Non-Monetary Incentives Vs ROI

	Model	Sum of Squares	df	Mean Square	*F*	Sig.
1	Regression	9.146	3	3.049	4.741	.003
	Residual	154.341	240	.643		
	Total	163.488	243			

Note. Predictors: ROI. Predictors: B-PPAs/IPPs, IPPAs, IEnv-IPPs-5Y). Criterion: ROI. *Source*: IBM SPSS Outputs

Table 43

Regression Coefficient for Non-Monetary Incentives with ROI

	Model	Unstandardized Coefficients		Standardized Coefficients	*t*	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.964	.254		7.723	.000
	B-PPAs-IPPs	-.004	.080	-.003	.048	.962
	IPPAs	.122	.076	.113	1.597	.112
	IEnv-IPPs-5Y	.180	.071	.172	2.528	.012

Note. Non-monetary incentives predictors: B-PPAs-IPPs**,** IPPAs, and IEnv-IPPs-5Y. Criterion: ROI**.** *Source:* IBM SPSS Outputs.

Hypothesis tests were conducted to assess the individual effects of non-monetary incentive variables, namely B-PPAs-IPPs, IPPAs, and IEnv-IPPs-5Y, on Return on Investment (ROI), as presented in table 42. The hypothesis decisions were based on the findings for B-PPAs-IPPs variable which showed a non-significant and negative association with RoI (*B* = - .003, *t* = .048, *p* = .962), leading to a failure to reject the null hypothesis H03 (b-i) Indicating that there is insufficient statistical evidence to support the alternative hypothesis, hence confirming that the observed results may have been due to random variation. Likewise, hypothesis testing for the IPPAs variable demonstrated a non-significant and weak association with RoI (*B* = .113, *t* = 1.597, *p* = .112), also resulting in a failure to reject the null hypothesis H03 (b-ii) or correspondingly providing insufficient support for the alternative hypothesis. In contrast, the hypothesis tests relating to the improvements in the investment environment over the past five years (IEnv-IPPs-5Y) showed a statistically significant albeit weak positive effect on RoI (*B* = 0.172, *t* = 2.528, p = 0.012). This result lead to the rejection of the null hypothesis H03 (b-iii), and consequently indicating that there is sufficient statistical evidence to conclude that a significant relationship or effect exists in line with the alternative hypothesis. The summary of the aforementioned hypothesis test decisions are outlined in table 44 for all non-monetary incentives regressed against RoI in Zambia’s solar energy investments. Overall, the hypothesis tests indicate that B-PPAs-IPPs and IPPAs exhibited non-significant effects on outcome variable (*p* = .962 and *p* = .112, respectively), while IEnv-IPPs-5Y showed a significant relationship, difference, or effect (*p* = .012). Collectively, these findings point to an overall non-significant influence of non-monetary incentives on the outcome variable

Table 44

Regression for Non-Monetary Incentives with ROI

Factors	*B*	*t*	*p*	Hypotheses (H03)	Outcome
B-PPAs-IPPs	-.003	.048	.962	H03 (b-i)	Failure to Reject
IPPAs	.113	1.597	.112	H03 (b-ii)	Failure to Reject
Env-IPPs-5Y	.172	2.528	.012	H03 (b-iii)	Rejected

Note. Predictors: (B-PPAs-IPPs; IPPAs; Env- IPPS -5Y). Criterion: ROI. *Source*: IBM SPSS Outputs.

Limitations

A thorough outline of limitations encountered in data handling up to results processing and interpretation stages is an important aspect of research reporting, as it provides clarity regarding factors that may affect the correctness and consistency of findings. This section recognises potential restraints arising from data quality, measurement error, missing values, and methodological options made during data handling and analysis. A clear outline of limitations defines boundaries within which the results should be interpreted, thereby mitigating the risk of over generalisation and reinforcing the study's credibility. Clearly articulated limitations also guide the readers or future researchers to appropriately evaluate the reliability of conclusions and identifying areas of improvement in subsequent studies (Theofanidis & Fountouki, 2018).

The successful attainment of results in this study was not without challenges or limitations. In an effort to systematically scrutinise the association between financial, fiscal, and non-monetary incentives with private sector solar investment rates, as well as return on investments as dependent variables, several limitations were encountered. One significant limitation was response apathy from some respondents, which posed the risk to introduce non-response bias which could potentially affect the validity and reliability of the study’s findings. To mitigate this issue, the study approach incorporated a diverse range of eligible research sites and participants. These included utility-scale solar organizations, small and medium-scale solar energy system installers, solar equipment traders, as well as financiers and implementers from government and donor partner agencies. This broad and inclusive approach aimed to enhance the study’s capacity to draw meaningful and representative conclusions, ensuring that the findings accurately reflected the varied dynamics within the solar energy sector.

In addition to the aforementioned limitations to avert the observed non-responsiveness to electronically disseminated questionnaires in the pilot study stage, administration of questionnaires in all targeted institutions was done through face to face physical means. This approach was aimed at reducing non-responsiveness and maximising the population frame to ultimately reduce the potential of negatively affecting generalisability and selection bias in the research with potential to skew findings (Groves et al., 2011; Reio Jr, 2007). Notwithstanding, the research focused primarily on financial, fiscal, and non-monetary incentives as key factors influencing solar investments. This focus inherently limited the scope of analysis by excluding other potential determinants that may also affect investment outcomes in the solar sector. Recognizing these limitations provided valuable insights into the challenges encountered during the research process and emphasised the importance of interpreting the study’s findings within the context of these constraints.

Similarly there were notable redundant questions in the questionnaire and to address the limitations caused by this development in the survey questionnaire, several steps were taken.

Firstly, questions that duplicated existing ones or did not target the variables of interest were identified and omitted to focus on the questions that best captured the intended information by comparing them based on criteria such as clarity, response rate, and variability in responses. The questions that demonstrated the highest quality responses were retained for further analysis. This process helped guarantee that the redundancy did not jeopardise the quality of the results, thereby allowing for accurate and reliable interpretation of data (Almquist et al., 2020a). Secondly redundant questions identified at pilot study stage were rephrased and restructured to capture the intended perspectives of the research objectives

Similarly, the study encountered instances of redundancy with regard to the questionnaire structure, where certain items overlapped or duplicated the intent of others. To address the limitations arising from this redundancy, several corrective measures were implemented. First, questions that were repetitive, unclear, or not directly aligned with the study variables were identified and omitted to ensure precision and focus. This refinement process involved comparing questions based on clarity, response consistency, and variability in answers, with only the items yielding the most relevant and high quality responses retained for analysis. These steps ensured that redundancy did not compromise the validity or reliability of the data, thereby supporting accurate interpretation of the findings (Almquist et al., 2020a). Additionally, redundant questions identified during the pilot phase were rephrased and restructured to better align with the research objectives and to capture the intended perspectives more effectively.

Evaluation of Findings

The Evaluation of Findings section in a research report is crucial because it enables the researcher to examine how findings support or challenge hypotheses, explain their implications for theory and practice, identify limitations, and highlight the contribution to knowledge. Thorough evaluation of findings ensures that conclusions are evidence-based and that the study’s conclusions are meaningfully assimilated and contribute to the broader knowledge body of a particular discipline (Ghasemi et al., 2019)

In this study the evaluation of findings section, presents a comprehensive assessment of the results, examining the observed relationships between financial, fiscal, and non-monetary incentives and private sector solar investment rates, and with return on investments as dependent variables in Zambia’s solar sector investments, as outlined in the preceding results section. The results, meticulously analysed using descriptive statistics, correlation, and linear regression, are presented in APA formatted SPSS tables with each set of findings is systematically aligned with respective research questions and hypotheses, ensuring a logical and coherent presentation of suggestions (Verma, 2012).. The analysis revealed diverse correlation patterns, highlighting significant positive correlations between financial incentives and solar sector investment levels, while identifying some notable non-significant correlations particularly for non-monetary incentives. These findings provide valuable understanding of the dynamics that influencing private sector investments in Zambia's solar energy sector. This evaluation section further incorporates comparisons with existing literature, thereby enhancing the overall understanding of the complex landscape of financial, fiscal and non-monetary incentives affecting solar investments in the country.

Recognising the important role that solar energy potential avails to promoting sustainable energy solutions, the study conducted a comprehensive examination of strategies aimed at improving solar sector investments in Zambia. The study explored the complex relationships among institutional financial, fiscal and non-monetary inducements intended to support solar energy investments and to boost exiting levels of private investments in solar to a higher rating. In accordance to the objectives of the study, this section assesses the significance levels of accessibility and suitability of existing financial, fiscal and non-monetary incentives for private sector investments in solar energy.

A quantitative correlational research approach was used to explore the relationship of financial, fiscal, and non-monetary incentives with performance indicators, such as private sector investment levels and return on investment (ROI) in the solar sector. Statistical techniques, including statistical association analysis, were applied using IBM SPSS Statistics software to interrogate the detailed interactions between the independent and dependent variables (Al-Riyami, 2008).

The primary data collection method involved a survey questionnaire comprising structured, close ended questions presented on a Likert scale with five answer options. This design facilitated the collection of accurate, reliable, and valid data, making it suitable for inferential statistical analysis and ensuring that the findings are generalisable to a broader research sample frame (Grove et al., 2012; Hazra, 2017).

The evaluation of results hinge on the findings presented in the results section, which detail key association and regression analyses results concerning the relationships between financial and fiscal incentives (independent variables) and private sector investment in solar, and including return on investment (RoI) (dependent variables) in Zambia’s solar energy sector. The analyses indicated varying levels of significance and strengths in the correlations between these incentives and investment outcomes, demonstrating diverse effectiveness in promoting private sector investment and enhancing returns within the solar sector. This suggests that while some incentives effectively stimulate investment, others may have a more limited impact.

This section is systematically organized into subsections to provide a comprehensive evaluation of the statistical test findings. Each subsection is aligned to a particular corresponding research question and hypothesis to examining financial, fiscal, and non-monetary associations with outcome performance indicators. The analyses are framed within the context of the applied theoretical framework and existing literature. This comprehensive approach serves a dual purpose. First, it aligns investment incentives with the theoretical framework, ensuring that the evaluation is grounded in the study's theoretical basis and thereby providing a structured lens for interpreting the results. Second, it facilitates a basis for comparison through existing literature in order to identify areas of convergence and divergence with previous studies. This approach ultimately helps to either confirm or challenge established suggestions in existing literature, thereby helping to identify Knowledge gaps and enhance the study’s findings and interpretations**:** Additionally, the approach helps to highlights gaps in the current knowledge of financial, fiscal and non-monetary incentives for solar sector investments which is crucial for future research and practices. Ultimately, the multifaceted approach to evaluating the results aim to provide complete understanding of features affecting solar sector investments in Zambia; and the insights to be gained will not only help to understand the underlying dynamics but also guide future policymaking in the solar energy sector. Ultimately, this positively contributes to the development of strategies for stimulating solar investments and enhancing returns.

Evaluation of Financial Incentives

In line with Research Question 1 (RQ1) and its corresponding null hypothesis 1 (H01)**,** this study examines the extent to which financial incentives influence the suitability and performance outcomes of private-sector solar energy investments in Zambia. Specifically, RQ1 enquires to what extent financial incentives are effective in meeting the suitability needs of private-sector solar energy investments**,** while H01 suggests that financial incentives have no statistically significant effect on the suitability of private-sector solar energy investments in Zambia.

Within the context the research question, financial incentives are defined as mechanisms that are monetary in nature and provide direct financial benefits or support to investors in the solar energy sector. These include loan facilities, grants, and guarantees, which are designed to reduce investment costs, enhance profitability, and stimulate private-sector participation in solar energy development.

By alleviating financial barriers and improving the economic feasibility of solar projects, these incentives help to inspire private investments in the solar sector and boost growth in the renewable energy in the country. Through appropriately targeted application, financial incentives have an important part in the accomplishment of growth in solar investments and in so doing promote sustainable energy solutions.

The first evaluation focuses on the results related to Financial Access Levels (FIAL) and the Private Sector Solar Investment Rating (PSIR) in Zambia. These indicators represent incentives that provide direct financial benefits to investors or serve as measures of such benefits, particularly in relation to their corresponding impact on return on investments. The detailed findings are outlined in table 45.

Table 45

Financial Incentives vs. ROI: Alignment with Literature

Variable	**Findings:**		**Evaluations**
	Correlation (r)	**p-value**	
PSIR	*r* = 0.20	*p* = .297	Findings align with literature recognising the importance of financial incentives in investment decision-making.
FIAL	*r* = 0.27	*p* = .462	Financial incentives show a weak and non-significant association with ROI**,** explaining limited variance.
MODEL	*F*(2, 241)= .655, *p* = .521 0.5% Variance		Despite their recognised importance and presence, accessibility gaps across investment scales, types & locations appear to limit their impact in solar sector.

Note. FIAL = Financial Incentives Access Levels**;** PSIR **=** Private Sector Investment Rates. *Source*: **(**Baye et al., 2021; ERB, 2020; Kihlström & Elbe, 2021)

The findings represent the critical position that financial incentives occupy in influencing investment progression within the solar energy sector. However, non-significant results and weak correlations for the identified financial incentive variables, highlights a substantial gap in their effectiveness. The failure to reject the null hypothesis (H01) confirms the absence of significant association between financial incentives and ROI. This suggests that financial incentives, despite their recognized importance, remain peripheral in fostering private sector solar investments. These results underscore a critical gap, with inadequate financial incentives contributing to low solar energy adoption, heightened barriers to entry, and stagnated sector growth.

Regression analysis of financial incentives, as detailed in the results section, examined the relationship between Return on Investments (ROI) in the solar sector (dependent variable) and Financial Incentive Access Levels (FIAL) and Private Sector Investment Rates (independent variables). The analysis revealed non-significant and weak correlations, with limited predictive power, F (2, 241) = 0.655, p = 0.521. The model's R square = 0.005 indicates that only 0.5% of variance in Return on Investments can be explained by these predictors, highlighting a significant gap in the influence of financial incentives on solar sector investments in the country.

Additionally regression statistical processes were undertaken to compute the individual effects of independent variables on Return on Investment (ROI) from private sector solar investments. For Hypothesis H1A, which examined the effect of Financial Incentive Access Levels (FIAL), the findings indicated a non-significant impact on the outcome variable (B = 0.028, t = 0.468, p = 0.640). This finding supports the rejection of the alternative hypothesis or failure to reject the null hypothesis, hence confirming the non-significant influence of this financial variable on improving solar sector investment levels. The results underscore the critical need to enhance financial access to foster increased investments in the sector.

Similarly, Hypothesis H1B, which examined the effect of Private Sector Investment Rates (PSIR) on Return on Investment (ROI), revealed a non-significant and weak relationship with the outcome variable (B = 0.055, t = 0.876, p = 0.382). This result led to failure to reject the null hypothesis, hence highlighting a gap in financial incentives suitability as reflected in the observed private sector investment rates. The findings emphasize the critical role of financial incentives and the necessity to enhance financial access to drive investment growth in the solar energy sector.

The overall results for FIAL and PSIR, both with p-values exceeding the set significance level of alpha = 0.05, demonstrate a statistically non-significant relationship with return on investments (ROI) from private sector solar investments. The observed probability values confirm the lack of significant associations. The non-significant correlations between the financial incentive variables FIAL and PSIR with ROI suggests that, although financial incentives are essential for enhancing investment levels, their current impact is weak. This highlights the need for strengthening these incentives alongside other factors to effectively influence private sector investment in Zambia's solar energy sector.

Evaluation of Fiscal Incentives

The evaluation of fiscal incentives was addressed through the second research question and its corresponding hypotheses, with the aim of examining the relationship between fiscal incentives and private-sector solar investment levels in Zambia. Specifically, Research Question 2 (RQ2) seeks to determine the extent to which fiscal incentives are effective in meeting the appropriate needs of private-sector solar energy investments. In line with this question, the null hypothesis (H02**)** posits that fiscal incentives have no statistically significant effect on meeting the appropriate needs of private-sector solar energy investments in Zambia.

Within this framework, fiscal incentives were assessed in terms of both their suitability and effectiveness, focusing on tax-based incentives, subsidies, customs and duty relief, and capital support measures, and analysed in relation to private-sector investment levels, which served as the dependent variable in this section of the study. Specifically, the study examined the Suitability of Fiscal Incentives (SFI)**—**including import tax exemptions, value-added tax reductions, and corporate tax incentives—and the perceived Effects of Fiscal Incentives (EFI) on solar investment rates, with the objective of understanding how fiscal policies influence private-sector solar investments.

The results revealed a significant but weak positive correlation between the suitability of fiscal incentives and private-sector investment rates (*r*(242)=.169, *p*=.008). In contrast, the perceived effects of fiscal incentives on private-sector investment rates exhibited a non-significant relationship (*r*(242) =.120, *p*=.062). These findings indicate a nuanced dynamic in which, although the suitability of fiscal incentives is acknowledged, their practical impact on stimulating private-sector investment remains limited, thereby suggesting the need for a complementary and more effective approach to the implementation of fiscal policies.

The contrasting outcomes suggests that although incentives like tax exemptions and duty reductions are beneficial, their ability to significantly boost solar sector investments remains modest. The weak but positive correlation for SFI implies that improving the alignment, design, and attractiveness of these fiscal policies could foster greater investment when combined with other supportive measures.

Additionally Regression analysis, including the examining of variance in reflected in the outcome variable including beta coefficients to outline strength and direction of associations were conducted for fiscal incentives variables in form of Suitability of Fiscal Incentives (SFI) and Effect of Fiscal Incentives (EFI) against private sector solar investment rates (PSIR). The goal was to establish level of influence from fiscal incentives on private sector investment rates in the solar energy investments and to further test the hypotheses related to these variables.

The regression model for SFI and EFI revealed statistically significant results, with *F*(2,241) = 3.766, *p* = 0.025, explaining 3% of the variance in the outcome variable i.e., R square

= 0.030. These findings suggest that fiscal incentives have a meaningful but limited impact on private sector investment rates. However, the explanatory power is weak, indicating that fiscal incentives alone are insufficient to significantly drive improvements in private sector solar investments. In Summary, while fiscal incentives are relevant and contribute to investment levels, however their limited influence underscores the need for a broader and more comprehensive set of fiscal measures to complement these incentives. This approach would enhance their effectiveness in boosting private sector investment in the solar energy sector. The examination of the hypotheses showed that the Suitability of Fiscal Incentives (SFI)**,** which includes measures such as tax exemptions and duty waivers, had a statistically significant and positive effect on private sector solar investment rates (*B* = 0.145, *t* = 1.995, *p* = 0.047). In contrast, the Effect of Fiscal Incentives (EFI) was found to have a non-significant impact (*B* = 0.050, *t* = 0.687, *p* = 0.493). These results highlight varied influences from these two predictors on investment outcomes, reinforcing the necessity for complementing fiscal incentives with additional supporting factors.

A significance correlation coefficient result for SFI, underscores the critical role well-designed fiscal policies play in creating a favourable investment environment for the solar energy sector investments. On the other hand the non-significant correlation coefficient finding for EFI suggest that when fiscal incentives are applied in isolation, they may lack sufficient impact to drive substantial investment outcomes. This finding supports the idea that targeted fiscal incentives can effectively lower upfront investment costs and enhance the attractiveness of solar projects to private investors, but only when used in conjunction with other supporting measures.

Hypothesis testing was conducted using a predetermined significance level of α = 0.05. The results indicated that the suitability of fiscal incentives (SFI) exerted a statistically significant positive influence on solar sector investments; accordingly, the null hypothesis relating to SFI was rejected. In contrast, the effects of fiscal incentives (EFI) did not reach statistical significance at the 5% level, indicating limited standalone effectiveness. This outcome underscores the importance of integrated policy frameworks that combine fiscal incentives with complementary measures to more effectively stimulate private-sector investment in the solar energy sector.

Evaluation of Non-monetary Incentives

In addressing the third research question and its corresponding hypothesis, the study examined the influence of non-monetary incentives on two outcome variables, namely Private Sector Investment Rates (PSIR) and Return on Investment (ROI) in the solar energy sector. The analysis considered regulatory support systems, capacity-building initiatives, infrastructure support, market access, and policy stability measures as non-monetary incentive variables. To assess these effects, several predictor vs. outcome relationships were evaluated. For PSIR, the study analysed the impact of the Initial Cost of Solar Investments (ICSI), Affordability of Solar Services (ASS), and Location, Value, and Type-Based Incentives (LVTI). For ROI, non-monetary incentives, namely Investment Promotion and Protection Agreements (IPPAs), improvements in the investment environment for IPPs over the last five years (IEnv-IPPs-5Y), and Bankability of Power Purchase Agreements for IPPs (B-PPAs-IPPs) were also examined. While non-monetary incentives are intended to ease investment burdens in the solar sector, the statistical tests revealed nuanced and non-uniform effects across the predictor sets as outlined in subsequent subheadings for PSIR and ROI respectively.

Initial Cost for Solar Investments. The evaluation of initial cost for solar investments (ICSI) revealed a weak but statistically significant positive correlation with PSIR, $r(242) = .166$, *p* = .009. The regression model was significant, *F*(1,242) = 6.876, *p* = .009, indicating that ICSI meaningfully explained variations in PSIR. The regression coefficient (*B* = .166, *t* = 2.662) confirmed its significant positive effect. The model accounted for 28% of the variance, demonstrating that ICSI contributes notably to predicting investment levels, even though additional complementary factors would be required for greater explanatory power. These findings emphasise the importance of ICSI as a key determinant of solar investment behaviour. For Non-Monetary Incentives and Private sector investment rates (PSIR), the evaluations of incentives were threefold as outlined in subsequent subsections

Affordability of Solar Services. The analysis of Affordability of Solar Services (ASS) showed a weak yet statistically significant positive relationship with PSIR, *r*(242) = .274, *p* = .001. The regression model was also significant, *F*(1,242) = 7.671, *p* = .001. The coefficient results (*B* = .204, *t* = 10.380) confirmed the strong statistical significance of ASS. While the model explained only 4.2% of the variance, affordability still demonstrated a meaningful, though limited, contribution to predicting investment outcomes. These findings highlight affordability as an important but not dominant factor influencing investment decisions

Location, Value, and Type-Based Incentives The Evaluation of Location Value and Type Incentives (LVTI) revealed a very weak, non-significant correlation with PSIR, *r*(242) = .160, *p* = .354. Contrary to expectations and literature suggesting its relevance, LVTI did not significantly influence private sector investment decisions. The regression model, *F*(1,242) = .864, *p* = .354, showed no predictive ability, with only 0.4% of the variance explained. Although the coefficient (*B* = .060, *t* = 16.460) indicated a minimal positive direction, LVTI proved ineffective as a standalone factor. These results suggest that LVTI requires integration with broader elements such as regulatory certainty, market demand, and infrastructure readiness to play a more substantial role in shaping the investment patterns. Collectively, the three predictors, namely ICSI, ASS, and LVTI revealed a statistically significant model, $F(3,240) = 7.653$, $p = .001$. Although the model explained only 8.7% of the variance in PSIR, the results confirm that non-monetary incentive factors collectively have an influence on investment rates, albeit with modest explanatory power. These results highlight the need for complementary policies and additional variables to strengthen predictive capacity. A summary of these findings is presented in table 46.

Non-Monetary Incentives and Return on Investment. The study further examined the relationship and effects of non-monetary incentives on Return on Investment (ROI) in Zambia’s solar energy sector using correlation and regression analyses. Three key independent variables were assessed: Investment Promotion and Protection Agreements (IPPAs), Investment Environment Improvements for Independent Power Producers over the Last Five Years (IEnv-IPPs-5Y), and Bankability of Power Purchase Agreements for IPPs (B-PPAs/IPPs). The results revealed variable impacts across these incentives. IPPAs demonstrated a weak but statistically significant positive correlation with ROI, indicating that investment protection and promotion measures modestly enhance returns and justifying rejection of the null hypothesis. Similarly, IEnv-IPPs-5Y showed a weak yet significant positive association with ROI, suggesting that improvements in the investment environment over the past five years contribute modestly to better returns on solar investments. In contrast, B-PPAs/IPPs did not exhibit a significant relationship with ROI, indicating limited standalone influence on investment outcomes.

Regression analysis confirmed that, collectively, these non-monetary incentives have a statistically significant effect on ROI**,** despite the model explaining only 5.6% of the variance. The modest explanatory power highlights that while certain non-monetary incentives are effective, others require structural refinement or integration with complementary measures to fully influence returns. These findings align with the Technological Innovation System (TIS) framework, which emphasizes the importance of structured, coordinated, and integrated incentive strategies. The results underscore that IPPAs and IEnv-IPPs-5Y, though modestly effective, need to be applied within a broader, cohesive framework to optimize ROI. Conversely, the lack of significance for B-PPAs-IPPs illustrates gaps in the current incentive design, reinforcing the need for a more comprehensive and strategically integrated approach. Evaluation results as presented in table 47 for non-monetary incentives versus ROI highlight the partial yet meaningful effect**,** emphasising necessity of strategic, integrated frameworks in to maximising impact on solar investment

Table 46

Evaluation of Non-monetary Incentive with PSIR

Independent Variable	**Nature of Results**	**Evaluation Statement**
Initial Cost of Solar Investments (ICSI)	Weak but statistically significant with PSIR (r = .166, p = .009; F = 6.876, B = .166, t = 2.662). With 28% of variance in PSIR.	ICSI significantly influences PSIR, albeit the effect is moderate, indicating that other factors also contribute substantially to investment decisions.
Affordability of Solar Services (ASS)	Weak but statistically significant with PSIR (r = .274, p = .001; F = 7.671, B = .204, t = 10.380). With 4.2% of variance in PSIR.	ASS positively impacts PSIR, though its limited explanatory power suggests additional interventions from other factors to stir the interventions course.
Location, Value, and Type-Based Incentives (LVTI)	Very weak and non-significant positive correlation with PSIR (r = .160, p = .354; F = .864, B = .060, t = 16.460). With 0.4% variance.	LVTI has negligible standalone impact on PSIR, suggesting need for complementarity with other factors to enhance its effectiveness.
Combined Model (ICSI, ASS, LVTI)	Statistically significant overall model (F = 7.653, p = .001). Explains 8.7% of variance in PSIR.	Collectively, the variables significantly predict PSIR but leave substantial unexplained variability is influenced by unexamined factors.

Note. Evaluation examining impact of non-monetary incentives on Private Sector Investment Rates (PSIR)**.** Significant relationship between the variables indicated. Data source**:** IBM SPSS Outputs. Refs: (Jiang, 2019; Lee et al., 2020; Columbia Center on Sustainable Investment 2022**)** *Source*: By Author.

Table 47

Evaluation of Non-Monetary Incentives with ROI

Variable	Nature of Results	Evaluation Statement
IPPAs	Weak but statistically significant positive correlation with ROI (r = 0.175, p = 0.006).	IPPAs have a significant yet modest positive impact on ROI, highlighting its importance in enhancing investment returns with other factors.
IEnv-IPPs-5Y)	Weak but statistically significant positive correlation with ROI (r = 0.212, p = 0.001).	IPPs-5Y shows significant yet modest positive influence on ROI, suggesting progress in creating a more conducive investment environment can be attained by promoting complementarity with other investment factors.
B-PPAs/IPPs	Non-significant correlation with ROI (r = 0.078, p = 0.223).	B-PPAs/PPPs lack a substantial relationship with ROI, pointing to the need for improved frameworks and structures that incorporate missing incentive structures to complement existing ones.
Model -Evaluation	Statistically significant p = .003 overall effect on ROI. Model explains 5.6% of variance.	Collectively, variables modestly influence ROI but highlight structural gaps and the need for an integrated incentive framework that strengthens t weak factors in the model.

Note. The evaluation suggests a strategic, complementary approach to optimizing non-monetary incentives**.** Data source: IBM SPSS Outputs. Refs: (Jiang, 2019; Lee et al., 2020; Columbia Center on Sustainable Investment 2022) *Source*: By Author

Evaluation of Results in line with Technological Innovation Systems Theory

This section evaluates the findings from the statistical analysis offering an in-depth overview of Zambia’s solar sector investment environment, specifically focusing on current financial, fiscal and non-monetary incentives and evaluated within the context of Technological Innovation Systems (TIS) theory framework, which underscores the need for integrated sectoral elements to foster positive investment outcomes.

The incentives which are a focus of this study are provided by the government and quasai government institutions, as enablers of a conducive investment environment in corroboration with the private institutions and donor partner organisations who provide some of such incentives in form of aid, grants or loan facilities contingent upon specific predetermined conditions. Key factors that influence these incentives include the reputability or capital base of an investing organisation, the practicability of a proposed investment project, and the level of risk factors associated with the envisaged investments.

Financial, fiscal and non-monetary incentives are categorized based on notable criteria such as the monetary value involved for a proposed investment, sector classification, and investment type. These criteria are used to determine specific negotiated concessions between investors and the government agency responsible for such promotions and negotiations. The Zambia Development Agency (ZDA) outlines several investment classes, which are subject to varying investment concessions. These classes consider factors such as the monetary value of investments, the type of investment (e.g., whether it aligns with priority sectors), and the investment scale. Investments are further categorized based on whether they fall under micro or small enterprises or are large-scale utility investments, including geographic location of the investment which also plays a critical role in determining the incentives (Walimwipi, 2012a).

Existing literature highlights that priority sectors in energy generation, such as solar energy, manufacturing, and food processing, often benefit from favourable incentives. These incentives include tax exemptions, import duty waivers, VAT deferment, and non-monetary supports such as regulatory assistance, capital support, infrastructure development, and capacity-building systems. However, a notable bias exists toward large-scale investments in these priority sectors, raising concerns about the limited focus on small and medium-sized enterprises (SMEs).

Small and Medium Enterprises face significant barriers to investment, including limited access to affordable financing due to procedural challenges and insufficient capital. These obstacles often prevent SMEs from effectively utilizing available investment incentives (Bhattacharyya, 2013; Haselip et al., 2013). Additionally, financial institutions are reluctant to fund SMEs due to perceived high default risks, lack of competitiveness, and inadequate guarantees within the sector (Avevor, 2016).

This review of existing studies establishes a foundation for evaluating the relationship between investments incentives and private sector solar investment rates, as well as return on investments in Zambia, within the context of current literature. Existing studies on scaling up measures for solar sector investments lay a groundwork for analysing the relationships between investment incentives and performance outcomes. Specifically, it examines the impact of financial, fiscal and non-monetary incentives on private sector solar investments in Zambia, providing a context for these relationships within the framework of documented experiences and observations.

The interpretations of study findings in line with the Technological Innovation Systems (TIS) framework, underscores the need for complementarity of various incentive elements that define the solar energy sector in Zambia. Financial incentives tests against dependent outcome variables (ROI) indicated weak, non-significant relationships, and accounting for only 0.5% of the variance in the outcome variable. This indicates that despite their recognized importance and corresponding efforts, the gaps in accessibility across investment scales appear to limit their impact. This further suggests presence of systemic barriers and facilitations within the sector to make these incentives affective. Weak correlations between financial incentives and return on investments, i.e., $r = 0.20$; $p = .297$ for PSIR and $r = 0.27$; $p = .462$ for FIAL suggest that while these factors are important in fostering investments in the solar energy sector , their influence is hampered by the lack of other supporting factors within a broader system of interactions to make them effective and in line with the TIS theory , financial incentives should not be applied as an isolated factor but should be part of a larger ecosystem that includes technology, market dynamics, and institutional frameworks. Additionally the regression for theses variable F (2, 241) = .655, $p = .521$ further underscored the non-viability of financial incentives on their own in enhancing private sector investments. The model's negligible predictive power, explaining only 0.5% of the variance, underscores the lack of impact of other financial incentives on performance outcomes.

The findings aligns with the Technological Innovation System (TIS) theory, which emphasizes that innovation, technology adoption, and market entry are driven by the interaction of multiple systemic components. The non-significant results highlight that improving financial access and private sector investments as standalone measures are insufficient. Instead, comprehensive interventions are required to address financial barriers alongside broader systemic factors, such as institutional support and policy frameworks, to foster a holistic approach for scaling up investments in Zambia’s solar sector. Similarly, the analysis of fiscal incentives through correlation and regression tests, focusing on the Suitability of Fiscal Incentives (SFI) and the Effects of Tax-Based Fiscal Incentives (EFI) as independent variables were undertaken. These variables encompassed tax-based incentives, subsidies, customs and duty relief, and capital support. Their relationships with private sector investment rates as the dependent variable revealed significant but weak correlations: ($r = .169$; $p = .008$) for SFI and ($r = .120$, $p = .062$) for EFI. The regression model further indicated statistical significance at threshold level = .05, with [$F\ (2, 241) = 3.766$, $p = .025$]. These findings align with the Technological Innovation System (TIS) theory, which advocates for a systematic and comprehensive approach to fostering technological development and diffusion. The results highlight the varied effects of fiscal incentives on performance outcomes in Zambia’s solar energy sector, emphasizing the importance of integrating fiscal incentives within a broader systemic framework to maximize their effectiveness. The significant but modest correlation between suitability of fiscal incentives (SFI) and private sector investment levels ($r = .169$, $p = .008$) highlights the critical role of tax and duty waivers or discounts in improving market entry and enhancing investment attractiveness. This aligns with the Technological Innovation System (TIS) theory, which emphasizes that effective innovation systems require more than a single support initiative which include complementary policies and incentives to facilitate market entry and adoption. Conversely, the non-significant correlation concerning the effects of tax-based fiscal incentives on the outcome variable $r = .120$; $p = .062$, underscores the need for stronger alignment of these incentives with market demands to fully realize their potential in stimulating investments.

The evaluation of non-monetary incentives against investment performance outcomes, consistent with the TIS Theory, was conducted in two stages using the same analytical approach applied to financial and fiscal incentives. The first stage assessed the relationship between key categories of non-monetary incentives and private sector investment rates. This analysis considered three broad incentive categories related to reducing cost barriers, improving affordability, and strengthening policy and regulatory support. The results indicated differentiated effects: incentives aimed at lowering investment costs and enhancing affordability had significant positive impacts on private sector investment rates, whereas those focused on policy- and location-related improvements showed no significant effect. This suggests that, although these policy-oriented incentives remain important, they are insufficient on their own to substantially stimulate private investment. In accordance with the TIS Theory, this finding reinforces the need for an integrated and systemic approach, where incentives operate collectively alongside wider market conditions, regulatory stability, and adequate infrastructure to create a conducive environment for technology uptake. Despite individual variations in significance, the combined model demonstrated a significant overall effect on investment rates, $F(3, 240) = 7.653$, $p < .001$, underscoring the importance of deploying incentive categories in a coordinated manner to strengthen their collective influence on solar sector investments in Zambia.

The second stage of evaluation examined additional categories of non-monetary incentives in relation to return on investments (ROI). These categories broadly reflected institutional support mechanisms, improvements in the investment environment, and contractual or agreement-based incentives. The results again showed mixed effects: institutional support and improvements in the broader investment environment had significant positive relationships with ROI, while agreement-based incentives did not show significant influence. The lack of significance in this category suggests possible shortcomings in the structure or implementation of these frameworks, such as limited risk mitigation, uncertainty in contractual obligations, or inadequate investor protections—factors that may undermine investor confidence. This outcome aligns with the TIS framework, which emphasises that strong institutional structures are essential for reducing risk and fostering private sector participation.

Despite the varied effects of individual incentive categories, the combined model for the second stage yielded statistically significant results, $F(3, 241) = 4.741$, $p = .003$, explaining 5.6% of the variance in ROI. Although the explanatory power is modest, the significant overall effect suggests that non-monetary incentives, when implemented collectively, can contribute positively to investment performance. This highlights the necessity for a holistic and well-aligned institutional framework of strengthened policies, improved contractual certainty, and stable regulatory systems which the TIS Theory identifies as critical for enhancing innovation diffusion and maximising the effectiveness of incentives in driving private sector investment in Zambia’s solar sector.

Table 48 outlines consolidated summary of incentive categories and their characteristics across the energy, manufacturing, and food processing sectors in Zambia, detailing their classification, value, precedence, and alignment with investment objectives.

Table 48

Incentives Categorization in Zambia

Incentive Category	Monetary Value of Investments	Sector Precedence	Type of Incentives
Withholding Tax	US$10 million or above	Priority Sectors	Reduction or waivers on dividends for the first five years of investment
Tax Rate on Dividends	US$500,000 or above in a priority sector. [a]	Priority Sectors	Zero % tax rate on dividends applied for investments of over US$10 million or US$500,000 in a priority sector[a]
Import Duty	US$10 million or above[a]	Priority Sectors	import duty on specific items is up to 40%; Raw materials import duty exemption @ 0%, waiver on capital goods / specialized motors for 5 years
Value Added Tax (VAT)	US$10 million or above[a]	Priority Sectors	16% VAT levied; deferment of VAT for investments of over US$10 million or US$500,000 in a priority sector
Corporate Tax	US$10 million or above[a]	Priority Sectors	5 years tax waiver from year 1 of profit & varying rates for later years
Corporate Tax	US$500,000 or above in a priority sector[a]	Priority Sectors	Tax waivers are for first five years from first profits; different rates for additional years
Corporate Tax	Micro or Small Enterprise Investments	Non-Priority Designated Sectors	3years tax waivers in built-up areas & 5 years in countryside

Note. Monetary value, prioritisation, and type-based categorization of investment incentives in Zambia. *Source:* (Halamwipi 2012; UNCTAD, 2011).

Evaluation of Results in line with Literature

The evaluation of results in line with existing literature entails systematic comparison of the study’s empirical findings with existing research to assess areas of convergence, divergence, or new contributions to the concerned field. This undertaking is vital because it positions the study within the broader academic landscape, validates findings through comparison, and highlights the originality or significance of the outcomes. By assessing how results align with or vary from reputable evidence, this section reinforces the credibility of the analysis and enhances comprehension of the broader implications for theory, policy, and practice.

The results of this research study were evaluated through the lens of existing literature, focusing on financial incentives and their role in supporting solar energy investments. The results revealed non-significant positive correlations between financial incentive levels and return on investments as well as between private sector investment levels, with return on investments. These results differ from existing literature, which often portrays financial incentives as effective tools for boosting solar investments.

Given the slow growth of the solar sector, these findings highlight the importance of ensuring financial incentives are both accessible and appropriate to accelerate investment in the industry. The weak correlations observed underscore deficiencies in the current financial incentive structures, pointing to ongoing disparities in financial access across solar institutions of various sizes, types, and locations. This emphasizes the need for tailored and equitable financial solutions to address these gaps and foster sector-wide growth. The findings suggest that small and medium-scale solar investments require better tailored financial incentives comparable to those available for large utility-scale projects. Challenges such as reputability of investors, guarantees, viability, and associated risks necessitate financial incentives that are more accessible and suitable for smaller projects. For instance, less rigorous procedural requirements and one-stop financing application facilities may help SMEs overcome investment deterrents such as limited capacity to manage and negotiate private power concessions, lack of scale which limits their ability to absorb larger projects, and the high transaction costs associated with individually negotiated contracts. Additionally, the perceived risk due to limited utility off-takers such as the vertically integrated ones, including political risks, further increases the cost of capital, thereby driving up tariffs. These negative aspects are part of a larger system that affects both smaller to medium investments and to a lesser extent, the utility-scale investments.

The regression analysis revealed significant deficiencies in the effectiveness of financial incentives for enhancing private sector investments in the solar energy sector. The findings showed a non-significant relationship between Financial Incentive Access Levels (FIAL) and Private Sector Solar Investment Rates, with financial predictors accounting for only 0.5% of the variance in return on investments (ROI). This result underscores the weak predictive power of financial incentives in driving private sector solar investments.

This finding contrasts with prevailing literature, which emphasizes the significant role of effective financial support measures, including incentives, in driving solar sector investments. Specifically, the non-significant effects of FIAL (B = .047, t = 4.240) and Private Sector Investment Rates (B= .67, t = 1.046) on ROI underscore the important need to improve financial accessibility to encourage private sector participation. While these results suggest that the current financial incentives are insufficient to drive meaningful investment outcomes, they align with broader literature advocating for enhanced and targeted financial measures. These measures are necessary to increase investment attractiveness, address market entry barriers, and guide future policy development and strategic initiatives to support solar sector growth.

The findings on the associations between fiscal incentives and private sector investment rates in the solar sector (PSIR), did not align with existing literature which highlights current fiscal incentives as effective when in fact the study results indicated varied correlation significances for fiscal incentives, i.e., for suitability of existing fiscal incentives (SFI) indicated significant albeit weak correlation results (r =.169, p = .008) while the effects of the fiscal incentives (EFI) indicated non-significant results (r = .120, p = .062). These results divergences from literature assertions which highlights positive effects of fiscal incentive, hence the need for improved fiscal incentives structures coupled with a comprehensive dissemination approach.

The findings conforms with existing literature which emphasizes that while fiscal incentives such as tax exemptions and duty reductions can play a role in attracting investments, their individual impact tends to be modest. Previous studies, such as those by Albers et al. (2013) and Granqvist (2017), similarly concluded that while well-designed fiscal policies can help reduce initial investment and operational cost barriers, their effectiveness in significantly driving investments relies heavily on the overall economic and regulatory environment. This underscores the need for a supportive and stable framework to maximize the potential of fiscal incentives in the attainment of sustainable investments growth in the solar sector.

In addition to the aforementioned analyses, correlation and regression analyses on non-monetary incentives were undertaken and revealed significant understandings into their impact on private sector investment rates (PSIR) and returns attained from the investments (ROI) in the solar energy sector. The first group of predictors consisting Initial Cost of Solar Investments in Zambia (ICSI), Affordability for Solar Services in Zambia (ASS), and Improvements on Policies Based on Value, Location, and Type of Renewable Energy Investments (LVTI), demonstrated a collective significant impact on PSIR, with *F*(3, 240) = 7.653, *p* < .001, despite varied individual factor contributions. These findings align with existing research that emphasizes the critical role of non-monetary incentives in promoting long-term investment security in the solar energy sector. For instance, previous studies emphasise the importance of structured and credible agreements in enhancing investor confidence, which appears underrepresented in the individual correlation results, signaling gaps in the fiscal incentives frameworks (Zhang & Fumo, 2020). Specifically, the positive but non-significant correlation between LVTI and PSIR *r*(242) = .060, *p* = .354 supports literature indicating that while these factors matter, they may not be decisive alone in driving significant investment. Additional considerations such as market access, infrastructure, and regulatory certainty are equally crucial, as highlighted in prior research (Anjanappa, 2024).

The second group of non-monetary incentive comprised Promotions and Protection agreements for Independent Power Producers (IPPAs), Investment Environment for IPPs over the Last Five Years (IEnv-IPPs-5Y), and Bankability of Power Purchase Agreements and Independent Power Producers (B-PPAs-IPPs) which were examined and evaluated against ROI. Regression results showed a statistically significant model, with *F* (3, 241) = 4.741, *p* = .003, with alpha level = .056, thus explaining 5.6% of the variance in the outcome variable. These results confirm the role of non-monetary incentives in influencing ROI, though the modest explanatory power suggests that additional supportive measures are needed to enhance effectiveness. This underscores the importance of a more comprehensive approach to investment structures, incorporating market dynamics, variability, and robust regulatory frameworks to effectively stimulate investment systems, as suggested in contemporary literature (González-Sánchez & Gómez, 2023). It is notable that existing literature has not been with numerous highlights on the need for measures to enhancement investor confidence and reduce risks in order to improve return on investments. Therefore the afore presented regression model for IPPAs and IEnv-IPPs-5Y and B–PPA-IPPs as independent variables, with ROI as dependent variable revealed a significant impact on the outcome variable underscoring the critical role that well-designed promotion and protection agreements, along with a conducive investment environment play in enhancing the profitability of solar investments and maximizing returns on investments (Chang et al., 2016). The results therefore further highlight the need for continued improvements in structuring and implementation of these incentives to better align with investor needs and market dynamics.

Table 49 provides a summary of the evaluation of fiscal and non-monetary incentives in relation to research questions 2 and 3. It also examines their alignment with existing literature on investments in the solar energy sector. The results reveal varying levels of correlation, offering detailed insights into the extents to which fiscal and non-monetary incentives impact private sector solar investments in Zambia

Table 49

Evaluation of Fiscal & Non-Monetary Incentives Vs Existing Literature

Incentive Category	IV	DV	Correlation (r)	Evaluation in Relation with Literature
Fiscal Incentives	SFI EFI	PSIR	*r* = .169, *p* = .008 *r* = .120, *p* = .062	Overall model - statistically significant (F = 7.653, p = .001), explaining modest 8.7% variance. Despite varied individual effects, combined positive influence aligns only weakly with literature, indicating that current fiscal measures require strengthening and better integration to more effectively complementary financial incentives.
Non- Monetary Incentives	ICSI ASS LVTI	PSIR	*r* = .166, *p* = .009 *r* = .274, *p* = .001 *r* = .060, *p* = .354	Statistically significant impact for majority variables albeit with on non- significant result, equally aligns weakly with literatures assertion of overall positive effects of fiscal incentives - suggesting need for improved location - value - type based fiscal incentives and to strategies with complementary financial incentive
	IPPAs IEnv-IPPs-5Y B-PPAs/IPPs	ROI	*r* = .175, *p* = .006 *r* = .212, *p* = .001 *r* = .078, *p*=.223,	Similarly, a combination of statistically significantly and non – significantly correlated individual incentives diverges from literature with assertions of positive correlations, highlighting need for a well-designed promotion and protection agreements, and conducive investment environment to complement these incentives in enhancing investment returns

Note. Evaluation of fiscal & non-monetary incentives shows divergence in fiscal incentives and convergence in non-monetary incentives, highlighting need for improvements and comprehensive application**.** *Source***:** IBM SPSS Outputs

Anticipated Findings

The expected findings of this study were informed by trends in existing literature, which generally suggest that financial, fiscal, and non-monetary incentives exert a positive, though often modest, influence on private-sector participation and returns in the solar energy sector. Consistent with these expectations, the correlation and regression tests were anticipated to reveal weak-to-moderate associations, reflecting the structural and market limitations widely documented in the Zambian and broader Sub-Saharan African energy landscape.

For financial incentives, it was expected that their contribution to investment performance would be limited, given persistent financing inefficiencies, high initial capital costs, and restricted access to credit factors extensively highlighted in earlier studies. The non-significant regression model observed in the analysis aligns with these expectations, reinforcing literature that identifies inadequate financing mechanisms as a major constraint to sector growth.

Fiscal incentives were expected to demonstrate modest and statistically significant effects, reflecting their potential to encourage investment while still being constrained by design, accessibility, and dissemination challenges. The observed weak associations and low explanatory power therefore align with earlier research indicating that fiscal interventions in Zambia often fall short of generating strong investment responses, despite being well-articulated in national policy frameworks.

Similarly, findings relating to non-monetary incentives aligned broadly with expectations but revealed a mix of anticipated and unanticipated outcomes. Weak effects were expected for incentive categories linked to administrative conditions such as those tied to value, location, or type of investment, given persistent affordability barriers and high operational costs for off-grid systems reported in prior literature. Conversely, improvements in the investment environment and formal investment agreements were expected to show small positive effects, consistent with the theoretical assumption that institutional stability and investor protections support moderate gains in ROI.

However, some deviations emerged from initial expectations, particularly regarding incentives linked directly to financial agreements. The weaker-than-anticipated influence of financing mechanisms on return on investments suggests limitations in current models that favour large-scale investors while leaving smaller private players insufficiently supported. Similarly, the absence of expected effects from certain institutional incentives such as those linked to the bankability of purchase agreements which indicate gaps in policy implementation and misalignment with market needs, despite recent government reform efforts.

Overall, the findings were expected to highlight both the potential and the limitations of existing incentive frameworks. While modest positive associations were anticipated, the results underscore the complex and interdependent nature of incentive effectiveness in the solar sector. This aligns with theoretical perspectives advocating for integrated, context-specific policy approaches as essential to improving investment outcomes and accelerating solar energy adoption in Zambia.

Summary

The findings chapter focused on outlining and evaluating the relationships between institutional measures supporting solar sector investments in Zambia, with an emphasis on financial, fiscal, and non-monetary incentives and their impact on private sector solar energy investments. Financial incentives, which include loans, grants, and their corresponding access levels and benefit indicators were examined alongside fiscal incentives in form of tax credits, customs and duty exemptions, depreciation benefits, and capital support. On the other hand, non-monetary incentives, encompassed regulatory support, capacity building, infrastructure support, market access, and policy frameworks as outlined in Zambia's National Energy Plan 2030 (Bowa et al., 2017), were also assessed. These measures were analysed in the context of their contribution to sustainable energy development (Bayliss & Pollen, 2021), particularly in relation to private sector investment levels and returns on investments.

The chapter is methodically structured to cover research findings in line with formulated research questions, hypotheses, objectives, methodologies, data collection, and analyses thereby ensuring a comprehensive outline of relationships and influences of financial, fiscal and non-monetary inducements on private solar sector investments, particularly examining the, accessibility, and suitability of these incentives using a quantitative research approach. The study evaluates their effects on private sector investment performance such as asset growth, increased service delivery, and return on investments (ROI).

In the data collection process, government organisations, private sector organisations, and donor-backed financier and implementers were accessed and interrogated on outlined important investment incentives in the sector, in order to examine their effectiveness in promoting solar investments in the country. Research questions were formulated to evaluate the current state of incentives and their impact on private sector investments. A structured questionnaire and analysis using SPSS was employed to ensure reliability and validity of the findings (Taherdoost, 2016).)

To guarantee the honesty of the results, the study undertook deliberate steps through rigorous data preparation and analysis methods, including correlation and regression tests, to guarantee consistency and validity of the study instruments. The chapter also outlined a pilot study and data coding procedures (Lee, 2016), which are critical in refining research tools and ensuring accurate, reliable results that are generalizable to the broader context of solar sector investments (Hammer, 2017; Soiferman, 2010; Tavakol & Dennick, 2011).

In line with trustworthiness the research deliberately undertook deliberate steps to guarantee integrity, transferability, dependability, and results confirmability. For credibility, data was systematically coded and anonymised, appropriate participants were identified and the sampling approach was applied to ensure fair representation from across the solar, these involved stakeholders in solar investment, policy, and supply chains (Lavitas et al., 2021). To assess the reliability of the measurement instrument, a pilot study was conducted and the internal consistency reliability was gauged using Cronbach’s alpha, ensuring accurate measurement of the intended variables. (Izah et al., 2023; Tavakol & Dennick, 2011). Histograms were also used to verify measurement assumptions necessary for correlational analysis (Field, 2013). Similarly Transferability was attained through systematic descriptions, including contexts and sample frame descriptions to ensured transferability through comparisons with other contextual settings (Munthe-Kaas et al., 2019). Dependability of the research results was addressed through systematic documentation of the research progression and information collection, collation, sampling and examinations which helped to logically structure and trace data, thereby ensuring trustworthiness (Ahmed, 2024). Finally a hypothesis driven analysis approach using SPSS statistical methods, based on empirical evidence ensured findings that are free from researcher bias hence ensuring objectivity and confirmability of the study (Kyngäs et al., 2019; Haq et al., 2023)

The questionnaire was methodically designed to assess the impacts of investment incentives on private sector solar investments to ensure reliability and validity in captured data (Kyngäs et al., 2020). The questionnaire design ensured that the operationalisation of the research constructs on accessibility and suitability of investment incentives, including performance variables was attainable (Lleo et al., 2021). A Likert scale was used to facilitate precise measurements, ensuring observed correlations accurately reflected true relationships. This thorough design enhanced internal validity by accurately establishing relationships between variables, thus providing a solid foundation for analyses (Hair et al., 2019). The rigorous undertakings were done with the aim of maintaining trustworthiness (Kyngäs et al., 2020); which included ensuring normality between variables which was addresses through the use of histograms generated with IBM SPSS software (Nguyen et al., 2020; Park et al., 2020). Q-Q plots ensured data distribution aligned with normality assumptions, essential for accurate statistical analysis (Loy et al., 2016). Similarly statistical tests were done to establish consistency of constructs measured in the questionnaire and a favourable coefficient of 0.75, was attained indicating high reliability (Tavakol & Dennick, 2011). Despite these efforts, however, potential weaknesses such as non-linearity, non-normally distributed data, measurement errors, sample size limitations, lack of generalizability, and multicollinearity were acknowledged, as they could affect interpretation and validity (Field, 2013; Hair et al., 2010).

Carefully formulated questionnaire averted ambiguities, bias, and redundancy, ensuring internal validity. Targeting appropriate participants and employing representative sampling facilitated external validity, making results generalizable to a broader sample frame. Data collection was through online platforms and physical means, however face-to-face questionnaires were later employed to address non-response bias, as observe in the pilot study to ensure comprehensive data collection (Brick & Tourangeau, 2017; Hossan et al., 2025). Operationalisation of Variables in Financial incentives included grants, loans, and tax credits, while fiscal non-financial incentives included tax exemptions, corporate tax holidays, and investment concessions. This process facilitated effective data collection and analysis (Mthembu, 2018; Onen, 2016; Qadir, 2021 ;). Additionally a Likert scale was applied to ensure correct and precise measurement of variables, furthermore the verification of variables using Cronbach's Alpha, with a high alpha level of greater or equal to (.70) indicating strong internal consistency of the measuring instrument (Khalid et al., 2012).

Statistical analysis for this study involved correlation and regression analyses through the use of SPSS analytical software to compute Pearson correlation coefficients to assess associations between variables and regression to establish the effect of independent variables on outcomes. Hypotheses testing was done using two-tailed significance tests. Additionally, despite the non-experimental nature of the study, external validity was addressed through representative sampling and targeting relevant participants (Kafle, 2019; Obilor & Amadi, 2018). Conducting a pilot research prior to the main study helped in refining the questionnaire. The sample size estimation for a pilot research was attained through rule of thumb suggesting 10 to 30% of the anticipated samples frame or a minimum range of 24 to 36 participants for a meaningful undertaking of a pilot study, hence with application of appropriate mathematical computations in relation to the anticipated sample frame and expected research sample for the main study, a sample size of 25 participants was attained. Identified flaws in the questionnaire were rectified to ensure clarity and relevance of the questions (Williams-McBean, 2019; Johanson & Brooks, 2010).

Ensuring Validity involved external and internal validities to ensure fair participation and generalisability of the finding through random sampling and identifying the appropriate sample for the study. Similarly by maintaining the study schedule and timely collection of research information and consequent analysis guaranteed Temporal Validity for the study **(**Bonett & Wright, 2015). This approach generally ensures that findings were reliable, generalizable, and applicable to the broader context of solar sector investments (Rovai et al., 2013).

The Results section was organized to systematically address the problem statement, research questions and corresponding hypotheses for the study. Starting with descriptive statistics, followed by inferential analyses, and ends with discussion of the results. Descriptive statistics provided summary of the demographics of respondents and key variables of interest related to financial and fiscal incentives. It highlights central tendencies such as means, medians, and modes, and the variability of data for variables like loan accessibility, tax holidays, and investment incentives. Tables and figures depicting the Demographic distribution by gender, age, and education were depicted in table format in the chapter, revealing a sample compositions were include, additionally Key variables, including initial cost of solar investments, affordability of solar services, and Financial Incentive Access Levels were describe through means and standard deviations in order to have a clear perspective of the research sample. Inferential statistics focusing on assessment of hypotheses regarding the effects of financial and fiscal incentives respectively regarding solar sector investments and performances were tested using correlation tests including regression for nature of correlations. The analysis of all variable were done in line with outlined hypotheses suggesting relationships with financial and fiscal incentives which revealed varying correlation and regression outcomes in relation to outcome variables for solar sector performances.

The results were evaluated in line with financial, fiscal and non-monetary incentives effects on the private sector solar investments in Zambia. Utilizing descriptive statistics, correlation, and regression analyses, this section systematically evaluated the relationships between various incentives and investment outcomes, and were presented in the results section (Verma, 2012). The study analysis generally revealed non-significant positive correlations between financial incentives, such as the financial incentives access level (FIAL) and Private sector investments rates as variables with direct bearing on financial access benefits and return on investments as the outcome variable to this analysis $F(2, 241) = .655$, $p = .521$. Explaining a paltry 0.5% Variance in the outcome variable (R square = .005) due to these financial incentives. Furthermore individual financial incentive's impact assessed revealed non-significant impact with FIAL in particular indicating a significant albeit weak correlation with the outcome variable consequently suggesting the need for additional factors to further enhance financial incentives contribution in solar sector investments in Zambia's

Similarly the evaluation of fiscal incentives comprising suitability of the fiscal incentives in the sector(SFI) and the effect of fiscal incentives revealed different relationships and impacts on the private sector solar investments, i.e., SFI revealed a significant albeit weak correlation with investment rates , $r(242) = .169$, $p = .008$. On the other hand effects of existing fiscal incentives in the sector EFI revealed a non-significant, and weak correlation with investment levels, $r(242) = .120$, $p = .062$. These results suggested the need to improve the structures and dissemination approaches for these incentive in order to equitably to cater for the entire solar energy sector so as to promote uniform growth.

On the aspect of non-monetary incentives comprised Initial cost of solar investments (ICSI), Policy improvements based on value, location & type of solar investments (LVTI). Affordability for solar services (ASS) as a first batch examined against private sector investments levels. The second group of analysis under non-monetary incentives category included Promotions & Protection Agreements for IPPAs ; Investment environment improvement for IPP's in last five years (IEnv-IPPs-5Y) and bankability of public-private agreements and public private Partnerships (B-PPAs-PPPs), examined against return on investment as the dependent variable

Finding for the first group of non-monetary incentives against private sector investment level revealed significant impact on the outcome variable $F(3\ \ 240) = 7.653$, $p < .001$ explaining 8.7% Variance in the outcome variable. Similarly second group of non-monetary incentives examined against return on investments revealed an equally statistically significant results $F\ (3, 241) = 4.741$, $p =.003$, explaining a 5.6% variance in the outcome variable. These results with low level variance explained in the outcome variable suggest gaps in the formulated structure and implementation of these incentives, suggesting the need for improvement and adoption of comprehensive approaches

The statistical findings on solar sector investments in Zambia were evaluated using the Technological Innovation Systems (TIS) framework and existing literature, focusing on the influence of fiscal, financial, and non-monetary incentives on private sector investments and return on investments (ROI) as output variables. The findings and evaluation revealed non-significant and weak correlations for financial incentives with ROI, indicating a gap in the formulation, structuring, and implementation of these incentives. In the context of the TIS framework, these findings highlight a divergence from the framework's advocacy for a systematic and comprehensive approach that involves multiple players and systems at all levels of incentive design, implementation, and structuring. Similarly the finding and evaluations diverge from existing literature which highlight the effort made in terms of financial access and delivery which unfortunately is non-cross cutting across the solar sector

The findings and evaluations of fiscal incentives, specifically the suitability of fiscal incentives in the solar sector (SFI) and the effect of fiscal incentives (EFI), revealed varied impacts. The overall regression model indicated non-significant results, suggesting that while these incentives are conceptually suitable, their implementation and dissemination approaches are insufficiently effective. And in relation to the applied TIS theory and also to existing literature these findings diverge as findings indicate that they do not conform to systematic and comprehensive approaches as per TIS theory, nor do they reflect the effort outlined in literature regarding formulation and disseminations respectively. These results generally equally suggest need for a broader context of investment support innovations to drive the solar sector investment agenda (Kauffmann, 2005).

The findings and evaluations of non-monetary incentives, including ICSI, ASS, and LVTI with private sector investment rates, as well as IPPAs, B-PPAs-IPPs, and IEnv-IPPs-5Y with return on investments, indicated statistically significant results $F(3, 241) = 4.741$, $p = .003$, explaining a modest 5.6% variance in the outcome variable. These results suggest that the non-monetary incentives model has a positive and statistically significant effect on return on investments (RoI). However, the modest explanatory power, reflected in the 5.6% variance, highlights the need for a more comprehensive approach inclusive of market stability and regulatory dynamism to effectively addressing barriers and stimulate solar sector investments (Oduro, et al 2024).The results also align with the TIS framework's emphasis on an integrated incentives approach and supports existing literature advocating for well-structured incentives to ensure their effective application. Additionally the results suggested the need for equitable financial and non-financial support across the solar energy sector, particularly for SMEs that face procedural and processing barriers, and indeed drawbacks arising from high capital costs (Bhattacharyya, 2013; Haselip et al., 2013).

Generally findings on financial, fiscal and non-monetary incentives emphasize the need for an all-inclusive approach, as advocated by the TIS framework, to foster solar investments in Zambia. Financial, fiscal and non-monetary incentives play critical roles which must be part of a broader supportive network including policy frameworks, institutional support, and market stability to overcome barriers and improve solar investments in Zambia.

The findings revealed both anticipated and unexpected outcomes regarding the relationship between investment incentives and private sector performance in Zambia's solar energy sector. As expected, a significant correlation was identified between the initial cost of solar investments and investment levels, reaffirming that high initial costs remain a major barrier to market entry (Ghaderi, 2024).

Similarly, the findings showed a significant yet weak correlation between affordability and private sector investments in solar energy, aligning with expectations and supporting existing literature on non-monetary incentives. This underscores the need to address high service tariffs to ensure affordability for low-income and seasonal earners, thereby improving access to off-grid solar energy services (Baye et al., 2021).

Additionally the analysis of individual incentive factors revealed notable expected and unexpected relationships and impacts on the outcome variables. Among the unexpected findings, non-significant and weak correlations were observed between Financial Access Levels (FIAL) ($r(242) = .047$, $p = .462$) *and* Private Sector Investment Rates ($r(242) = .067$, $p = .297$) with Return on Investment (ROI) as the output variable. These results suggest limited access to financial incentives, particularly for small and medium enterprises (SMEs), as most benefits are directed toward utility-scale investors (Haselip et al., 2015). Similarly, weak correlations were noted between Suitability of Fiscal Incentives (SFI) and Effect of Fiscal Incentives (EFI) with private sector investment levels, despite government efforts to design and implement targeted incentives. This outcome points to the slow diffusion of solar energy adoption and highlights the need for enhanced policy frameworks, aligning with Technological Innovation Systems (TIS) theory, to comprehensively address investment barriers (Köhler et al., 2016; Chen & Lin, 2020). Contrary to expectations, there was also no significant correlation between the Bankability of Power Purchase Agreements and Public Private Partnerships (B-PPAs/IPPs) with ROI, despite notable government initiatives to improve the investment environment. This finding underscores the necessity for more inclusive policies and clearer guidelines catering to both utility-scale and SME investments (Bowa et al., 2017; USAID, 2018).

On the other hand, some clearly anticipated findings were encountered by the study. The lack of correlation between Value, Type, and Location (LVTI)-based investment concessions and private sector investments aligned with expectations, as high initial costs and operational challenges—particularly for remote off-grid systems—continue to pose significant barriers (JICA, 2009). Similarly, the weak correlation between the prevailing investment environment for independent power producers (IPPs) and private sector investment levels reinforced the unattractiveness and slow adoption of commercial renewable energy projects in sub-Saharan Africa (Fischer et al., 2011). Generally, the findings underscore the necessity for more robust, inclusive, and targeted policies to address financial and operational barriers, thereby promoting broader participation and growth in Zambia's solar energy sector.

To conclude, the findings highlight the necessity for comprehensive, context-specific policy interventions and innovations. With notable efforts by the government to boost the solar sector through creation of a conducive investment environment, it is anticipated that financial accessibility results would have significant outcomes in relation to return on investments. There is therefore a need to enhance financial accessibility to smaller institutions, and formulate more effective fiscal and non-monetary incentives to accelerate solar energy diffusion. Clearer guidelines and inclusive policies for smaller-scale investments in mitigating high initial investments costs, operational costs, and investment environments is crucial.

CHAPTER 5: IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSIONS

In research studies, the conclusions, implications, and recommendations are very important for the purpose of blending the findings and explaining their wider meaning. Conclusions represent a summary of key findings and clearly respond to the research questions, thereby bringing the inquiry to a close. Implications explain why the findings are important to a particular field and also outline their contribution to existing literature, inform practice, apprise policy, or define future research to ultimately link the evidence attained to the area of interrogation and associated fields. Finally recommendations are anchored in the study's findings to offer accurate practical guidance for practitioners in the field of study or future research in examining identified concerns or improve on identified solutions. Ultimately these aspects improve credibility of the research study by guiding explanation, application, and future steps for effective contribution to the body of knowledge (Kohli & Haenlein, 2021).

Chapter Overview

Likewise this chapter presents a combination of the study's key results, underscoring their implications, recommendations, and overall conclusions. It starts by explaining the implications of financial, fiscal, and non-monetary incentives on private-sector solar energy investments, addressing policy, research, and practice, including practical applications. The chapter additionally deliberates on study limitations and the influence they have on the interpretation and generalisability of findings; and further positions the findings within the relevant theoretical framework and existing literature. Basing on the aforementioned understandings, the chapter also provides targeted recommendations to improve incentive structures for enhancing the effectiveness of investment mechanisms. Last but not least, the chapter ends by providing a summary of the overall contributions of the study, highlighting the importance of amalgamated and context-specific methods to growing sustainable private-sector investments and utilisation in Zambia’s solar energy sector.

Implications for Policy, Research and Practice

The implications subsection of this chapter amalgamates the importance of the study results, stressing on their relevance for policy formulation, investment practice, and research. It validates how the results expand the understanding of the factors that shape private-sector investment in Zambia’s solar energy sector and offers direction on improving institutional support mechanisms, enhancing operational practices, and informing future research directions. By connecting empirical findings with practical and theoretical realities, this section brings out the essence of incorporating findings into decision-making processes, policy interventions, and the broader theoretical body of knowledge relating to solar investments.

The study results carry several important implications, and from a policy perspective, the limited effectiveness of existing incentive approaches indicate a pressing need for tailored, contextualised, scale-aware, and better-coordinated designs. Particularly, legislators are encouraged to improve fiscal instruments, introduce affordability-enhancing programs, and develop integrated deployment frameworks that clearly align with sector priorities based on the findings. In terms of practice, the results highlight the importance of operational efficiency, including streamlined access to financial support, improved investor administrative facilitations, strengthened contractual mechanisms such as consistent power purchase agreements, and better institutional support structures. For future research, the findings indicate that, there is a need for longitudinal, comparative, and context-specific studies to better understand the long-term effects of incentives and guide adaptive policy-making in evolving solar markets.

Financial incentives are a key area for targeted interventions and the findings in this study indicate that while existing financial support mechanisms are intended to stimulate investment, their limited effectiveness hampers private-sector investments. This therefore highlights the necessity for designing adjustable, accessible, and tailored financial instruments that mitigate entry barriers, improve affordability, especially for smaller investors, and complement other fiscal and non-monetary incentives. By addressing these gaps, financial incentives can more effectively contribute to enhancing private-sector participation and supporting broader objectives of expanding solar energy development in Zambia.

Implications of Financial Incentives

Aligned with the study's problem statement, the research sought to establish whether relationships exist between financial incentives variables with investments rates and return in private solar energy sector in Zambia. The correlation analysis conducted using IBM SPSS Statistics (21) revealed non-significant and weak relationships between Financial Incentives Access Levels (FIAL) and Return on Investment (ROI*)*, r =.047, p = .462, as well as between Private Sector Investment Rates (PSIR) and ROI, r = .067, p = .297. The financial incentives variables comprised Financial Incentives Access levels (FIAL**)**, representing access to financial amenities such as grants and loans for solar investments; and private sector investments rates (PSIR**)**, reflecting direct benefits or participation levels resulting from financial incentives in the sector. Findings for regression analysis of FIAL and PSIR against ROI indicated a statistically non-significant predictive effect, $F(2, 241)$ = .655, p = .521, with the model's R square = .149, thus explaining only 14.9% of the variance in ROI. Generally, these findings suggest limited impact of existing financial incentives on investment returns, highlighting two key policy implications: the need for improved financing structures and equitable financial access across different investment scales, types, and geographical locations.

The non-significant correlation between financial incentives and return on investments underscores the need for better-structured financial incentive programs to support policy formulation aimed at enhancing the availability and accessibility of these incentives in the solar energy sector. To achieve this, measures such as introducing subsidies, grants, and low-interest loans could help mitigate the high initial costs of solar investments. These initiatives would also improve the affordability of solar services for rural populations, particularly those with low or seasonal incomes, ultimately encouraging greater private sector participation (Ghaderi, 2024).

Furthermore, financial incentive structures should be developed comprehensively and systematically in a c complementary manner which incorporates other influential investment factors. Alongside these structural improvements, a review of existing policies is necessary to ensure they address investments across all scales in the solar sector, including both large-scale utility projects and small and medium enterprises (SMEs). Enhanced policies that ensure equitable distribution of financial incentives will level the playing field, enabling SMEs to participate effectively and contribute meaningfully to the growth and expansion of the solar energy sector (Baye et al., 2021).

Given the non-significant correlation between financial incentive accessibility (FIAL & PSIR) with investment performance, there is a clear need for policies aimed at improving and streamlining financial access for solar investments. These policies should prioritize simplifying application procedures and reducing the capital base and reputational requirements including bureaucratic barriers. Such measures mitigations have potential to enhance access to financial investment incentives, thereby encouraging growth and development within the solar energy sector (Lilliestam & Patt, 2015; Reio Jr, 2007).

With respect to the implications of financial incentives for future research, the observed correlations and regression analysis results point to several important research directions. Future studies could further examine incentive effectiveness by applying impact analysis approaches, supported by longitudinal study designs. Such studies should incorporate comparative, regionalised analyses, as well as impact assessments of integrated energy-source mixes, including conventional hydropower and alternative renewable energy sources. These approaches could provide deeper insights into how financial incentives may be optimally designed, applied, and implemented to support solar sector investments. (Markard et al 2012; Muhammed & Tekbiyik-Ersoy, 2020).

Specifically, in order to identify most efficient financial initiatives to promote solar investments, research can interrogate existing incentives through comparative impact analysis for initiatives, such as tax breaks, waivers, delayed tax payments, feed-in tariffs and investment grants (Stritzke, 2018). Similarly conducting longitudinal studies has potential to provide better insights into influence of financial incentives on investment performance over time (Amankwah-Amoah, 2015). To promote rural energy investments and expand solar energy mini-grid establishments in remote areas without access to the national grid, a comparative study across different regions within Zambia could provide valuable insights into how regional variations influence incentive criteria and market conditions. These findings could guide the development of policies that are suitable for specific regions or locations, thereby addressing localised challenges to solar investments (Mwanza & Ulgen, 2020). Additionally, future research could explore the integration of solar energy with other renewable energy sources, thereby promoting diversification in energy investments and helping in the creation of comprehensive energy frameworks.

More specifically, financial incentives findings suggest some significant practical implications for the solar energy sector and four notable implications to energy practices are identified, namely to undertake strategic investments planning, to identify and create competitive markets, undertake policy reforms which incorporate robust investment support initiatives. Findings in this study can help private sector investors by way of informing strategic planning and investment decisions. Understanding the importance of financial incentives can guide investors in identifying investment priorities with better potential for return on investments (Bowa et al., 2017). Similarly competitive markets creation is one salient avenue for SMEs to pursue and advocate for policies reforms in order to enhance their participation in the market (Massihi et al., 2021; Pitt et al., 2018). The non-significant correlation between financial incentives and investment performance provides a strong signal base for advocating for policies that enhance the solar sector's growth and it negative effect are confirmed by the diminutive nature of the solar industry in the country. Ultimately**,** the solar sector can use findings to development of support initiatives to avert obstacles to investment growth through organised technical assistance forums, financial advisory services and capacity-building programs to help investors effectively utilise available investment incentive. Table 50 outlines the implication for policy, research, and practice relating to financial incentives 'findings.

Future research should systematically assess the long-term trends in impacts of financial, incentives on solar energy investments through longitudinal studies spanning the next 5 to 10 years. Such studies will help determine evolving trends and ensure that policy interventions remain relevant, measurable, and adaptable to emerging market and technological changes. Additionally, comparative regional analyses across Sub-Saharan Africa to identify best practices and contextual differences, while also exploring amalgamation of solar energy with other renewables such as wind and biomass. Similarly there is need to pursue and develop rural-focused investment approaches aimed at expanding access, inclusivity in fostering sustainable growth countrywide.

Table 50

Policy, Research & Practice Implications of Financial Incentives

	Policy Formulation	Future Research	Sector Practices
Financial Incentives	Strategic formulation of investment incentives deployment tailored for local investment environment in order to speed up and increase solar sector growth by 50% by 2035.	Pursue longitudinal studies spanning 5 to 10 years so as to map & predict trends, thus ensuring relevant and adaptable policies for emerging markets & changing technologies	Non-significant findings suggest need for strategic investment planning and alignment with localised investments needs
	Promote private sector growth by simplifying SME financial access, reducing bureaucratic barriers, and enhancing incentive policies to foster competitive solar markets within 5 to 10 years**.**	**C**omparative regional analyses in SSA to identify best practices & to identify best energy mixes with other renewables.	Non-significant findings imply need for improved practices in prioritising investments that demonstrate potential for profitability & growth.
	Equitable Financing	Pursue rural focused investment models to help expand access, inclusivity, & foster sustainable solar growth in rural locations	Non-significant results suggest need for practices that foster competitive market structures, encourage SMEs participation

Note. Outline of financial incentives' implications for policy, research, and practice. *Source*: (Organisation for Economic Co-operation and Development, 016).

Policy, Research and Practice Implications of Fiscal Incentives

This study, aligned with the research problem statement and corresponding null hypothesis on fiscal incentives in the solar energy sector, examined the relationship between fiscal incentives and private sector solar investment levels. The findings revealed varying impacts of individual factors on the outcome variable, emphasizing the critical role of fiscal incentives in encouraging private investment in solar energy. The implications of these findings are presented in three key areas: policy formulation, future research directions, and practical applications within the solar sector. These categories highlight the need for targeted strategies to maximize the effectiveness of fiscal measures in driving sustainable growth in the industry.

The Results indicated that the suitability of fiscal incentives (SFI), such as tax breaks and investment concessions, had a statistically significant positive correlation with private sector solar investment rates (PSIR), $r(242) = .169$, $p = .008$. Furthermore, SFI demonstrated a significant positive effect on performance, $B = .169$, $t = 2.660$, $p = .047$. Conversely, the effects of fiscal incentives (EFI) on investment levels revealed a non-significant weak correlation, $r(242) = .120$, $p = .062$, and had no significant effect on the outcome variable, $B = .050$, t = .687, $p = .493$. Consequently, the null hypothesis at the individual factor level for EFI could not be rejected.

Policy implications of fiscal incentives. The findings of this study highlight critical implications for policy formulation regarding fiscal incentives and their influence on private sector investment rates (PSIR) in the solar energy sector, with two distinct categories of fiscal incentives examined. The first category, concerning the suitability of fiscal incentives, revealed significant correlations with private sector investment levels. This suggests that well-designed and effectively implemented fiscal incentives have the potential to stimulate investments in the solar energy sector. Conversely, the second category, focusing on the effects of fiscal incentives**,** showed no significant correlation with the dependent variables. This indicates that current fiscal incentives may not be achieving their intended impact, necessitating reassessment or refinement to better align with the investment goals of the sector.

The contrasting findings in which correlations for the suitability of fiscal incentives are significant but non-significant results for their effects, underscore the need for more tailored fiscal policies. Such policies should prioritize the design and implementation of fiscal incentives that align closely with the needs of the solar energy sector. These may include structured tax breaks, comprehensive import duty exemptions, and favourable depreciation allowances, which directly reduce operational costs and encourage investment (Kulichenko & Wirth, 2011; Amankwah-Amoah, 2015).

The varied effects of these fiscal incentives imply that, in their current form, they do not effectively address the barriers impacting solar energy investment models. Policymakers are thus encouraged to re-evaluate and refine strategies for the availability and dissemination of these incentives to better mitigate challenges specific to different categories of solar investments. It is particularly important to address location-specific challenges and enhance the financial viability of public-private partnerships. This will ensure that fiscal incentives are aligned with investor requirements and contribute meaningfully to the growth of the solar energy industry (Ghaderi, 2024).

Research Implications of Fiscal Incentives. In terms of future research, the findings for fiscal incentives with private sector investment levels suggest several avenues through which improved benefits can be attained and that is through further exploration of the gap in the dynamics between fiscal incentives and solar sector investments, namely in-depth analysis, regional Studies, longitudinal studies for investment protection, including market conditions

Practice Implications of Fiscal Incentives. The research results equally offer practical insights for all stakeholders in the development and utilisation divisions ranging from planning, Risk Management, policy engagement and promotions of best practices in solar investments. Salient factors to be considered under implications for practice are Strategic Planning and Advocacy, Investment Risk Management and encouraging best practices in the sector.

Policy, Research and Practice Implications of Non- Monetary Incentives

Non-monetary incentives under consideration for implications are Initial cost of solar investments (ICSI), Affordability of solar services (ASS) and Policy improvements based on value, location & type of investment (LVTI) for the solar sector which were examined in relation to private sector investment level as the first category. The second category comprising , Investment Promotions & Protection Agreements (IPPAs) in solar sector investments; Investment environment improvement for independent power producers for last Five years IEnv-IPPs-5 years; Power Purchase Agreement for Independent Power Producers (B-PPAs-IPPs) in Zambia.

Policy Implications of Non-Monetary Incentives. The examinations of ICSI, ASS, and LVTI revealed mixed results in terms of correlations and significance levels, with some of the factors showing non-significant outcomes. Notwithstanding, the overall regression model demonstrated statistically significant results, F (3, 240) = 7.653, $p < .001$, accounting for 8.7% of the variance in the outcome variable. These findings led to the rejection of the null hypotheses. Similarly, the second category, comprising IPPAs, B, IEnv-IPP-5Y, and B-PPAs-IPPs, also exhibited varying levels of significance. Some individual factors showed non-significant correlations and impacts on returns on investment within the solar sector. However, the overall regression model indicated statistically significant results, *F* (3, 241) = 4.741, *p* = .003, explaining 5.6% of the variance (R square = 0.056) in the outcome variable. These results underscore the complexity of the relationships between the examined factors and sector performance, highlighting the need for a nuanced interpretation of individual and collective influences.

The policy implications of these findings indicate that while the overall model is significant, the lack of impact from some individual factors suggests that current policies fail to adequately address the nuanced complexities of the solar sector regarding non-monetary incentives. This underscores the need for complementary and well-targeted incentives to ensure more effective support and to achieve the desired investment goals in the sector.

The findings highlight important policy implications for non-monetary incentives in relation to private sector investment rates (PSIR) and return on investment (ROI) across two distinct categories. The first category includes independent variables that demonstrated significant correlations with the dependent variables, indicating that well-designed and effectively implemented non-monetary incentives in these areas have the potential to stimulate investment levels in the solar energy sector. The second category pertains to incentives that showed non-significant correlations with the dependent variables, suggesting that they are less effective than intended hence underscoring the need for reassessment and refinement of these incentives to ensure better alignment with the investment objectives of the solar energy sector.

Significant correlations between non-monetary incentives, such as the positive relationship between the Initial Cost of Solar Investments (ICSI) and the affordability of solar services in Zambia (ASS), underscore the importance of tailored fiscal policies. These policies should focus on designing and implementing fiscal incentives that align with the specific needs of the solar energy sector (Amankwah-Amoah, 2015; Kulichenko & Wirth, 2011). Furthermore, the significant correlation between Investment Promotion and Protection Agreements (IPPAs) and the investment environment improvement for independent power producers over the last five years (IEnv-IPPs-5 years) with Return on Investment (ROI) highlights the necessity of policies aimed at safeguarding investments. Such policies should incorporate legal and regulatory frameworks to protect investments, power purchase agreements (PPAs), and guarantees against political and market risks. These measures are critical for creating a favourable investment climate that attracts private sector participation (Bowa et al., 2017)

The findings also emphasise the importance of a conducive investment environment. Policymakers should prioritize improving this environment by streamlining administrative procedures, reducing bureaucratic barriers, and enhancing transparency and consistency in policy formulation and implementation. These efforts are essential to boost investor confidence and encourage private sector investment in the solar energy sector (Mungai et al., 2022; Baye et al., 2021). Conversely, non-significant correlations were identified between non-monetary incentives, particularly 'Location-Value-Type' based incentives (LVTI) and private sector investment rates, as well as between the Bankability of Power Purchase Agreements for Independent Power Producers (B-PPAs-IPPs) and returns on investments. These findings indicate that, in their current form, these incentives fail to sufficiently impact investment models within the solar energy sector. This underscores the necessity for policymakers to reassess and enhance the design and implementation of these incentives to improve their effectiveness and better align with sector needs (Ghaderi, 2024).

Research Implications of Non-Monetary Incentives. Future research should focus on addressing gaps in the relationship between fiscal incentives and solar sector investments to identify ways to enhance their impact. Key areas of exploration include; in-depth Analysis to conduct comprehensive studies to better understand the factors influencing the effectiveness of fiscal incentives. This includes examining how different types of fiscal and non-monetary incentives, such as tax waivers, exemptions, reductions, and deferments, impact various investment outcomes (Amankwah-Amoah, 2015). Regional Studies to undertake comparative research across Zambia’s regions can reveal how local variations in fiscal policies and market conditions influence solar sector investments. Insights from such studies can guide region-specific policy recommendations tailored to unique challenges and opportunities (De Laurentis & Pearson, 2021; Stritzke, 2018). Longitudinal Studies on Investment Protection which will enable the evaluation of the effectiveness of investment protection measures for independent power producers (IPPs) in sustaining investments. These studies could assess how policy changes over time affect investor confidence and long-term returns on investment (Bowa et al., 2017; Polzin et al., 2015). Market variability’s should also be tracked in order to assess how fiscal incentives can be adapted to align with changing market conditions, such as electricity demand, tariff structures, and competition. This would help in formulating strategies responsive to market dynamics, ensuring the incentives remain relevant and impactful (Timilsina et al., 2012; Bowa et al., 2017). Finally, literature should address the streamlining, licensing and technical support in order to identify simplified licensing processes, fast-tracked project approvals, and technical support services in encouraging solar energy investments. By understanding the effectiveness of these non-financial incentives, policymakers and industry stakeholders can design more comprehensive strategies to support the solar energy sector (Kihlström & Elbe, 2021; Oduro et al., 2024). Addressing these key areas in the sector, future research can contribute immensely in developing fiscal and non-monetary incentive frameworks that effectively drive solar energy investments while considering regional, market, and temporal factors.

Practice Implication of Non-Monetary Incentives. Non-monetary incentives play a vital role in driving the investment landscape by influencing investor confidence, reducing operational obstacles, and fostering a supporting environment for private-sector participation. In research studies examining investment behaviour such as those focused on renewable energy or solar sector development these incentives provide valuable insight into how regulatory support, institutional efficiency, power-purchase agreement (PPA) bankability, and streamlined investment procedures affect real-world decision-making and not just direct monetary benefits. Understanding their practical implications is significant because it allows policymakers, industry regulators, and development agencies to identify structural improvements that reinforce market appeal, improve project feasibility, and enhance long-term sector performance. Consequently, analysing non-monetary incentives within a research context provides an evidence-based basis for recommending actionable improvements that can drive sustainable private-sector growth.

The research results equally offer practical insights for all stakeholders in the development and utilisation of solar energy ranging from planning, Risk Management, policy engagement and promoter of best practices in solar investments. Strategic Planning and Advocacy entails that solar energy companies need to apply the study's findings to inform strategic planning, specifically aligning fiscal incentives with areas where they are likely to yield most benefits. Focusing on type, location and scale-specific incentives, organisations can enhance overall investment in the sector.

Targeted approach has ability to ensure efficient allocation of resources and maximise the impact of fiscal incentives on investment growth. Furthermore, solar organisations can use results to advocate for policies that are aligned with the needs of the solar energy sector in order to promote more favourable investment climate (Massihi et al., 2021; Pitt et al., 2018). Similarly Investment Risk Management boarders on the impacts of investment protection measures on ROI highlighting the importance for investors to seek out projects with strong legal and regulatory safeguards, through prioritizing investments with stable PPA agreements and strong investor protection frameworks (Abba et al., 2022). Additionally Stakeholders can use the study results to engage policymakers to seek out better protection frameworks free of political and financing risks and also to advocate for reforms on non-performing fiscal incentives. By highlighting areas where existing policies fall short, stakeholders can partake in the development of better and efficient incentive schemes for the sola sector (Pueyo, 2018; Rambo, 2013). Finally the findings can be applied to encourage best practices by ensuring that all practices in the sector conform to best practices through, through promotion of strategies that align with effective incentivization and investment protection measures so as to enhance the overall investment atmosphere (Abdmouleh et al., 2015). Generally, by addressing these implications, policymakers, researchers, and industry practitioners can collectively help to attain a favourable environment for private sector investments and consequently help build supportable and robust schemes in energy provision especially with the advent of climate change. Table 51 outlines salient implications on policy, future research and practice for the investment incentives in the solar energy sector, namely non-monetary and fiscal incentives.

Table 51

Fiscal & Non-Monetary Incentives' Implications on Policy, Research & Practice

Incentive	Associative & Predictive Relationships	Policy	Future Research	Practice
Non-Monetary	Relationship with PSIR - Significant associations - Significant Predictions	Tailored policies for diverse investments , with 5 yearly assessments of effects to gauge progress & make follow-ups	Conduct 5 to10yr longitudinal studies to refine incentive models & align with market variability, for adaptive & resilient solar investment strategies.	Improve deployment & monitoring of localised incentives; institute 5 to10 year assessment periods for appropriate adjustments & sustained growth
Non-monetary	Relationship with ROI - Varied Associations - Significant Predictions	5year reviews of investment environment to support positive energy growth & sustainability.	Undertake 5to 10-yr regional longitudinal studies to assess varied incentive effects, develop context-specific investments strategies	Develop localized fiscal strategies; adaptive, risk managed; 5 to10 year monitoring for measurable growth
Fiscal	Relationship with (PSIR) - Varied correlation results - Significant prediction power	Revamp incentives with comprehensive & inclusive framework under 5 yearly monitoring to enhance investment financing	Undertake longitudinal regional studies (5 to10 years) to refine incentive models, develop context-specific, proven strategies to enhance solar investments.	Localised strategies, risk management, adaptability in investments structures- monitored 5 to10 yrs periods to gauge progress

Note. PSIR = Private sector investment rates; ROI = Return on Investment. *Source*: IBM SPSS Outputs.

Study Limitations and Their Impact on Interpretation

Study limitations are methodological, contextual, and real-world restrictions that may affect the interpretation, generalisability, and strength of a study’s findings. These limitations do not overturn the results but help clarify the confines within which the conclusions should be understood. Acknowledging limitations is indispensable because it affords transparency about factors such as sample characteristics, measurement constraints, data collection challenges, or analytical restrictions that may affect the extent to which the results can be applied to generalised wider settings. By outlining these constraints, the study offers a well-adjusted interpretation of its outcomes and guides readers in understanding how the findings should be viewed within the specific circumstances under which the study was undertaken.

The study generated significant insights into the influence of financial, fiscal, and non-monetary incentives on private-sector solar investments in Zambia; however, several limitations must be acknowledged. First, the scope of incentives examined was restricted to three primary categories, excluding other potential determinants of solar sector growth such as technological innovation, infrastructure, and regulatory enforcement. Second, the variability observed in correlation and predictive results across incentive types may have stemmed from differences in investment needs and requirements among various solar sector segments. These limitations suggest that the derived implications and recommendations for policy, research, and practice should be interpreted with caution and viewed within the contextual boundaries of the study’s scope. Additionally, the cross-sectional research design restricts the ability to ascertain causality between variables or overtime influence of the variables. Therefore, the findings should be interpreted within these boundaries with the understanding that financial incentives are those that provide direct financial benefits or are direct indicators of financial benefits, while fiscal incentives entail tax related mechanisms such as adjustments, waivers, deferments, or exemptions that indirectly benefit investments. Similarly Non-monetary incentives are those that address logistical aspects of solar sector investments, including regulatory support, capacity-building initiatives, market stability, and policy consistency.

Even though these identified incentives were deliberately targeted and individually analysed as key factors in investment dynamics, the study did not extensively explore other potential influences, such as systematic approaches, infrastructure development, or localized conditions. This limitation suggests the need for upcoming studies to consider a wider range of variables and relevant investments conditions for examination, in order to provide a more comprehensive understanding of the factors impacting solar sector investments.

In the data gathering process, notable variations emerged in the responses relating to utility-scale solar projects (USSE) and those relating to small and medium-sized investors (SMEs). Responses from SMEs largely perceived the incentives to be less accessible and less suitable for investments, while USSE stakeholders perceived them to be generally suitable and improving. This discrepancy introduced response variability, with potential to affect the interpretation and evaluation of results, including subsequent recommendations. To address this, future studies need to consider conducting separate analyses of the impacts of more varied incentives and based on the scale, type, and location of investments in solar energy. Additionally, the limited number of respondent for the study corresponding to the small size and slow growth of the solar sector in Zambia posed a risk of introducing generalisability deficiencies. This underscores the importance of employing improved data collection methods in future research and incorporating a wider coverage of solar sector players in the solar sector to ensure more representative and reliable findings. Despite these limitations, the study contributes valuable empirical evidence to the existing body of literature on investments in alternative renewable energy, particularly in developing countries like Zambia. It emphasises the need for more effective and tailored incentive programs to stimulate independent producers' investment in solar energy. Furthermore, the findings provide a foundation for future research to explore the complex interplay between incentives, institutional frameworks, and market dynamics in fostering sustainable energy development.

Alignment and Comparison with Theory

Aligning and comparing research findings with established theoretical frameworks involves probing how the study’s results support, extend, or oppose the assumptions and propositions of the underlying theory underpinning the investigation. This process is imperative because it positions the study within a broader academic context, reinforces the interpretive trustworthiness of the results, and establishes how empirical evidence contributes to theoretical progression. By assessing the extent to which observed patterns, relationships, or outcomes match with theoretical expectations, scholars can highlight meaningful consistencies, identify deviations that may warrant further investigation, and probably refine the conceptual understanding of the circumstance under study. Ultimately, the alignment guarantees that the study’s deductions are not only grounded in data but also connected to recognised academic trend of thought, enhancing both the validity and relevance of the inquiry.

This section examines the alignment of the study’s findings with the applied theoretical framework (TIS theory) and compares expected outcomes to those observed for each category of incentives. The purpose is to evaluate the consistency between theoretical expectations and empirical evidence, thereby identifying how financial, fiscal, and non-monetary incentives can be improved to enhance solar investment patterns in Zambia. In this context, the study's findings are examined against the guiding theoretical framework, which suggests that well-designed incentive mechanisms across financial, fiscal, and non-monetary domains as well as effective interactions among actors and institutions, should stimulate private-sector participation and improve solar investment performance (Esmailzadeh et al., 2020). This analysis assesses the extent to which observed empirical outcomes correspond with theoretical predictions and the broader principles underpinning investment models.

The varied findings and their corresponding implications align well with the Technological Innovation Systems (TIS) framework, particularly its functional approach, which emphasises the critical role of systemic interactions among actors, networks, and institutions in developing renewable energy technologies. The framework underscores the importance of identifying contributions from various institutions within the solar investment value chain and highlights the necessity for coordinated efforts in policy formulation, project implementation, regulation, and investment promotion to foster private-sector growth in solar energy (Topal & Erdil, 2024).

In Zambia, the electricity sector is monopolised by ZESCO, a vertically integrated utility overseeing the entire energy value chain. However, ZESCO has struggled to provide the necessary financing and infrastructure to support solar energy development and to effectively act as an energy off-taker for Independent Power Producers (IPPs). Its prioritization of financial undertakings with foreign-owned IPPs at below-commercial tariffs exacerbates financial pressures for local investors, discouraging their participation. Commitments under Power Purchase Agreements

(PPAs) with foreign entities impose significant financial burdens on ZESCO, underscoring the need for comprehensive reforms that align its operations with both local and international market realities to maintain the viability of domestic investors (Mukisa et al., 2022).

Policy implications arising from the study suggest the need to effectively integrate solar energy with other renewable energy mechanisms in Zambia’s energy mix. Mechanisms should be designed to enable systematic dissemination and deployment of investment incentives, creating a supportive environment for local IPPs and private-sector involvement in general. Tariff reforms are particularly critical to achieving cost-reflective energy pricing, while targeted subsidies can help mitigate affordability challenges for local electricity producers and consumers. Cost-reflective tariffs are central to attracting private investment, ensuring project viability, and safeguarding returns on investment (Mukisa et al., 2022; Ochieng Omollo, 2025; Van Schalkwyk & Scholtz, 2024). The study findings therefore suggest that current policies are not entirely favourable for local investors, highlighting the necessity for tailored interventions that address specific constraints and opportunities within the solar energy sector. Such targeted policies should prioritise equitable development, reduce dependency on foreign IPPs, and promote greater participation from domestic investors.

The TIS functional approach, when adapted to developing countries, provides valuable guidance for addressing the challenges such as those facing Zambia’s solar energy sector by stressing systematic and coordinated innovation processes. By fostering effective interactions among stakeholders, policymakers can design targeted interventions that overcome barriers and create a supportive investment environment. Achieving sustainable and equitable energy development in Zambia requires an adjustment from generalized policies toward strategies tailored to the specific needs of various solar sector investment settings. Such an approach would reduce risks, enhance private-sector participation, and promote long-term growth and stability. The following sections build on this framework by examining the alignment and observed effects of financial, fiscal, and non-monetary incentives on solar investments, highlighting how each category can be optimized to strengthen investment outcomes.

Consistent with the Technology Innovation System (TIS) framework, financial incentives were theoretically expected to stimulate private-sector solar investments by improving access to capital and reducing financial barriers. The framework assumes that well-structured financial mechanisms, combined with systemic interactions among actors and institutions, should enhance investment participation and performance. However, contrary to these theoretical expectations, the study's findings revealed statistically non-significant correlations between financial incentives variables and investment performance outcomes indicating that financial factors on their own were insufficient to effectively drive substantial solar investment growth. Regression analyses equally confirmed the weak predictive power of financial incentives, with these variables accounting for only a minimal portion of the variance in investment rates.

While prior studies emphasize the critical role of financial incentives in promoting solar sector development (Kulichenko & Wirth, 2012; Sarzynski et al., 2012), the limited observed impact in this study suggests challenges in the practical implementation and accessibility to financial incentives. Despite government initiatives aimed at supporting independent power producers, the weak associations indicate that these efforts may not have fully translated into enhanced private-sector investment benefits. These findings however generally align with some of the existing literature which highlighting inconsistencies and inadequacies in the provision and utilisation of financial incentives within the solar energy sector (Amankwah-Amoah, 2015).

With the study's findings indicating that financial incentives alone have limited impact on private-sector solar investment, attention must shift to fiscal and non-monetary incentives, which are designed to provide broader structural and institutional support. Examining these incentives highlights how policy frameworks, regulatory mechanisms, and targeted non-financial measures can complement financial interventions, potentially creating a more conducive and sustainable investment environment in the solar sector.

In a similar manner and consistent with the Technology Innovation System (TIS) framework, fiscal and non-monetary incentives were theoretically expected to exert a strong positive influence on private-sector solar investments by mitigating operational barriers, fostering institutional support, and promoting systemic interactions among sector actors and networks. This is because the framework highlights the need for well-designed mechanisms, such as tax reliefs, regulatory support, and institutional facilitation including green finance which significantly influences renewable energy innovation and improves private participation and performance (Shi & Shi, 2025).

Nonetheless contrary to these theoretical expectations, the study revealed a pattern of mixed and nuanced outcomes for both fiscal and non-monetary incentives. While some overall regression models were statistically significant, indicating that groups of incentives could predict private-sector investment levels some of the individual incentive variables displayed generally weak or inconsistent correlations. Additionally, some variables showed modestly positive effects, while others were statistically insignificant, highlighting variability in their practical effectiveness.

These inconsistent outcomes may stem from the generic and broad design of fiscal and non-monetary policies. Although well-intentioned, many of these measures lack localised and scale-specific incentives which should differentiate suitability of incentives for large-scale and small-to-medium enterprises (SMEs). Implementation gaps and limited adaptation to local investment contexts likely constrained their overall impact (Deichmann et al., 2011; Blimpo & Cosgrove-Davies, 2019). Overall, these findings underscore a misalignment between theoretical expectations and observed outcomes, highlighting the need for tailored, context-responsive non-financial and fiscal frameworks. Such targeted approaches are essential to effectively stimulate diverse investment participation and enhance the practical impact of incentives within Zambia’s solar energy sector.

Contribution to Literature

This section highlights the significance of the study in advancing theoretical and practical understanding of solar energy investments in Zambia. By empirically examining the effects of financial, fiscal, and non-monetary incentives on private-sector engagement, the study provides evidence-based insights that bridge gaps in existing literature, underscoring importance of context-specific interventions and systemic stakeholder interactions, aligning with the Technological Innovation Systems (TIS) framework, and offering actionable guidance for policymakers, practitioners, and researchers seeking to improve solar sector growth in a sustainable way.

With a focus on examining incentives in scaling up of solar sector investments in Zambia, this study makes a significant contribution to the existing body of knowledge by empirically evaluating the impacts of financial, fiscal, and non-monetary incentives on private-sector investments. It addresses a critical knowledge gap in contexts typical of Sub-Saharan African countries, which face some of the highest energy deficits globally. Despite favourable conditions for solar production and a number of government initiatives aimed at reducing reliance on hydroelectric power which is increasingly becoming vulnerable to climate change impacts, growth in the solar industry remains limited. By examining the relationships between various incentive mechanisms and investment outcomes, the study provides robust empirical evidence that informs both theory and practice, highlighting the importance of tailored, context-specific policies for solar sector development.

The findings offer valuable insights for policymakers and practitioners, supporting evidence-based decision-making to address barriers in solar sector incentives. Key practical implications include advocating for equitable distribution of incentives to ensure access across all investor scales, streamlining financial policies to improve accessibility for small and medium scale investors, and designing targeted support mechanisms. Additionally, the study informs strategic planning, resource allocation, and the development of supportive investment environment that addresses high upfront costs and mitigates risks. Collectively, these contributions help strengthen the sustainability and effectiveness of solar investments in Zambia.

From a theoretical perspective, the study contributes to the literature in line with the Technological Innovation Systems (TIS) framework, emphasizing the importance of systemic interactions among stakeholders, i.e., policymakers, investors, regulatory bodies, and institutions in fostering technological advancement. By demonstrating how financial, fiscal, and non-monetary incentives influence private-sector participation, the study notably highlights the need for integrated incentive structures and coordinated stakeholder engagement. Furthermore, it fills a gap in existing research by providing empirical evidence on the effectiveness of specific incentives in

Zambia’s solar sector, challenging generalized approaches and advocating for more nuanced, locally tailored interventions.

The research also advances discussions on sustainable energy provision in Sub-Saharan Africa by offering insights applicable to other countries facing similar challenges. The findings illuminate the broader dynamics and implications of renewable energy investment decisions and the necessary conditions for their success. In terms of future research, the study underscores the importance of investigating the effectiveness of specific incentives for particular applications, exploring additional non-monetary and fiscal mechanisms, and conducting longitudinal and comparative studies to capture nuanced effects.

To conclude, this study provides a comprehensive examination of barriers and mitigation strategies associated with investment incentives in Zambia’s solar sector. By focusing on financial, fiscal, and non-monetary incentives as key determinants of private-sector engagement, the study outlines critical principles and theoretical frameworks for successful solar investments. It offers practical insights for policymakers, researchers, and industry stakeholders, advocating for the collaborative application of diverse incentives to create a more favourable environment for private investment and sustainable solar sector growth. Ultimately, it highlights the necessity of context-specific policy interventions, regulatory frameworks, and strategies, serving as a foundation for informed policy and future research. Table 52 outlines key contributions aligned to financial, fiscal, and non-monetary incentives in a clear view of each incentive contribution to literature and solar sector investments.

Table 52

Summary of Literature Contributions by Incentive Category

Incentive type	Contributions to Literature	Practical Implications
Financial Incentives	Examined impact on capital access and investment barriers; revealed limited standalone effect on investment outcomes	Highlights need for tailored financial mechanisms, improved accessibility for SMEs, and structured consumer support mechanisms
Fiscal Incentives	Assessed tax reliefs, import duty exemptions, and government subsidies; identified mixed effectiveness and inconsistent correlations with investment levels	Informs design of scale-sensitive fiscal policies, equitable incentive distribution, and cost-reflective tariffs to enhance private-sector participation
Non-Monetary Incentives	Evaluated institutional support, regulatory facilitation, and network interactions; demonstrated nuanced effects on investment performance	Supports development of integrated incentive frameworks, enhanced institutional capacities, streamlined regulatory processes, and investor protection mechanisms

Note. Summary of key scholarly contributions by incentive categories (financial, fiscal, and non-monetary). *Source*: By Author

Recommendations

The recommendations section is an important section of a research study as it translates empirical findings into actionable guidance for policy, practice, theory, and future research, thereby availing the study's findings to the broader body of knowledge. This section builds on results within the confines of research objectives and limitations to identify practical steps for stakeholders in a particular field of study, to improve study approaches for scholars, and to provide conceptual guidelines for advancing theory. Well formulated recommendations validate the importance of the research, links the gap between evidence and decisions to ensure that findings are not deemed as isolated outcomes but as stepping blocks for growing knowledge. By strongly founding the recommendations in collected data and linking them to real life contexts, academic research, practice and socio economic significance is enhanced (Serra et al., 2024)

Recommendations for Policy and Practice

Recommendations for policy and practice present actionable insights derived from the study findings that can assist stakeholders in addressing identified challenges, consolidating current systems, and enhancing decision making processes. This section is critical because ultimately research is intended to inform real world improvements by linking and translating empirical evidence into practical interventions that support policymaking, industrial practices. By grounding recommendations in data driven evidence, the study ensures that proposed actions are feasible, contextually relevant, and aligned with observed sector dynamics, while also providing guidance for future reforms and sustainable implementation.

The recommendations arising from this study on scaling solar energy investments in Zambia are directed at key sector stakeholders which include government institutions, development partners, academic and research bodies, and private sector investors operating at different investment scales. Collectively, these recommendations seek to improve policy implementation, enhance operational effectiveness, and strengthen incentive deployment mechanisms within the solar energy sector, while promoting greater coordination and consistency among actors involved in sector development.

Generally the findings indicate that incentives demonstrating stronger associations with investment outcomes are more effective in supporting solar sector growth, whereas financial, fiscal, and non-monetary incentives with weak or non-significant relationships highlight the need for better-designed and more targeted mechanisms (Dagnachew et al., 2020). These results point to limitations in current incentive structures, including institutional inefficiencies, administrative barriers to financing access, and inadequate mechanisms to offset high capital and operational costs. They further underscore the importance of improved policy alignment and coordination to enhance sector performance. The subsequent sections therefore present specific recommendations for policy and practice relating to financial, fiscal, and non-monetary incentives, consistent with the study's empirical findings.

Recommendations for Financial Incentives. In line with the study's results arising from financial incentives, findings revealed mixed significance levels and weak predictive effects for individual variables, in which overall regression model showed no predictive power for return on investment, thereby accounting for a modest variance in the outcome variable. These results point to the need for more robust and targeted financial policies and practices that directly address the high initial and operational costs associated with solar investments. Policy interventions should focus on broadening the accessibility of financial incentives to cover a wider spectrum of solar-related investment constraints, ensuring balanced growth across the sector. Strengthening the viability of mini-grid and off-grid solar systems requires the development of tailored financing frameworks that support both utility-scale investors and small-to-medium enterprises (SMEs). In addition, policy should incorporate structured financing for consumer-support mechanisms such as periodic, socio-economically aligned subsidies aimed at improving affordability for households that adopt solar technologies. The weak associations observed between financial-access incentives and private-sector investment rates also highlight limited coordination among local actors and international financing institutions hence the need to promote stronger synergies among players in the solar sector in order to create a more enabling and rewarding investment environment (Ochieng Omollo, 2025).

The key recommendation for practice is to strengthen the practical implementation of financial-support mechanisms by improving access to tailored financing for all categories of solar investors and ensuring that financial incentives effectively reduce both initial and operational costs. Practitioners should prioritise financing models that enhance the viability of mini-grid and off-grid systems, especially for SMEs, while also supporting end-users through well-structured and context-appropriate subsidy schemes. Additionally, enhancing coordination among sector actors and financing institutions is essential to streamline access to funds, improve investor confidence, and create a more favourable environment for scaling private-sector solar investments.

On a global scale, it is notable that, Sub-Saharan Africa has limited access to global climate finance, getting only 3% despite accommodating huge populations and difficulties faced to scale up green energy solutions. Green Bond initiatives still remain at low levels indication potential while financing challenges remain high at household and mini-grid levels due to currency instability and inconsistent PAYG models. In this regard policy should endevour to expand access to green and climate bonds and promote innovative mini-grid system designs that enhance affordability, resilience, and sustainability for rural and underserved communities (GET.invest, 2019; Tan et al., 2022; Asuamah et al., 2021). Ultimately, persistent barriers such as high upfront costs for solar technology, limited financing channels, and other affordability constraints particularly for household scale and off-grid systems, need to be systematically addressed through strategic policy reforms which cater for all factors so as to accelerate solar uptake in Zambia (Kachapulula-Mudenda et al., 2018; Ochieng Omollo, 2025).

Recommendations for Fiscal Incentives. Results relating to fiscal incentives showed a statistically significant overall effect but with a modest explanatory power of approximately 3%. Individual fiscal variables produced mixed outcomes, suggesting uneven effectiveness and limited implementation impact. This highlights the need for policymakers to strengthen and better target fiscal measures so they yield consistent, measurable improvements in solar investment levels. Policy efforts relating to fiscal incentives should begin with broadening and refining import duty and tax reliefs to cover a wider range of solar equipment, particularly components essential for mini-grid systems and household-level installations. In practice, an updated list of duty- and tax-exempt items, including their validity periods, should be made readily available to investors. Progress should then be monitored by tracking annual import volumes and investment uptake. In addition, consumer cost pass-through mechanisms should be ensured so that tax reductions translate into lower prices for end users. This can be achieved through clear, time-bound regulations and regular monitoring to evaluate compliance. Policymakers should also design scale-sensitive fiscal incentive frameworks**,** offering differentiated packages for large-scale projects and smaller investments. These frameworks should be published, piloted, and assessed within defined time frames to determine their effectiveness.

To further support market growth, fiscal policy should incorporate measures that improve affordability**,** such as consumer subsidies or rebate schemes aligned with local socio-economic conditions (Amankwah-Amoah, 2015; Dagnachew et al., 2020; Ochieng Omollo, 2025). For practice, pilot programmes in selected locations can be implemented for fixed periods such as one year to help assess adoption rates and cost recovery outcomes. Improving access to finance is another equally important aspect in policy formulations. This could be done through facilitating climate finance and green investment instruments, such as green or climate bonds, and creating regulatory environments that attract and support these financial flows into solar projects. Finally, stronger coordination is required across government agencies. Establishing cross-agency working group**s** involving finance, energy, trade, and regulatory institutions to help harmonise fiscal measures, oversee implementation, and evaluate progress against clearly defined targets within set timelines.

Recommendations for Non-Monetary Incentives. Non-monetary incentives in this study exhibited mixed associations with PSIR and ROI. Some variables showed significant but weak relationships, while others were non-significant. These outcomes indicate that institutional, contractual, and market-readiness barriers contribute to limiting the effectiveness of non-monetary incentives. Accordingly, policy efforts should focus on strengthening institutional capacity, improving contractual bankability, and enhancing investor protections. A key policy need is the standardisation and improvement of contractual instruments. This includes developing and issuing standard, bankable PPA prototypes along with accompanying regulatory frameworks to help reduce contractual risks and attract private financing. For practice, these templates should be piloted for specified time periods to evaluate their effectiveness. Strengthening investor protections and dispute-resolution mechanisms through clear, time-bound processes is also essential to build investor confidence. Practice approach should further focus on establishing centralised one-stop investor facilitation points to streamline administrative procedures for solar projects. This effort must be coupled with monitoring systems to evaluate effectiveness over time. Improving institutional capacities including technical expertise, advisory support, project appraisal skills, and bankability assessment capability is crucial for investments. Targeted capacity-building programmes for regulators and intermediaries should be implemented within defined timeframes and measured using clear performance indicators. Simplifying and accelerating approvals and licensing is also necessary hence administrative reforms should introduce time-bound permitting rules, digital submission platforms, and monitoring of average approval times to track improvements and reduce uncertainty for developers.

In addition to the above, policymakers should promote integrated non-monetary incentive packages aligned with the TIS framework, which should combine institutional support measures and be tailored to different project scales and geographic locations. For practice, selected regions should be monitored over set periods e.g., 12 to 18 months to assess investor uptake and project completion rates. Most importantly, a comprehensive integrated incentive framework should be developed which combines all categories of incentives with clearly assigned execution roles, monitoring mechanisms, and periodic effectiveness review cycles. Continuous monitoring and evaluation will enable evidence-based adjustments, while aligning fiscal and non-monetary reforms with the Technology Innovation System (TIS) perspective will help strengthen institutional capacity, market formation, and overall sector development. Table 53 presents recommendations for policy and practice relating to the three categories of incentives, namely financial fiscal and non-monetary for the solar energy sector.

In summary, recommendations of findings for practice and policy relating to financial, fiscal and non-monetary incentives indicate that fiscal incentives bring forth statistically significant influence on solar investment outcomes, however their limited explanatory power and non-consistent effectiveness point to gaps in targeting, implementation, and coordination. Strengthening fiscal measures through broader and clearer tax and duty reliefs, scale-sensitive incentive designs, affordability-enhancing mechanisms, and improved access to green finance is therefore essential. Similarly, the mixed performance of non-monetary incentives highlights persistent institutional, contractual, and market-readiness constraints that weaken investor confidence. Addressing these challenges requires improved contractual bankability, stronger investor protections, streamlined administrative processes, and enhanced institutional capacity. Collectively, the results underscore the need for an integrated incentive framework in line with the Technology Innovation System (TIS) perspective that combines various types of investment reforms, supported by clear implementation roles, monitoring tools, and periodic evaluations to sustainably scale solar investments

Table 53

Recommendation for Policy and Practice

Incentive	Variables		Results Summary	Recommendation for policy and Practice
	LV	DV		
Financial	FIAL PSIR	ROI ROI	Statistically Non-Significant and weak correlations	**Policy**: Broaden access to tailored incentives covering more solar activities; Develop tailored /integrated finance frameworks for utility & SMEs**;** introduce pilot, socio-economic subsidies to improve affordability; Strategies to address high upfront costs & weak financing. **Practice**: Initiate tailored pilot financing for SME; Expand financial access with regular updates; Introduce periodic reviews for socio-economic activities to improve affordability**;** institute quarterly meetings for cross-institutional platforms to enhance coordination. Measure mitigations within pilot timeframes
Fiscal	SFI EFI	PSIR PSIR	Mixed effects with significant and non-significant relationships with outcome variables	**Policy:** Foster coordinated scale-specific incentive framework to expand tax & duty exemptions for solar components, foster time-bound consumer-protection, pilot tailored incentives for various investments, foster affordability through socio -economic subsidies, improve access to climate-finances, & foster inter-agency synergies **Practice:** Implement time bound (3–5-year) coordinated & regularly updated incentive frameworks designed to: - broaden duty & tax waivers, enforce time-bound cost-pass-through regulations, pilot scale/location specific incentive packages, initiate affordability measures through socio economic schemes, enhance access to climate-financing & start inter-agency synergies & monitoring.

Continued on Next page

Table 53 - Continued

Incentive	Variables		Results Summary	Recommendation for policy and Practice
	LV	DV		
Non-monetary	ICSI	PSIR	Mixed effects with significant and non-significant relationships with outcome variables	**Policy:** Strengthen institutional/contractual frameworks for bankable PPAs; Enhance investor protections with clear, time-bound dispute-resolutions & risk-mitigations; Create central facilities for streamlined administration/regulation; grow institutional capacity through training of regulators & intermediaries; Implement integrated incentives aligned with TIS framework tailored for various scales/locations; develop defined integrated incentive frameworks with clear roles. **Practice:** Disseminate standard PPAs piloted across projects with time frames to assess effectiveness; introduce clear, time-bound dispute-resolutions & risk-mitigations assessed by time reductions & satisfaction scores; Implement structured, competency based training & monitor through KPIs; Design TIS-aligned incentive packages tailored to investment types/locations which are time bound & measurable through project uptakes & investor rates; Pilot centralised facilitation centres & measure success levels by observed reduced administrative time & increased service utilisation.
	ASS	PSIR		
	LVTI	PSIR		
	IPPA	ROI	Mixed effects with significant & non-significant relationships with outcome variables	
	IEnv-IPP-5Y	ROI		
	B-PPAs /IPPs	ROI		

Note. Recommendations for policy and practice for all targeted incentives: ICSI = Initial Cost for Solar; KPIs = key performance indicators; TIS =Technological Innovation System. *Source*: By Author.

Recommendations for Application

The recommendations for application based on the findings, are mainly directed towards a broad range of stakeholders in the solar sector value chain, i.e., government agencies, international donor partners, academic and research institutions and private investors in various scales and types of solar investors including those involve in purchasing and supplying of solar equipment. These recommendations are intended to influence policy, drive initiatives, and shape the investment landscape for renewable energy technologies (RETs), particularly solar. In addition, the recommendations are intended to help promote collaboration between local and international investing partners, thereby fostering a unified location and scale appropriate approach to advancing solar energy development.

The recommendations for application section therefore holds vital significance as it bridges the gap between study findings and practical implementations through the provision of important investments insights in the solar sector specifically on financial, Fiscal and non-monetary incentives. The findings provide a pathway for policymakers, financiers, and implementers who support the growth of the private sector in solar energy. Unveiling of various aspects of financial and fiscal and non-monetary incentives and their relationship to solar sector investment performance equips policy makers and implementers with the information required to undertake knowledgeable resolutions to drive more investments in the private sector solar investments. This section plays a vital role in explaining research findings into tangible practical applications that can influence sustainable future investments in solar energy.

To systematically and effectively outline the recommendations from the findings, this section identifies key insights from the findings from relationships of financial, fiscal and non-monetary incentives with outcome variables in the solar energy sector, detailing the nature and strength of their associations and effects on performance outcomes, and to ultimately provide effective practical applications.

Recommendations for Application: Financial Incentives

Findings on financial incentives for the private sector solar energy investments shed vital points on the dynamics in the sector, offering invaluable insights for various stakeholders. These findings highlight the impact of financial incentives on private sector solar investments in the country, emphasising the crucial role they play in shaping the solar energy sector. For financiers, regulators, and implementers involved in the solar sector, these research findings provide comprehensive understanding of solar investments dynamics and offer guidance on best approaches to enhance measures for the growth of the solar energy sector and ultimately contribute positively to policy formulations. Through these findings pathways for effective financial strategies and policies that can drive increased private sector solar investments are highlighted, evaluated and recommendations given for future improvements or pursuits. A summary of the correlation tests for financial incentives' variables with private sector investment outcomes in form of return on investments are presented in table format, outlining independent and dependent variables, the nature of correlation and corresponding recommendation for applications. Table 54 presents an outline of the recommendations for application relating to financial incentives.

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Table 54

Recommendations for Applications for Financial Incentives

Incentive	**Variables**		**Results**	**Recommendation for Application**
	I.V	**D.V**		
Financial Incentives	FIAL	ROI	Significant, yet weak correlation	• Implement targeted financial support to improve effectiveness thereby enhancing ROI • Introduce 5-year tax holiday for SMEs to enhance investment viability. • Introduce flexible financial access requirements for SMEs with limited capital, collateral, or credit history. • Formulate a dedicated solar low-interest financing facility for green loans & credit guarantees. • Streamline grant & loan application procedures to reduce bureaucratic delays & improve accessibility.
	PSIR	ROI	Non-Significant & weak correlation	• Enhance accessibility to financial incentives to boost private sector solar investment rates albeit with other initiatives. • Promote mixed financing models combining Govt subsidies with private financing to de-risk solar investments

*Note***.** Outcome Variable = ROI**;** Predictors- FIAL, PSIR; IV= Independent Variables; DV**=** Dependent Variables.
Source: By Author.

Recommendations for Application: Fiscal and non-monetary Incentives

Similarly, correlation and regression analyses were conducted to examine the relationships between fiscal and non-monetary incentives and private-sector solar investment rates, as well as their effects on return on investment (ROI). These analyses produced varied levels of statistical significance and correlation strengths, underscoring the complex interactions between different types of incentives and investment outcomes. The findings are particularly valuable for policymakers and practitioners, as they provide empirical guidance for designing effective fiscal measures to stimulate private-sector participation in solar energy investments. The diverse results observed from fiscal and non-monetary incentives variables equally inform equally diverse recommendations for application, which are summarized in table 55.

The key recommendations for application relating to fiscal and non-monetary incentives are derived from the associations and predictive effects of fiscal and non-monetary incentives on investment performance variable in Zambia’s solar energy sector. The outcome variables were divided into two, namely private sector investment rates (PSIR) and return on investments (ROI). The findings and corresponding recommendations are important as they offer critical insights to support evidence-based policymaking and the formulation of targeted fiscal interventions in enhancing sustainable growth in solar investments (Hussain et al 2025). Moreover, the observed variability in the influence of non-monetary incentives further highlights the need for integrated and adaptive incentive frameworks. By leveraging these insights, stakeholders can formulate more responsive fiscal strategies and policy applications that effectively promote solar sector development (Hartley, 2013

Table 55

Recommendations for Applications for Fiscal and Non-Monetary Incentives

Incentives	Results	Recommendation for Application
Fiscal Incentives	• Non-Significant weak correlation with PSIR	• Implement targeted tax relief & rebate schemes to enhance ROI. • Introduce a 5-year tax holiday for SMEs to boost investment viability. • Offer duty & VAT exemptions on solar equipment to reduce upfront costs. • Develop flexible fiscal frameworks for varied investment scales. • Streamline and digitalize tax incentive administration to improve access.
Non- Monetary Incentives	• Significant Associations & Effects With PSIR • Varied Associations & Significant effects with ROI	• Strengthen institutional support and investor facilitation services. • Enhance access to technical training and capacity-building programs. • Promote transparent & stable regulatory frameworks for investor confidence. • Foster public-private partnerships to improve project implementation. • Simplify licensing & approval procedures to accelerate investment processes.

Note. Criterion: PSIR = Private sector investment rates**.** Predictors**:** SFI = Suitability of Fiscal Incentives, EFI **=** Effect of Fiscal Incentives. *Source***:** By Author

Recommendations for Future Research

Recommendations for future research are an important section of academic investigation and writing because they extend the contribution of a study to the attained insights past the prevailing findings**,** guide consequent examinations, and help build a collective body of knowledge. By thoroughly identifying gaps, unanswered questions, or methodological limitations exposed through the current study, this section provides a direction for future researchers to improve, reproduce, or expand on the existing work, ultimately advancing theoretical understanding, empirical evidence and practical approaches in the field (Arviansyah et al., 2024). Well outlined recommendations also improve the significance and effect of a study by suggesting how future work can address background variations, implement alternative designs, explore new variables, or improve generalisability, which ultimately supports continuing academic investigations. In the context of investment incentive strategies in the solar energy sector, such recommendations help to concentrate forthcoming research on developing dynamics or underexplored relationships that were not considered in the current scope of the study, thereby ensuring that follow-up studies provide deeper insights in informing policy and practice in the concerned field of study (Connelly, 2023).

Future research for this research focuses on examining the impacts of financial, fiscal, and non-monetary incentives on solar sector investment performance levels. This study revealed nuanced relationships and varying effects of these incentives on performance outcomes, pointing to the need for tailored incentive strategies that address specific types, scales, and locations of solar investments. Such a study has ability to explore how customized approaches can better support diverse investment needs in the sector. Future research should therefor further investigate incentives aimed at mitigating key challenges, such as high initial investment costs, limited affordability, and barriers to obtaining financing in complementarity with diverse socio-economic factors. Studies should also focus on strategies to improve the investment environment by enhancing the bankability of partnership agreements and solar energy projects basing on ad-hoc local socio-economic factors. By addressing these gaps, future studies can contribute to the development of more effective incentive structures that support sustainable growth in solar energy investments. This continued exploration is critical to ensuring the long-term viability and success of renewable energy projects.

Within the context of Zambia's solar energy sector, several critical deficiencies have been identified that warrant further exploration. Notably, the lack of sufficient operating capital for the state-owned utility company has resulted in inadequate generation capacities, leading to unreliable and unstable power supplies. This shortfall also undermines the company’s ability to fulfil its commitments under agreements with independent power producers (IPPs). Furthermore, the implementation of non-cost-reflective tariffs by ZESCO which have been in effect until as recent as October 2024, has been causing significant operational challenges, resulting in systemic inefficiencies that impede progress in the solar industry (Bayliss & Pollen, 2021). These challenges underscore the intricate link between financing gaps and the need for targeted policy reforms to attract private capital investments into Zambia's solar sector. Addressing these gaps requires a focused research agenda that builds on existing studies while identifying new avenues for exploration. Future research should concentrate on the inherent variations in the suitability of incentive structures across different scales, types, and locations within the solar industry.

This recommendation aligns with prior literature and underscores the importance of systematically linking existing knowledge to current studies. As highlighted by Torraco (2016), integrating insights from previous findings establishes a solid foundation for robust future research. Therefore, forthcoming studies should prioritize investigating how tailored policy reforms and incentive strategies can address the identified gaps and support the sustainable growth of Zambia's solar sector. By bridging these research gaps, future inquiries can provide actionable insights that inform policy formulation, improve investment frameworks, and foster a more stable and inclusive solar energy ecosystem.

Building on this overarching overview, it is also essential for future research to interrogate the individual incentive areas examined in the study, namely financial, fiscal, and non-monetary incentives in order to fully understand their distinct effects on solar investment outcomes, thereby enabling future studies more precisely leverage on evidenced gaps, and how each incentive type can be refined to better support sector-wide growth. The following subsections outline targeted recommendations for future research relating to each of these incentive categories.

Recommendation for Future Research: Financial Incentives

The correlation test results for financial incentives, specifically access to financing opportunities and private sector investment rates as indicators of financial injections into the solar sector, revealed non-significant correlations with the return on investment from private solar investments. Additionally, the correlation strengths were generally weak, emphasizing the need for complementary measures and tailored interventions to enhance the effectiveness of existing financial incentives. To address these gaps, future research should explore synergies between investment interventions and existing financial incentives. This includes examining ways to supplement these incentives with measures such as improving regulatory frameworks, addressing technical requirements, and enhancing market availability to reduce variability and foster a stable investment environment. Such a comprehensive approach can significantly boost solar investments.

The first research question focused on the association between financial incentives and performance. Findings on financial incentives access level (FIAL) revealed a non-significant relationship, and so did the private sector investment rates suggesting that inadequate financial access adversely affects investment performance. While existing literature underscores the importance of financial incentives, their actual impact on investment remains low. This underscores the need for coupling financial incentives with non-financial or fiscal measures to address challenges such as high initial costs for solar equipment and infrastructure. Additionally, stringent financing mechanisms should be introduced to ease access to funding for solar investments (Babu et al., 2025; Bowa et al., 2017)

Future research should prioritize measures to streamline and enhance financial incentives. Specifically, studies should aim to identify diverse financing sources and develop long-term initiatives beneficial for both financiers and investors. It is also crucial to investigate the processes and procedures for obtaining financing to propose solutions for streamlining these steps and reducing demanding requirements, such as historical reputations or high financial capital criteria for investing institutions. While reducing barriers to access, research must also address necessary stringent measures to mitigate investment risks, ensuring a balanced approach.

In summary, future research should refine financial incentives to make them more accessible and effective across various investment scales and types. By doing so, it will address a critical gap in the literature, promote private sector investments, and contribute to the sustainable growth of the solar energy sector.

Recommendations for Future Research: Fiscal Incentives

The second research question was formulated to examine the relationship between the effectiveness of fiscal incentives and private sector investment rates in the solar energy sector. The overall model results for fiscal incentives were significant, leading to successful rejection of the null hypothesis, which suggests that a noticeable relationship existed between the independent variable (fiscal incentives) and the outcome variable. Two-variable correlation model tests were conducted using SPSS, revealing varying relationships and effects on the outcome variable. However, while the overall model demonstrated a statistically significant effect, the individual factor correlations were inconsistent and lacked strong impact.

These findings indicate that fiscal incentives, as currently implemented, do not comprehensively address the diverse needs of varying investment levels, types, and values. This limitation undermines their effectiveness in fostering robust private sector investments in the solar industry. The results highlight the need to refine fiscal incentives into practical, accessible, and broadly applicable support mechanisms tailored to suit different investment contexts.

The subsequent subsection elaborates on the specific fiscal incentives identified in the study and offers corresponding recommendations for future research. These recommendations aim to address the gaps and inefficiencies revealed by the findings, ensuring fiscal incentives are more impactful and aligned with the diverse needs of the solar energy sector.

Recommendations for Future Research: Non-Monetary Incentives.

Under the scope of the third research question relating to non-monetary incentives, first correlation test examined the relationship between the Initial Cost for Solar Sector Investments (ICSI) and private sector investment rates. The results revealed a significant but weak positive correlation, consistent with existing literature affirming the critical importance of mitigating initial costs in driving solar energy investments (Wu, 2025). Key findings from the literature highlight several barriers to sectoral growth, including stringent institutional requirements for working capital, traceable reputations, project viability assessments, and the high credit risk associated with limited investment experience. These challenges are particularly pronounced for smaller investors. Additionally, there is a noticeable bias favoring utility-scale investments, which often have superior technologies and larger capital bases (Chukwuma-Eke, 2023).

In light of these results, future research is recommended to focus on streamlining procedural requirements for accessing non-monetary incentives. This entails evaluating the effectiveness of tailored initiatives designed to meet localized investor needs, such as Aligning non-monetary incentives with varying capital bases of investing organizations, addressing income levels of potential energy service clients, considering the technological landscape of specific locations and accounting for the economic status of target areas. The ultimate goal is to develop locally tailored non-monetary incentives that align with the specific characteristics of the investment environment. By removing barriers that limit participation especially for smaller-scale investors and projects, therefore future research should endevour to contribute by establishing a more accessible and equitable incentive framework. This approach has the potential to foster increased investment levels in the solar sector, ensuring that the benefits of renewable energy development are widely distributed.

Similarly, under non-monetary incentives, the study also explored the relationship between Type-Value-Location based incentives and solar sector investment rates. The correlation test results indicated a non-significant and weak correlation, diverging from existing literature that generally highlights effectiveness of these concessions, particularly in promoting low tariffs for renewable energy from mini-grid plants in remote areas over a sustained period to boost solar sector investments (Bowa et al., 2017). This discrepancy highlights the inconsistency in the design and application of Type-Value-Location-based incentives across the solar sector. The recommendation for future research is to explore refiner and enhanced incentives and concessions that are specific to particular levels of investment so as to appropriately conform to their needs. In turn this will guarantee more targeted and impactful approach that encourages solar sector investments, especially in off-grid areas. By addressing disparities between utility-scale and small to medium-scale investments in Zambia, future research can contribute to refining fiscal incentives, aligning them more closely with the needs and dynamics of different scales of solar investments, thereby promoting a more effective and equitable incentive framework for the solar sector. Additionally, it is notable that while the literature confirms that effectiveness of incentive structures is influenced by dynamic investment climates in which different scales, types, and locations of solar investments thrive (Michoud & Hafner, 2021) the availability of such incentives in the sector is marred by bureaucracies, irregularities and inconsistencies in dissemination procedures.

It is notable that Mini grid systems employed in remote locations cannot be compared to typical retail businesses as they are small-scale utilities often facing challenges of high upfront investment costs, high operation costs, unclear regulations, licensing or permits, and sometimes tariff settings (Blimpo & Cosgrove-Davies, 2019; Ondraczek, et al., 2015). For the Zambia perspective, many of the investments in solar are at household level and mini-grid systems, categorized under the small and medium enterprise (SME) scale. Challenges of investments under this scale are social and technical in nature, such as low affordability levels among consumers who are often are low-income- seasonal earners and also high initial and maintenance costs respectively (Stritzke & Jain 2021; Kachapulula-Mudenda et al., 2018). Recommendation for research on this aspect thus focuses on further examination of deficiencies in the existing Location- Type- value based concessional incentives so as allow pursuit of approaches that target the needs of potential investors by ensuring that small scale investors' prospects are more attractive

Finally, the examination of Affordability of Solar Services (ASS) revealed significant results, though the impact on the outcome variable was modest, explaining only 4.2% of the variance ($r = .274$, $p < .001$, R Square = .042). These findings align with the insights outlined in literature, which underscore the fact that low affordability levels, particularly in lower-income rural communities, remain a substantial barrier to sustainable solar energy investments. (Ochieng, 2025). This highlights affordability as a critical factor influencing private sector solar investments, however current framework empirically exhibits limited predictive strength.

Building upon these results, future research should focus on refining financial frameworks by enhancing accessibility through identifying and creating financial tools and platforms that are accessible to a diverse range of investors, including small and medium-scale players. It is also vital to introduce less stringent and adaptable requirements for accessing financial incentives, ensuring alignment with varying investment capacities and regional contexts. Furthermore, research should explore viable approaches to subsidizing solar energy services for low-income consumers at reduced tariffs, potentially through initiatives that promote income growth or enhance affordability levels over time. Addressing these aspects can create a more comprehensive and impactful financial framework, fostering inclusivity and equitable access within the solar energy sector.

To further align with the findings, future research should prioritize innovative strategies to overcome financial barriers. This includes streamlining processes by addressing the rigorous requirements imposed by financial providers, simplifying processes, and reducing administrative inconsistencies. Additionally, efforts should focus on reducing the cost of capital by tackling bureaucratic hurdles and revisiting stringent application criteria imposed by financing institutions. Future studies should also consider practical solutions, such as developing tailored financial frameworks that meet localized investor requirements, aligned with varying capital bases, income levels, technological landscapes, and economic contexts. Promoting strategies to subsidize solar services in low-income areas can enhance their affordability while fostering localized development. By attending to these gaps, prospective research can bridge limitations in preceding literature, advancing frameworks into robust, inclusive, and effective systems. These efforts would contribute to a more conducive financial environment for solar energy investments, thereby supporting sustainable growth and fostering equitable progress across the entire solar energy sector. Under the ambit of research question 3, the second set of investment incentives, namely Investment Promotions and Protection Agreements for Independent Power Producers (IPPAs)**,** Investment Environment Improvements for IPPs over the Last Five Years (IEnv-IPPs-5Y)**,** and the

Bankability of Power Purchase Agreements and Independent Power Producers (B-PPAs-IPPs) were examined with return on investments (ROI) as the dependent variable. The findings revealed varied correlation strengths and statistical significances indicating non-significant and weak correlations for B-PPAs-IPPs, while IPPAs and IEnv-IPPs-5Y indicated statistically significant albeit with weak correlations.

With the aforementioned findings, future research should aim at streamlining the investment environment by enhancing initiatives such as localised promotion of solar energy adoption and Power Purchase Agreements (PPAs) that extend to third-party financing and maintenance. Additional emphasis should be placed on exploring measures to support investors through mechanisms like duty and tax waivers, tax credits, grants, and subsidies. Addressing these aspects in future studies can contribute to developing a more conducive investment environment, ultimately fostering greater private sector participation in solar energy projects.

In examining IPPAs and IEnv-IPPs-5Y in relation to RoI, both variables displayed significant correlations, confirming their importance as pivotal investment promotion strategies in the solar sector. However, the weak correlations observed could stem from inconsistent application across different investment scales or an overemphasis on large-scale investments, as suggested by Haigh (2023). Moreover, the absence of clear and effective guidelines, particularly for utility-scale investments, may have further constrained broader adoption (Timilsina et al., 2012). Future research should therefore focus on tailoring promotional incentives and partnership agreements to align with the unique characteristics of the local investment environment. This includes investigating economic levels, technological capacities, and the financial capabilities of investing institutions. Special attention should be given to developing Power Purchase Agreements (PPAs) and Public Private Partnerships (PPPs) tailored to small and medium-scale (SME) Independent Power Producers (IPPs). By addressing these elements, research can facilitate the accelerated adoption of solar technologies within SME groupings, promoting inclusive and sustainable growth in the solar energy sector. These tailored approaches have the potential to overcome existing barriers, foster innovation, and ensure the equitable diffusion of solar technologies, thereby contributing to the attainment of a robust and maintainable solar energy industry. Recommendations for future research relating to financial fiscal and non-monetary incentives are outlined in table 56.

Table 56

Recommendation for Future Research

Incentive	D.V	Findings Summary	Recommendation for future research
Financial	PSIR	Statistically non-significant Model results, weakly correlated with outcome variable ((ROI), indicating non-significant prediction of variations in ROI.	Undertake targeted investments review & redesigning of incentive mechanisms within 5 years to enhance effectiveness & predictive influence on ROI, through data-driven monitoring & stakeholder feedback in the solar sector
Fiscal	PSIR	Model results significantly predicted private-sector solar investment rates albeit, strength of individual variable correlations with outcome variable varied across the predictors.”	Strengthen & harmonise investments implementations in the next 5 yrs for improved consistency & predictive influence of all factors on PSIR, supported by continuous performance assessments.
Non-Monetary	PSIR	Model significantly predicted private sector investments in solar energy in Zambia, despite explaining a mere 8.7 % variance in the outcome variable	Improve investments design & implementation per 5 yrs durations to increase explanatory power in solar investments, through structured investor engagement & regular performance appraisals
	ROI	The model results indicated that non-monetary incentive variables significantly predicted Return on Investment (ROI) in private solar energy investments in Zambia, F(3, 240) = 4.741, p = .003, accounting for approximately 5.6% of the variance in ROI	Reinforce & expand category-incentive strategies in subsequent 5 yrs to attain positive effects & with good variance in the outcome variable, through periodical monitoring & factoring in, investors views in the sector.

Note. Recommendations highlight in-depth/ longitudinal research PSIR- private sector investments rates; ROI- Return on Investments.

Source: By Author

Research Recommendations for Future research: Regulations and Markets

Future research recommendations on regulations and markets are an important aspect for promoting evidence based policy designs and refining the effectiveness of market frameworks that ultimately shape the investment atmosphere. This section outlines an orgainised foundation for identifying regulatory gaps, market distortions, and ever changing institutional dynamics or nuances that may not be fully captured within the scope of the current study. By highlighting areas where regulatory instruments, incentive structures, and market mechanisms require further empirical scrutiny, future research directions help refine policy receptiveness, augment market efficiency, and uphold adaptive approaches in the ever evolving renewable energy landscape. Such discussion also ensures continuity of academic inquiry through guiding future studies toward context-sensitive regulatory reforms and market novelties that can help sustain lasting sector growth (Gwerder, 2019).

Therefore for this study, future research on regulatory and market dynamics should build on existing literature that confirms the positive influence of incentives such as tax credits, subsidies, import duty exemptions, VAT relief, and investment guarantees, while also reflecting the study's findings that reveal uneven effects across different investment contexts. These variations are largely driven by differences in the investment climate, project scale, technology type, and geographical location within the solar sector (Stritzke & Jain, 2021b). In light of these complexities, future studies should adopt more targeted methodological approaches and examine regulatory and market adjustments that better account for contextual differences, with the aim of supporting more predictable and sustainable growth in solar energy investments.

Future research should employ a multifaceted correlation approach to incorporate variables specific to utility-scale and those specific to small-to-medium-scale investments. This involves considering attributes such as location, scale, and investment type. The disparity between utility-scale and smaller-scale investments highlights the need for location-specific and type-specific analyses through advanced quantitative methods, such as multiple regression and econometric models in order to uncover nuanced correlations of incentive with utility scale and small scale investments and also their individual and collective impacts on investment outcome variables (Delapedra-Silva, 2022). Such an approach is essential, given the partial and fragmented investigative methods in existing literature.

Similarly it is important to adopting cross-disciplinary collaboration which incorporate expertise from different back grounds such finance, economics, technology and energy in order to provide diverse valuable insights into the composition, efficacy or computations of taxes, loans, excise duty, and other related incentives to the sector. This approach promotes innovative responses to complex issues and helps foster holistic understanding of the comprehensive frameworks that can influence solar sector investments growth. Additionally cross-disciplinary collaboration can lead to more practical and inclusive solutions, particularly for small and medium-sized investors (Van Rijnsoever & Hessels, 2011).

Longitudinal studies are recommended to track changes in the effectiveness of financial, fiscal and non-monetary incentives over time. Such studies help to examine trends and patterns and to determine whether the impact of incentives varies correspondingly to deferent economic conditions. Factors such as economic growth, exchange rates, macroeconomic stability, and resource rents may significantly influence domestic and foreign direct investments in a sector such as solar energy (Hassett & Paavilainen-Mäntymäki, 2013). By incorporating policy measures for macroeconomic stabilization and inflation control, future research can identify long-term attributes of incentives that propel solar energy development.

Comparative analysis is another essential approach for future research. This involves comparing the effectiveness of financial and fiscal incentives across different regions or countries to identify contextual variations. Socio-economic development, population growth patterns, and corresponding energy demands vary greatly, necessitating tailored incentive schemes. Comparative studies have demonstrated differences in the impacts of incentive models across Europe, America, Asia, and Sub-Saharan Africa, highlighting the importance of localized solutions (Muhammed & Tekbiyik-Ersoy, 2020). In Zambia, where small and medium-scale solar investments dominate, research should prioritize these sectors to improve the overall solar industry outlook.

Given the variations in incentive structures across investment climates (Michoud & Hafner, 2021), future research should further focus on developing tailored incentive frameworks. This includes analyzing how customized incentives optimize investment levels and efficiency within the solar sector. The diffusion of solar investments depends on the diversity of incentives and policy implementation (Kılıç & Kekezoğlu, 2022). Separate analyses of variables for different geographical locations and scales should be conducted to understand how local and international factors influence the effectiveness of incentives (African Development Bank Group, 2018a).

On the other hand, future research should also explore ways to improve regulatory environments and create viable financial markets to accelerate private sector investment flows into solar energy projects. Adjustments to regulatory frameworks should align with financial market behavior, in facilitating international and domestic fiscal support for solar projects in Zambia

(Lyambai, 2018). These efforts will help enhance the understanding of financial and fiscal incentive dynamics, ultimately promoting equitable growth and sustainable energy development in the country. By addressing these recommendations, future studies can contribute significantly to advancing Zambia's solar sector and fostering a more inclusive and effective investment landscape.

In closing, future research recommendations are essential for advancing academic understanding and practical applications in solar energy investment as the recommendations highlight gaps in existing knowledge and propose pathways to enhance the financial, fiscal, and non-monetary incentives critical for promoting solar energy investments (Lwesya, 2025). This study revealed varied and nuanced relationships between different investment incentives and performance outcomes, highlighting the necessity for more targeted and context-sensitive strategies (Benedetta et al., 2025). Accordingly, future research should examine how tailored regulatory instruments can better respond to the specific needs of different investment scales, technology types, and geographic locations, while ensuring alignment with existing and emerging solar markets. The findings should guide the development of regulatory and market strategies that address persistent challenges such as high upfront costs, limited affordability, and barriers to accessing finance (Bowa et al., 2017). Further investigations should also explore how strengthening market conditions, particularly through enhanced bankability and standardisation of partnership agreements can improve investor confidence and support sustainable growth across solar energy markets (Onabowale, 2024).

The inconsistent results observed in this study may stem from broader systemic inefficiencies within Zambia’s solar industry, particularly the inadequate operating capital for state owned utility electricity organisation (ZESCO), combined with continued application of non-cost-reflective tariffs, weakens the financial sustainability of the electricity sector and slows down the development of solar energy markets in Zambia.” (Bayliss &Pollen, 2021; Ministry of Energy, Republic of Zambia, 2022). Given ZESCO’s central role as the sole off-taker and a key actors in shaping regulatory and market dynamics, these challenges highlight the need for future research focused on strengthening regulatory frameworks and improving market structures. Such research should explore policy reforms that enhance financial sustainability, promote cost-reflective pricing, and support competitive market mechanisms capable of attracting capital inflows. Addressing these gaps through targeted regulatory and market-oriented research can contribute to more robust investment environments and accelerate the adoption of sustainable solar energy solutions.

Financial incentives, such as expanded access to financing, have shown limited effectiveness in enhancing private-sector investment returns in the solar industry. The study’s weak correlations between financial inflows and investment outcomes indicate that financial mechanisms alone are insufficient to overcome high upfront costs and restrictive lending conditions (Aristizabal et al., 2025; Nwala et al., 2025). This underscores the essential role of strong regulatory frameworks and vibrant market structures in unlocking the full value of financial interventions. Future research should therefore examine how financial incentives can be integrated with regulatory reforms such as clearer and cost reflective tariff structures, predictable approval processes, and enforceable contractual frameworks, including market-building efforts such as competitive procurement systems Strengthening these regulatory and market foundations is necessary to reduce investment uncertainty, stabilize market performance, and create the enabling environment required for meaningful private-sector participation in solar energy.

Finally, future research on regulations and markets should prioritize justifiably strengthening energy-tariff regulation, as tariff structures fundamentally define and influence the financial viability of solar investments. Market availability must be examined alongside tariff frameworks and consumer purchasing capacities, which vary significantly by region’s socio-economic status and consequent demand for solar services. This understanding highlights the need for tailored, inclusive, and effective incentive structures that are able to stimulate broader and more sustainable energy markets. By addressing gaps in financial, fiscal, and non-monetary mechanisms, future studies can contribute to the development of improved investment frameworks grounded in clear regulatory standards and market-supportive policies. Such progress will enable expanded market participation and support the long-term growth of the solar sector (Smith et al., 2023; Johnson, 2021). Achieving this requires innovative policy thinking, cross-sector collaboration, and localised research approaches that generate practical insights for equitable and resilient market development.

In closing, it is worth noting that implications and recommendations, while closely related, serve different purposes within research. Implications highlight the significance and potential impact of the study’s findings, demonstrating how they contribute to existing knowledge, inform theory, or impact practice. Recommendations, on the other hand, offer tangible, actionable direction for policymakers, practitioners, or future research based on those findings. Understanding their distinction is vital, as implications provide the rationale for the study’s significance, whereas recommendations translate that relevance into practical or strategic actions. Together, they ensure that research not only advances understanding but also offers meaningful directions for application and further inquiry (Kohli & Haenlein, 2021).

Conclusions

The Conclusion section is an important component that concisely outlines key findings, responses to formulated research questions, and highlights the broader significance of the research study within its context. It provides closure by drawing together all insights derived from the study analyses, reiterating the contribution to the body of knowledge, and underscoring the implications of findings to practice or policy. A structured conclusion also positions the research within the existing literature, to concisely explain how the study improves understanding the field of study while offering a pathway for future interrogations (Liu & Xiao, 2022).

Stemming from the study's problem and purpose statement, which emphasises the need to explore the relationship between institutional investment incentives and private sector performance in Zambia's solar energy sector, this research addressed critical factors contributing to the limited growth of the sector. Despite Zambia’s favorable solar generation conditions and notable governmental efforts, private sector investment remains less than optimal. The study aimed to identify and evaluate financial, fiscal, and non-monetary incentives capable of stimulating solar sector development, providing actionable insights into addressing these challenges. In order to ensure the credibility of these insights, the study employed a rigorously structured methodological approach, aligning the research questions, hypotheses, and objectives with robust data-gathering and analytical procedures. Using a quantitative correlation design supported by structured questionnaires and SPSS-based statistical analyses, the research generated reliable evidence and revealed nuanced incentive vs. investment relationships within the sector. Building on this systematic foundation, the conclusion now synthesises the key findings, interprets their broader significance, and draws together the overarching implications for policy, practice, and future research.

Research Audiences

Identifying the target audiences of this research is essential for ensuring that the study's findings are both relevant and actionable within Zambia's solar energy landscape. This is because insights generated are particularly valuable to key public institutions which include the Ministry of Energy, the Energy Regulation Board (ERB), the Zambia Development Agency (ZDA), ZESCO, and the Rural Electrification Authority (REA) whose mandates span policy development, regulatory oversight, investment facilitation, and national electrification. These organisations can apply the findings to refine incentive frameworks, strengthen strategic decisions, and support energy diversification efforts. Agencies promoting private-sector participation, such as those implementing the National Investment Promotion Strategy (NIPS), as well as international development partners like USAID, GIZ, AfDB, and the Swedish Embassy, can also leverage the evidence to align bilateral and multilateral support with sector needs. Academic and research institutions stand to benefit by identifying knowledge gaps and guiding future inquiry that advances solar energy innovation and investment. By clearly linking the study's results to the responsibilities of these diverse stakeholders, the research enhances the practical relevance, uptake, and collaborative potential of the recommendations, thereby promoting coordinated and effective approach to consolidating the solar energy ecosystem in Zambia.

Summary of Findings

Overall, the study found that financial, fiscal, and non-monetary incentives currently offer varied and generally limited influence on private-sector solar investment performance in Zambia.

While some incentive measures show modest or context-specific effects, many exhibit weak or non-significant relationships with key investment outcomes. These results indicate that the existing incentive framework is uneven in effectiveness and highlight the need for more coordinated, well-structured, and complementary incentive strategies to better support solar sector growth.

Financial Incentives. Financial incentives such as access to finance and private-sector investment levels displayed very weak and statistically non-significant relationships with return on investment. This suggests that, although conceptually important, these incentives in their present form do not appear to meaningfully influence investment performance. This highlights the need to improve their design, targeting, and accessibility to achieve intended outcomes.

Fiscal Incentives. For fiscal incentives, measures related to the suitability and effects of fiscal support showed weak but occasionally marginally significant associations with investment rates. The overall statistical model for fiscal incentives was significant but explained only a very modest variance in investment outcomes. This suggests that although fiscal incentives have some measurable effect, their practical impact remains limited and would benefit from better structural alignment with other policy mechanisms, consistent with Technological Innovation Systems (TIS) principles.

Non-Monetary Incentives. These incentives produced the most varied results. Incentives connected to lowering initial costs and improving affordability showed positive and statistically significant relationships with investment outcomes. In contrast, location- or value-based non-monetary incentives displayed no meaningful association. Together, these incentives were statistically significant and explained a modest variance in investment performance suggesting some level of relevance when implemented in complementarity.

Collectively, the findings revealed that Zambia's current incentive mechanisms yield irregular and often limited effects on solar investment performance. Such incentives be most effective when applied coherently, designed with stronger structural support, and complemented by predictable regulatory and market conditions**.**

Implications for Policy, Practice, and Research

The results highlight several important implications. From a policy viewpoint**,** the limited effectiveness of current incentive instruments indicate the need for more context-specific, scale-sensitive, and better coordinated incentive designs. This includes refining fiscal approaches, introducing affordability-enhancing programs, and developing integrated, clearly structured deployment frameworks. From a practice perspective, the findings highlight the importance of operational efficiency to streamline financial access procedures, improve investor service facilities, strengthening contractual mechanisms such developing standardised PPAs, and enhancing institutional support structures. From a research standpoint**,** the study indicates the need for longitudinal, comparative, and context-sensitive investigations to better capture long-term incentive effects and inform adaptive policymaking in evolving solar value chain.

Contribution to Theory

The study offers notable contributions to the Technological Innovation Systems (TIS) theoretical framework by providing empirical evidence from a Sub-Saharan African context. It demonstrates that incentive effectiveness depends not only on their individual designs but also on how they interact with broader systemic functions such as institutional capacity, market formation, actor harmonisation, and network strength. The findings highlight that incentives must operate within a comprehensible, stable, and interactive institutional environment to generate meaningful investment outcomes. The study also addresses critical empirical gaps by identifying which incentive types produce the strongest or weakest signals within Zambia’s solar ecosystem, thereby upgrading the theoretical understanding of how policy instruments influence technology diffusion in emerging energy markets.

Recommendation for Policy.

Policy recommendations for this study highlight the necessity for more targeted, inclusive, and coordinated incentive structures. For financial incentives, policies should broaden access to tailored financing solutions for SMEs and mini-grids, streamline loan and grant processes, and introduce socio-economic affordability schemes. For fiscal incentives, government should expand duty and VAT exemptions for solar technologies, adopt time-bound consumer-protection measures, pilot scale-sensitive fiscal packages, and strengthen access to climate-financing instruments. For non-monetary incentives, policy emphasis should include developing bankable and standardized PPA templates, reinforcing investor-protection frameworks, simplifying regulatory procedures through centralized facilitation platforms, and enhancing institutional capacity through structured training and performance monitoring.

Recommendation for Practice

Practical actions relating to the finding of this study should target the improvements in the operationalisation of incentives. For financial support, practitioners should implement SME-focused financing pilots, establish green loan facilities, and conduct periodic reviews of affordability-enhancing schemes. Within fiscal instruments, utilities and project developers should apply updated and time-bound fiscal packages, integrate digitalised tax processes, and monitor the performance of scale-sensitive exemptions. For non-monetary incentives, practitioners should employ standardized contracts, implement structured training programs for regulatory agencies, foster cross-institutional collaboration, and create one-stop service centers to reduce administrative bottlenecks and enhance investor experience.

Recommendation for Application

Application-focused recommendations target policymaker, financiers and implementers and support organisations for solar projects at institutional level; which according to these finding should include introducing a five-year tax holidays for SMEs**,** expanding duty and VAT waivers, establishing flexible financial-access criteria for low-capital SMEs, and operationalizing a low-interest national green financing facility. Additional measures should involve digitalising incentive administration systems, simplifying licensing and approval procedures, and expanding public private partnerships to strengthen project execution, resource mobilization, and technology transfer within the solar sector. Similarly standardised PPAs and PPPs should be formulated for utility scale investments to clear establish relationships between IPPs and energy up takers.

Recommendations for Future Research

Basing on the varied findings on relationships between investment incentive variable and outcome performance variables, future research should focus on extending on the findings by investigating the long-term effects of redesigned financial incentives through 3–5 year performance reviews and 5–10 year longitudinal studies focusing on ROI predictability and capital accessibility. For fiscal incentives, research should explore the consistency and sector-wide influence of scale-sensitive fiscal frameworks through multi-year comparative assessments. For non-monetary incentives, future studies should examine the effectiveness of integrated institutional and regulatory packages, assess PPA bankability under varying market conditions, and evaluate investor perceptions using mixed-method approaches. Cross-country comparative studies within Sub-Saharan Africa are further recommended to identify regional best practices and inform policy harmonization.

Overall, the study concludes that no single incentive type is sufficient to catalyse substantial private-sector solar investment. Instead, well-designed, targeted, and systematically coordinated amalgamations of financial, fiscal, and non-monetary incentives, supported by stable regulatory and market conditions are essential for expanding solar investment in Zambia. By addressing gaps in incentives design, strengthening implementation capacity, and enhancing institutional alignment, stakeholders can significantly accelerate solar sector development and contribute to long-term energy sustainability.

Future Research - Regulations and Markets

In line with the findings of the study, Future research on regulations and markets should adopt more targeted, context-sensitive, and methodologically robust approaches to better understand how financial, fiscal, and non-monetary incentives function across Zambia’s varied solar investment environments. Key priorities include analysing incentive impacts across different investment scales, technologies, and geographic locations; integrating advanced quantitative methods to capture nuanced relationships; and promoting cross-disciplinary collaboration to generate practical, holistic solutions suitable for ever evolving renewable energy markets. Additionally research focus should be on strengthening regulatory frameworks that improve actual market structures, through rigorous pursuance of tariff reforms which are equally cardinal in addressing systemic constraints such as high upfront costs, limited affordability, and non–cost-reflective pricing. Comparative, longitudinal, and tailored incentive studies will help reveal how incentive models can be optimised to attract investments, enhance bankability, and create predictable and sustainable solar markets. Collectively, such a research agenda for the future will support effective policy designs, expand market participation, and accelerate solar sector growth in Zambia and similar contexts.

Limitations

The study's findings and implications were shaped by several contextual and methodological limitations with potential to influence generalisability and depth of the results. A key challenge arose from the relatively small and unevenly developed Zambia's solar energy sector, resulting in a thinly distributed population, resulting in difficulty accessing sufficient respondents in one location during the pilot and main study. This was mitigated through travels & physical dissemination of surveys. Additionally access to participants particularly within government, quasi-government, and utility-scale institutions remained constrained by bureaucratic processes. The diverse composition of the research population, spanning utility-scale investors, SMEs, government agencies, private firms, and development partners, introduced variability in responses and reflected differing perceptions of incentives suitability. Some SMEs in particular expressed reluctance to participate due to concerns about business confidentiality, resulting in sample imbalances tilting findings toward more established investors. Additionally, structural disparities between large-scale and SME investors especially regarding eligibility and access to- incentives introduced potential bias, as larger firms typically easily accessed incentives than small scale investors. While these limitations did not significantly undermine the study's core objectives, they may have affected the representativeness and scope of the results. Addressing these issues in future research through more targeted sampling strategies and development of more inclusive incentive policies would enhance the robustness, fairness, and applicability of insights aimed at strengthening solar investment in Zambia.

Summing it up, the study’s empirical results, implications, and recommendations collectively provide a structured foundation for evidence base decision making by policymakers, regulators, private sector investors, including developmental partners in Zambia’s solar sector. The correlation and regression analyses revealed varied relationships and differential effects between investments incentive types and performance outcomes relating to investment scale, location, and types. The mixed effects revealed in the findings suggest that individually deployed or weakly structured financial, fiscal, and non-monetary incentives have limited effect in stimulating sustained private-sector investments. The findings therefore point to the need for a systematically aligned and complementary incentive framework in which financial, fiscal, and institutional measures reinforce one another rather than operate independently. Such coordinated deployment has the potential to enhance policy effectiveness, improve investment outcomes, and support a more balanced diffusion of solar technologies. Accordingly, the study’s implications underscore the importance of integrated incentive design for policy refinement, practical implementation, and future research, relating to investment interactions, regulatory predictability and market coherence to ultimately create a competitive investment landscape in solar energy.

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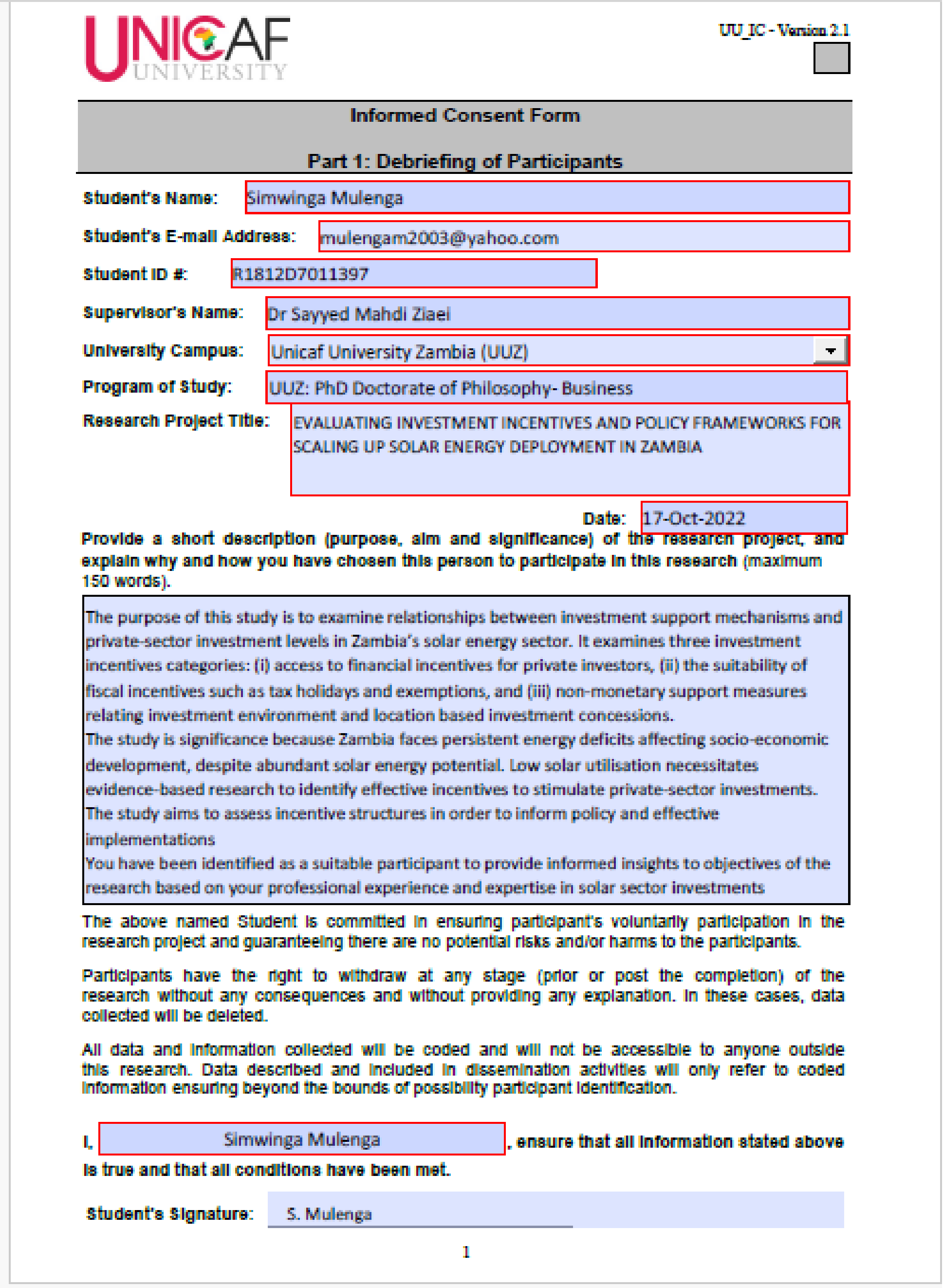
Appendix A

Informed Consent Form (IC)



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UU_IC - Version 2.1

Informed Consent Form

Part 1: Debriefing of Participants

Student's Name: Simwinga Mulenga

Student's E-mail Address: mulengam2003@yahoo.com

Student ID #: R1812D7011397

Supervisor's Name: Dr Sayyed Mahdi Ziaei

University Campus: Unicaf University Zambia (UUZ)

Program of Study: UUZ: PhD Doctorate of Philosophy- Business

Research Project Title: EVALUATING INVESTMENT INCENTIVES AND POLICY FRAMEWORKS FOR SCALING UP SOLAR ENERGY DEPLOYMENT IN ZAMBIA

Date: 17-Oct-2022

Provide a short description (purpose, aim and significance) of the research project, and explain why and how you have chosen this person to participate in this research (maximum 150 words).

The purpose of this study is to examine relationships between investment support mechanisms and private-sector investment levels in Zambia's solar energy sector. It examines three investment incentives categories: (i) access to financial incentives for private investors, (ii) the suitability of fiscal incentives such as tax holidays and exemptions, and (iii) non-monetary support measures relating investment environment and location based investment concessions.
The study is significance because Zambia faces persistent energy deficits affecting socio-economic development, despite abundant solar energy potential. Low solar utilisation necessitates evidence-based research to identify effective incentives to stimulate private-sector investments.
The study aims to assess incentive structures in order to inform policy and effective implementations
You have been identified as a suitable participant to provide informed insights to objectives of the research based on your professional experience and expertise in solar sector investments

The above named Student is committed in ensuring participant's voluntarily participation in the research project and guaranteeing there are no potential risks and/or harms to the participants.

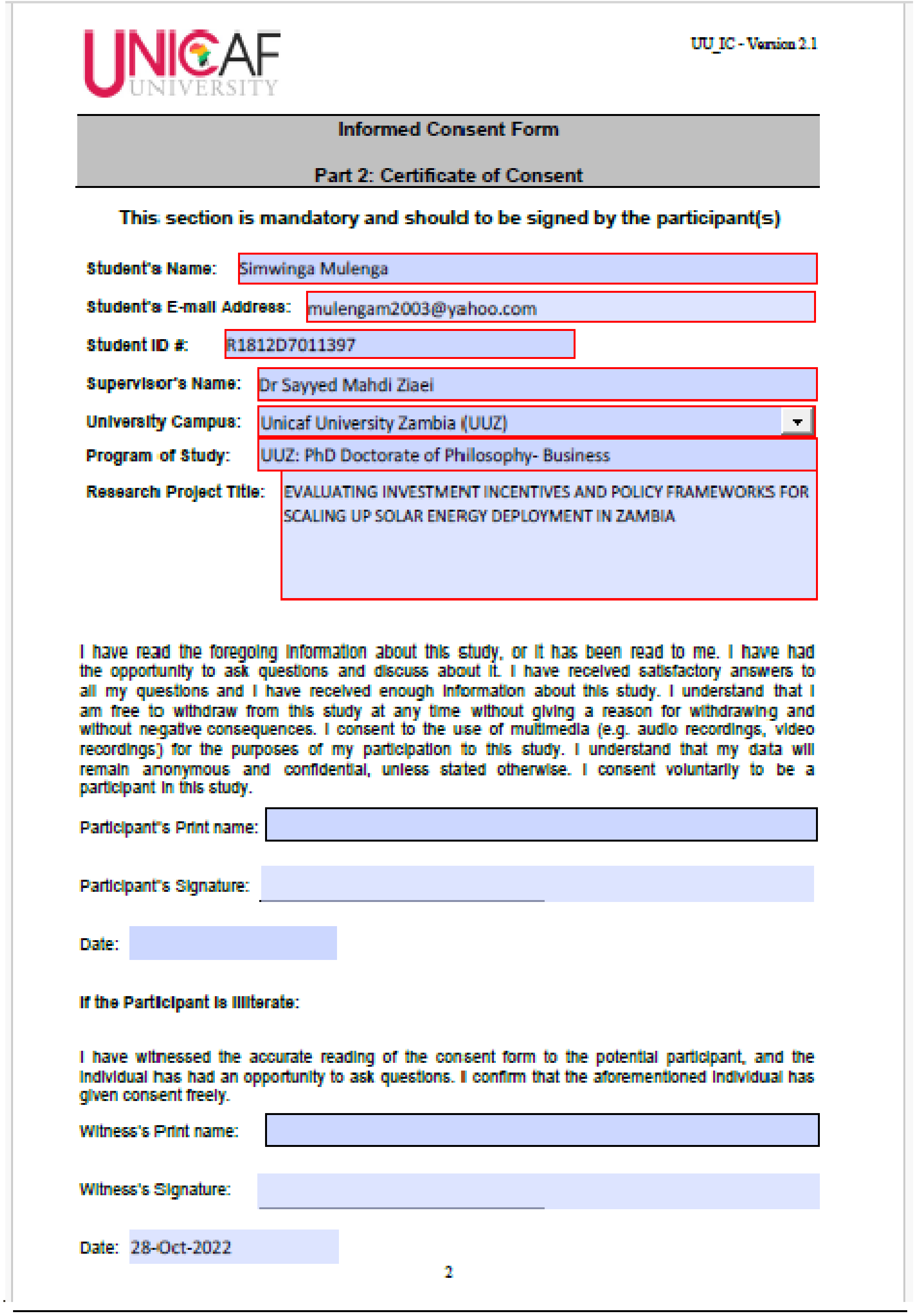
Participants have the right to withdraw at any stage (prior or post the completion) of the research without any consequences and without providing any explanation. In these cases, data collected will be deleted.

All data and information collected will be coded and will not be accessible to anyone outside this research. Data described and included in dissemination activities will only refer to coded information ensuring beyond the bounds of possibility participant identification.

I, Simwinga Mulenga**, ensure that all information stated above is true and that all conditions have been met.**

Student's Signature: S. Mulenga

1



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Informed Consent Form

Part 2: Certificate of Consent

This section is mandatory and should to be signed by the participant(s)

Student's Name: Simwinga Mulenga

Student's E-mail Address: mulengam2003@yahoo.com

Student ID #: R1812D7011397

Supervisor's Name: Dr Sayyed Mahdi Ziaei

University Campus: Unicaf University Zambia (UUZ) ▾

Program of Study: UUZ: PhD Doctorate of Philosophy- Business

Research Project Title: EVALUATING INVESTMENT INCENTIVES AND POLICY FRAMEWORKS FOR SCALING UP SOLAR ENERGY DEPLOYMENT IN ZAMBIA

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions and I have received enough information about this study. I understand that I am free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of my participation to this study. I understand that my data will remain anonymous and confidential, unless stated otherwise. I consent voluntarily to be a participant in this study.

Participant's Print name:

Participant's Signature:

Date:

If the Participant is illiterate:

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had an opportunity to ask questions. I confirm that the aforementioned individual has given consent freely.

Witness's Print name:

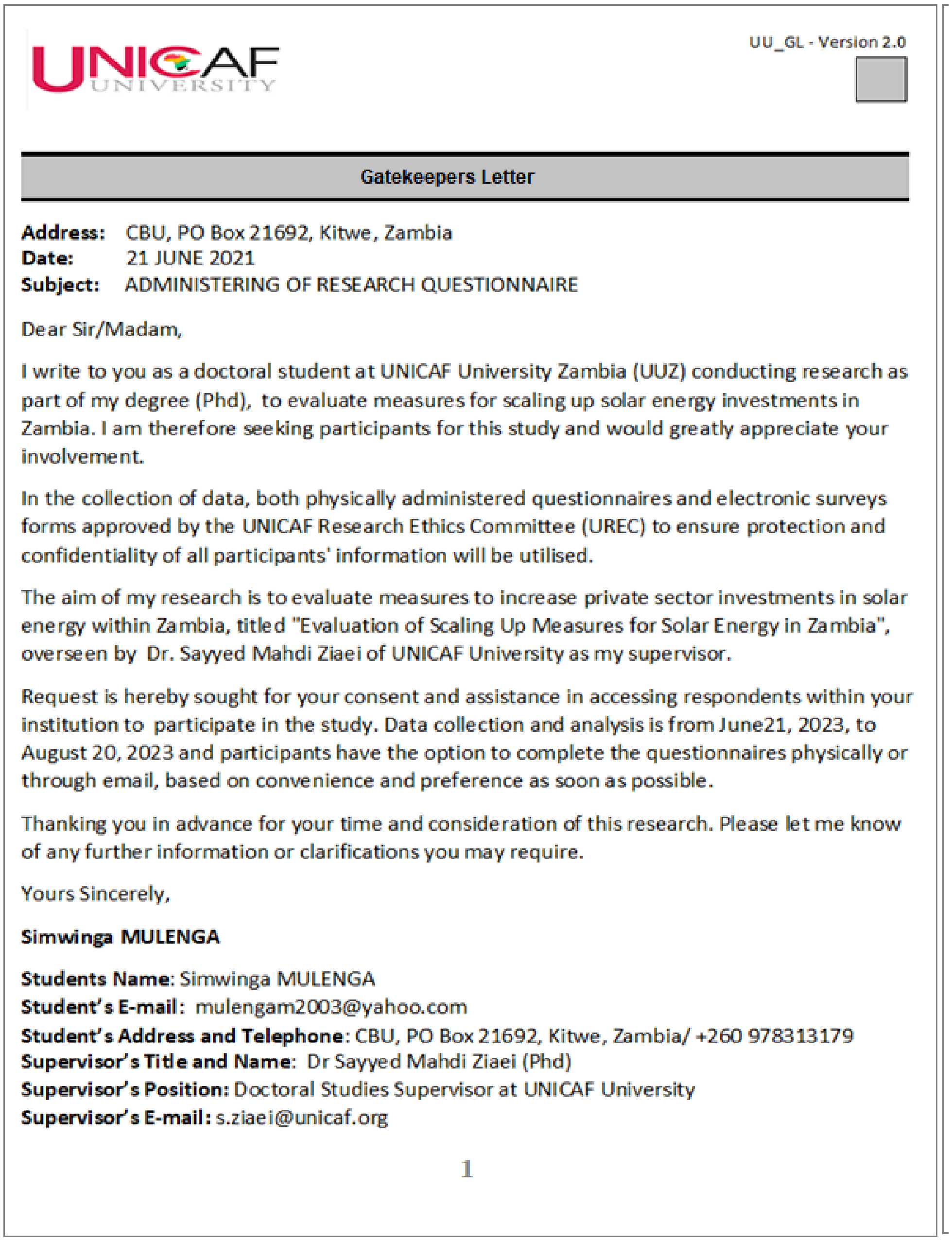
Witness's Signature:

Date: 28-Oct-2022

2

Appendix B

Gate Keepers Letter



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Gatekeepers Letter

Address: CBU, PO Box 21692, Kitwe, Zambia
Date: 21 JUNE 2021
Subject: ADMINISTERING OF RESEARCH QUESTIONNAIRE

Dear Sir/Madam,

I write to you as a doctoral student at UNICAF University Zambia (UUZ) conducting research as part of my degree (Phd), to evaluate measures for scaling up solar energy investments in Zambia. I am therefore seeking participants for this study and would greatly appreciate your involvement.

In the collection of data, both physically administered questionnaires and electronic surveys forms approved by the UNICAF Research Ethics Committee (UREC) to ensure protection and confidentiality of all participants' information will be utilised.

The aim of my research is to evaluate measures to increase private sector investments in solar energy within Zambia, titled "Evaluation of Scaling Up Measures for Solar Energy in Zambia", overseen by Dr. Sayyed Mahdi Ziaei of UNICAF University as my supervisor.

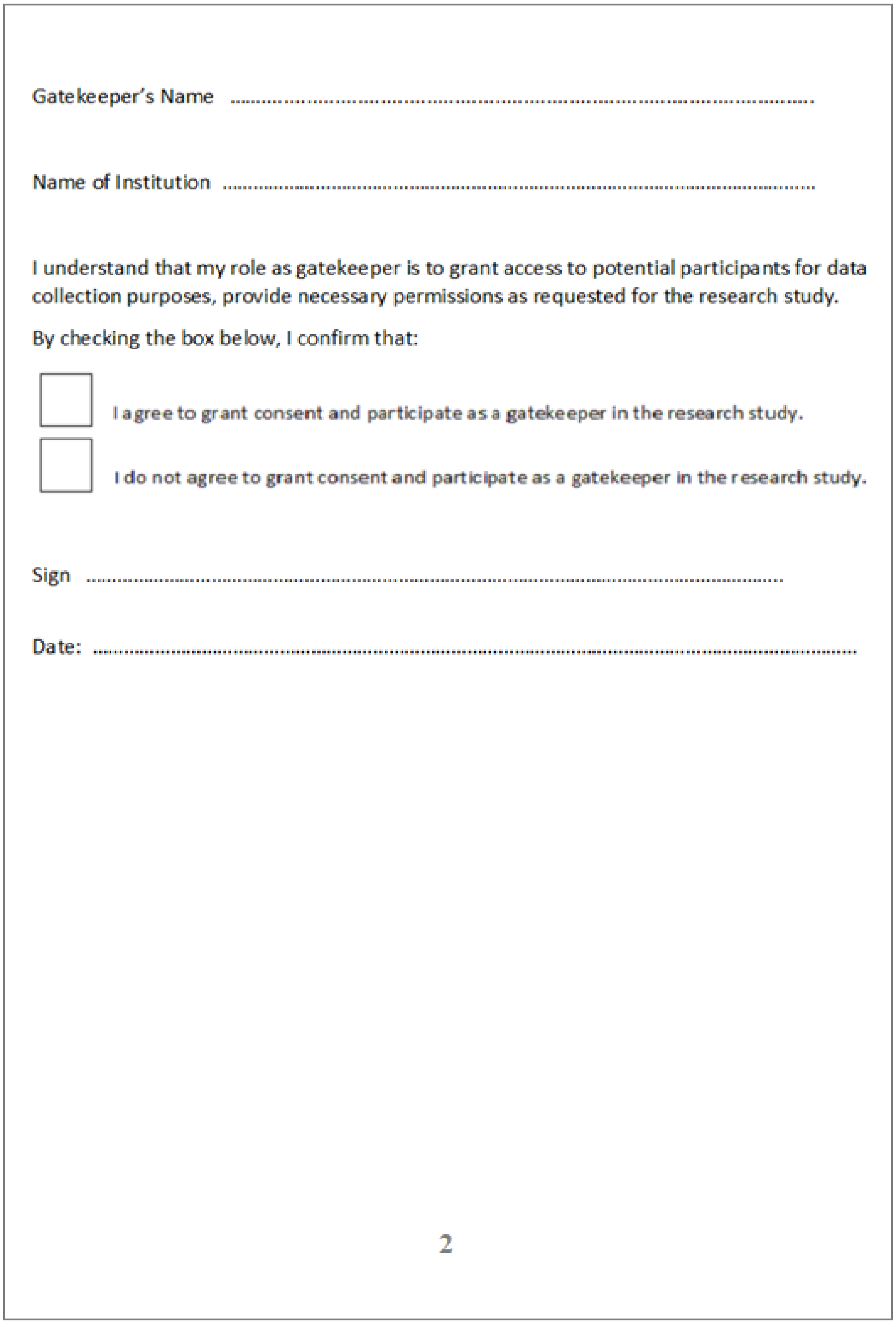
Request is hereby sought for your consent and assistance in accessing respondents within your institution to participate in the study. Data collection and analysis is from June21, 2023, to August 20, 2023 and participants have the option to complete the questionnaires physically or through email, based on convenience and preference as soon as possible.

Thanking you in advance for your time and consideration of this research. Please let me know of any further information or clarifications you may require.

Yours Sincerely,

Simwinga MULENGA

Students Name: Simwinga MULENGA
Student's E-mail: mulengam2003@yahoo.com
Student's Address and Telephone: CBU, PO Box 21692, Kitwe, Zambia/ +260 978313179
Supervisor's Title and Name: Dr Sayyed Mahdi Ziaei (Phd)
Supervisor's Position: Doctoral Studies Supervisor at UNICAF University
Supervisor's E-mail: s.ziaei@unicaf.org



Gatekeeper's Name ……………………………………………………………………………………….

Name of Institution ………………………………………………………………………………………

I understand that my role as gatekeeper is to grant access to potential participants for data collection purposes, provide necessary permissions as requested for the research study.

By checking the box below, I confirm that:

☐ I agree to grant consent and participate as a gatekeeper in the research study.

☐ I do not agree to grant consent and participate as a gatekeeper in the research study.

Sign ……………………………………………………………………………………………………

Date: ………

2

Appendix C

Local Research Approval

HEAD OFFICE:
Engineering House
Stand No. 2374, Kelvin Siwale Road, Showgrounds
P. O. Box 51084, Lusaka - Zambia
Tel: +260 211 255 161 / 256 205
E-mail: info@eiz.org.zm
Website: www.eiz.org.zm

Ref: EIZ/CEO/INCO/005/01/2024

10 January 2024

UNICAF UNIVERSITY
Plot 20842, Off Alick Nkhata Road,
Longacres
Lusaka

Dear Sir,

APPROVAL FOR PhD RESEARCH TITLED "EVALUATION OF SCALING UP MEASURE FOR SOLAR ENERGY INVESTMENTS IN ZAMBIA"

We acknowledge receipt of your letter dated 08 January 2024 regarding the above matter.

As you may know the Engineering Institution of Zambia (EIZ) is a statutory professional regulatory body mandated by the EIZ Act No.17 of 2010 to promote and regulate the practice of engineering and allied disciplines in Zambia.

We write to affirm that Simwinga Mulenga NRC number **197011/73/1**, EIZ number 003216 and EngRB number 002423 is a registered member of our Institution. Kindly grant him any assistance he may require to do his research and further advise that the results of the research be shared with the institution for future reference.

Kindly contact the undersigned for any further clarifications regarding the aforementioned matter.

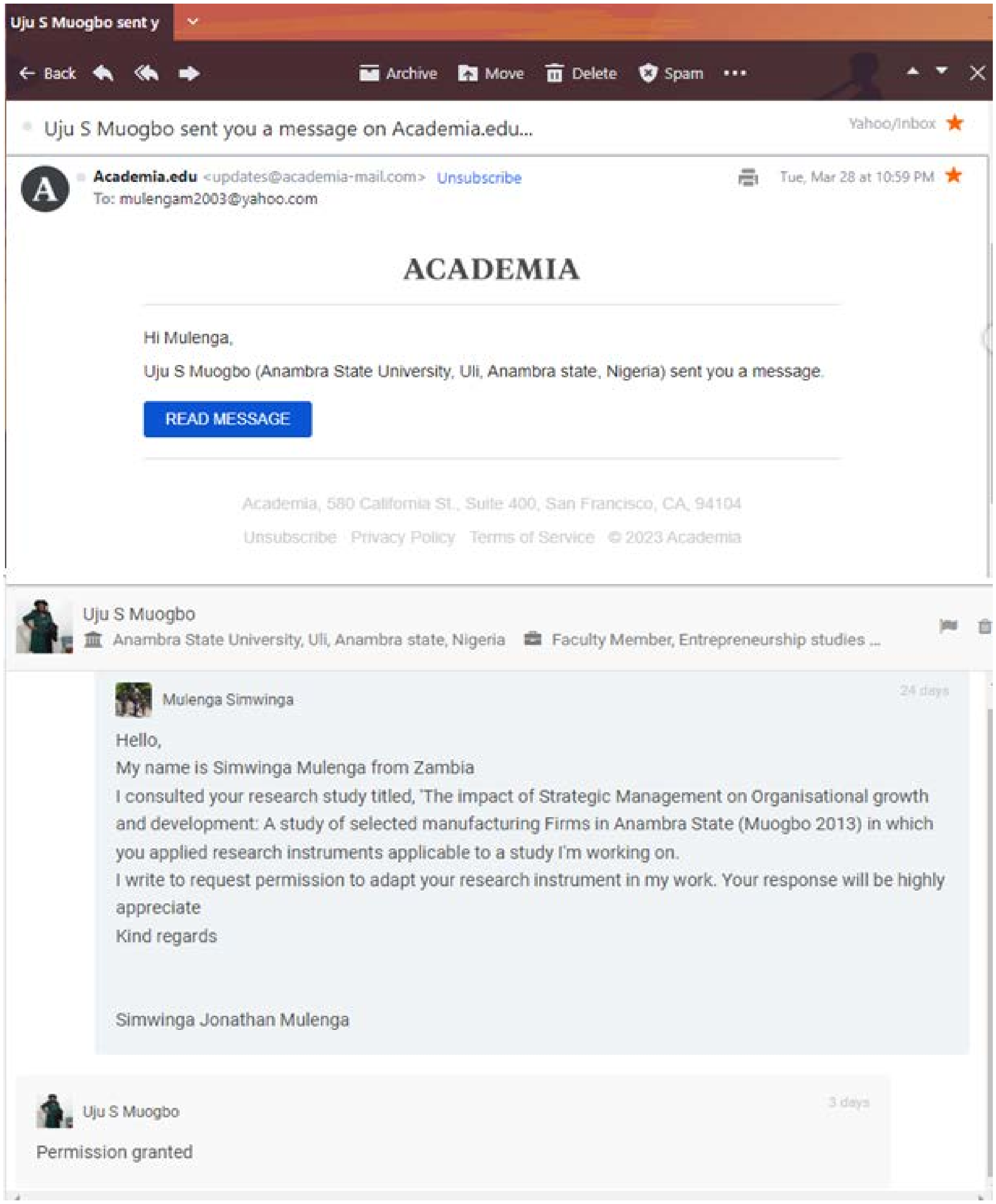
Yours faithfully,
ENGINEERING INSTITUTION OF ZAMBIA

Eng. Phanuel Jimaima
Ag. Regional Manager - South
For REGISTRAR/CEO

THE ENGINEERING INSTITUTION
OF ZAMBIA
12 JAN 2024

Appendix D

Research Instrument Adaptation Approval



Uju S Muogbo sent you a message on Academia.edu...

Academia.edu <updates@academia-mail.com>
To: mulengam2003@yahoo.com
Tue, Mar 28 at 10:59 PM

ACADEMIA

Hi Mulenga,

Uju S Muogbo (Anambra State University, Uli, Anambra state, Nigeria) sent you a message.

Academia, 580 California St., Suite 400, San Francisco, CA, 94104

Unsubscribe Privacy Policy Terms of Service © 2023 Academia

Uju S Muogbo
Anambra State University, Uli, Anambra state, Nigeria   Faculty Member, Entrepreneurship studies ...

Mulenga Simwinga
24 days

Hello,
My name is Simwinga Mulenga from Zambia
I consulted your research study titled, 'The impact of Strategic Management on Organisational growth and development: A study of selected manufacturing Firms in Anambra State (Muogbo 2013) in which you applied research instruments applicable to a study I'm working on.
I write to request permission to adapt your research instrument in my work. Your response will be highly appreciate
Kind regards

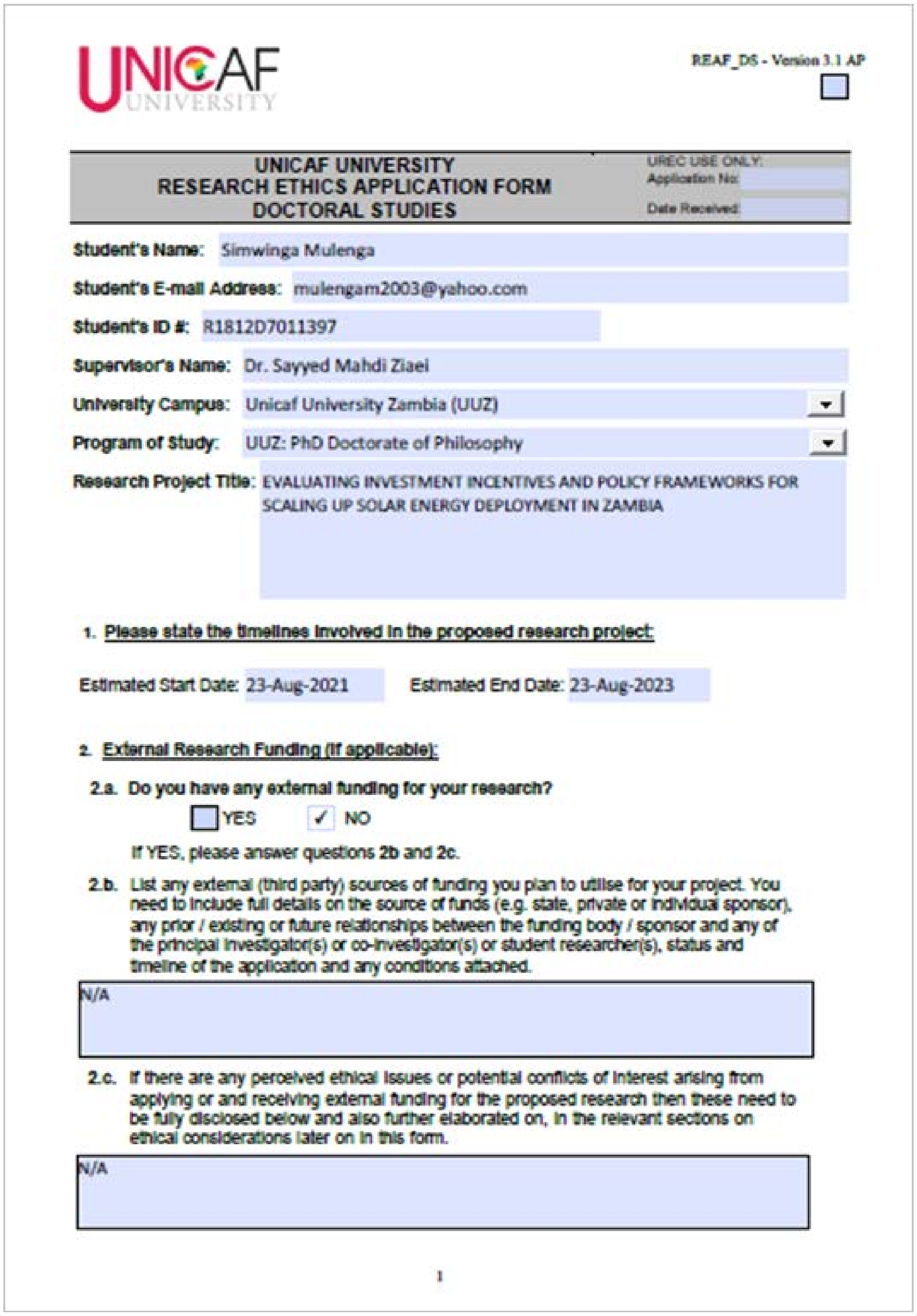
Simwinga Jonathan Mulenga

Uju S Muogbo
3 days

Permission granted

Appendix E

REAF Form



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REAF_DS - Version 3.1 AP ☐

UNICAF UNIVERSITY
RESEARCH ETHICS APPLICATION FORM
DOCTORAL STUDIES

UREC USE ONLY:
Application No:
Date Received:

Student's Name: Simwinga Mulenga

Student's E-mail Address: mulengam2003@yahoo.com

Student's ID #: R1812D7011397

Supervisor's Name: Dr. Sayyed Mahdi Ziaei

University Campus: Unicaf University Zambia (UUZ)

Program of Study: UUZ: PhD Doctorate of Philosophy

Research Project Title: EVALUATING INVESTMENT INCENTIVES AND POLICY FRAMEWORKS FOR SCALING UP SOLAR ENERGY DEPLOYMENT IN ZAMBIA

1. **Please state the timelines involved in the proposed research project:**

Estimated Start Date: 23-Aug-2021 Estimated End Date: 23-Aug-2023

2. **External Research Funding (if applicable):**

2.a. **Do you have any external funding for your research?**

☐ YES ☑ NO

If YES, please answer questions **2b** and **2c.**

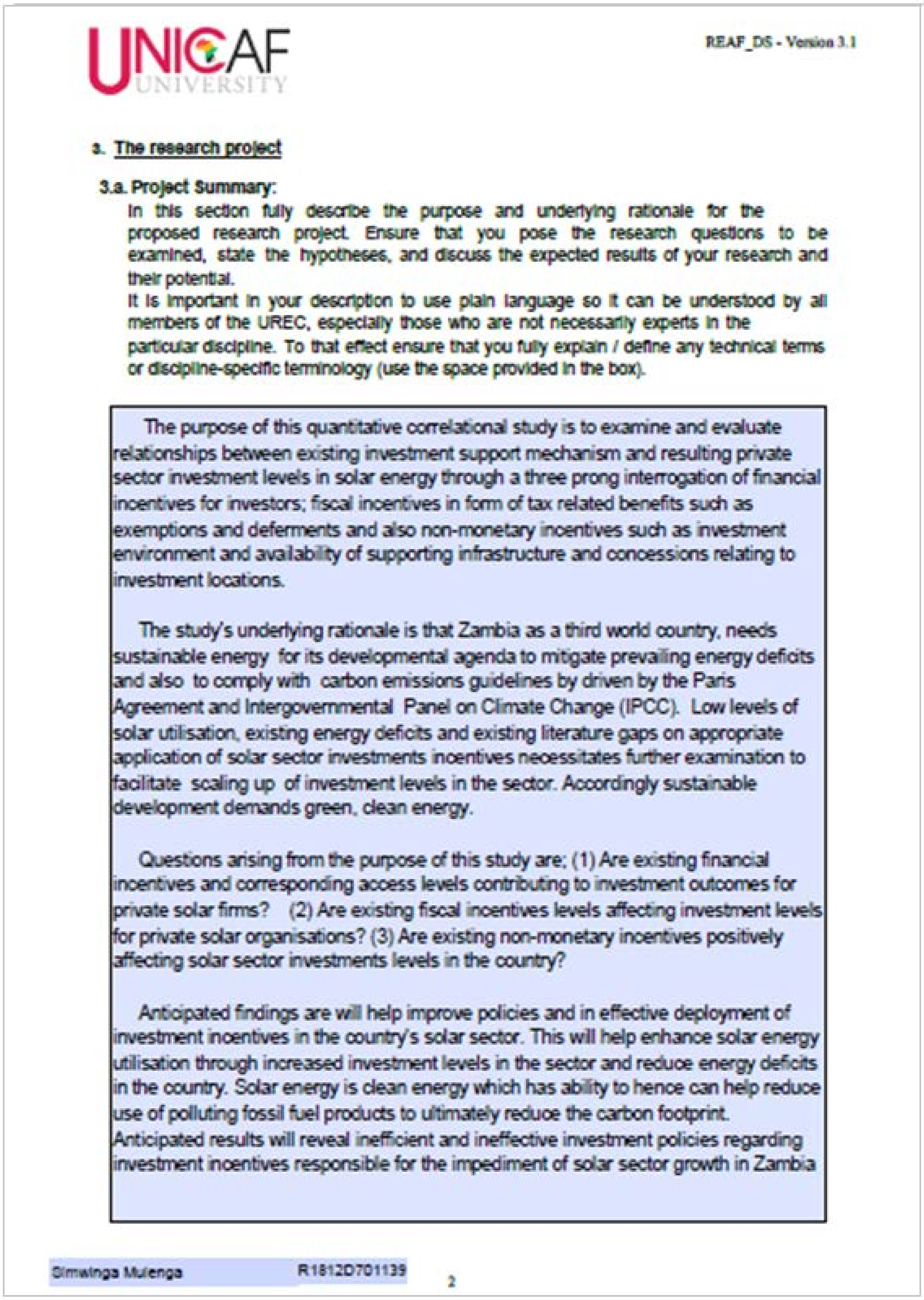
2.b. List any external (third party) sources of funding you plan to utilise for your project. You need to include full details on the source of funds (e.g. state, private or individual sponsor), any prior / existing or future relationships between the funding body / sponsor and any of the principal investigator(s) or co-investigator(s) or student researcher(s), status and timeline of the application and any conditions attached.

N/A

2.c. If there are any perceived ethical issues or potential conflicts of interest arising from applying or and receiving external funding for the proposed research then these need to be fully disclosed below and also further elaborated on, in the relevant sections on ethical considerations later on in this form.

N/A

1



3. The research project

3.a. Project Summary:

In this section fully describe the purpose and underlying rationale for the proposed research project. Ensure that you pose the research questions to be examined, state the hypotheses, and discuss the expected results of your research and their potential.

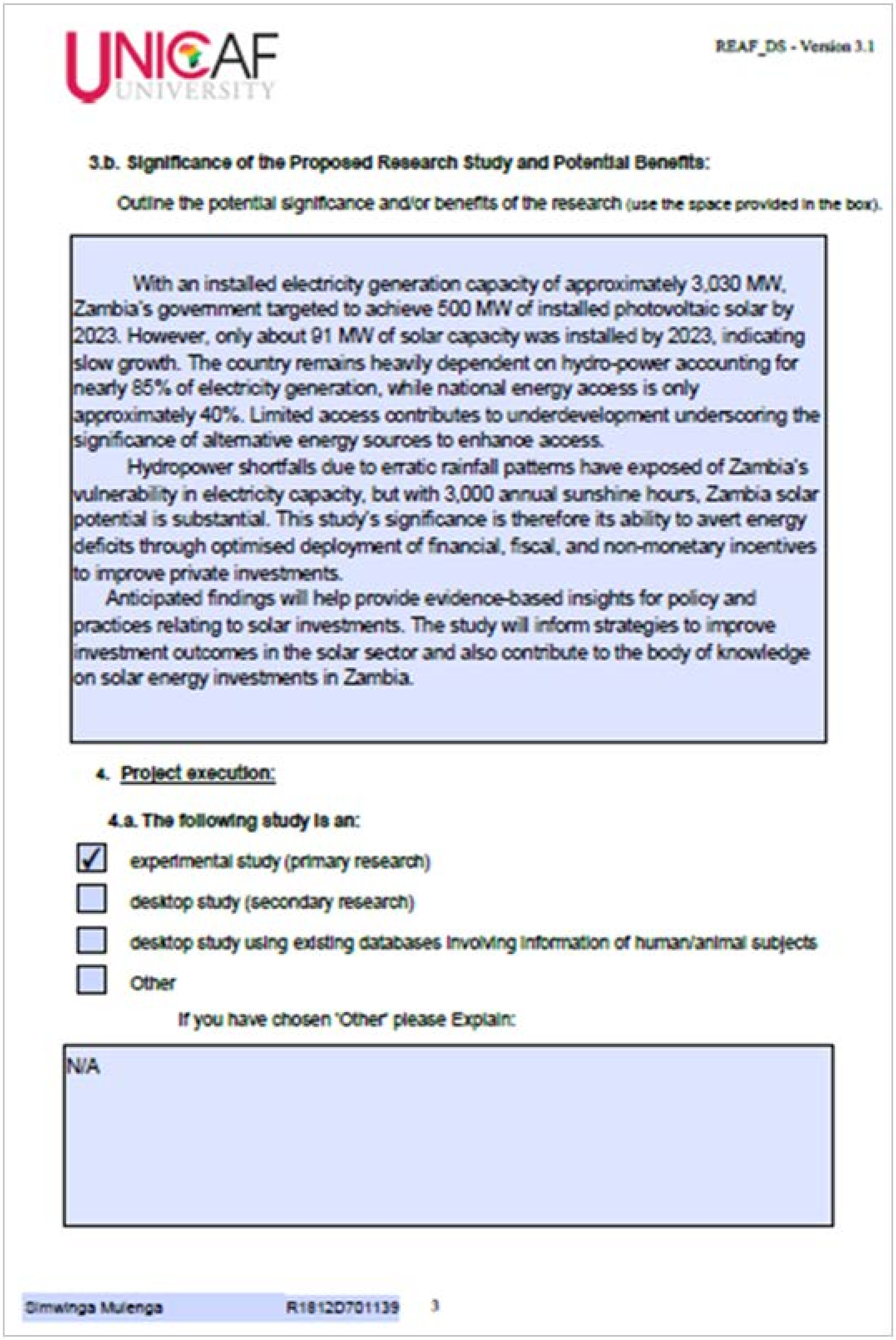
It is important in your description to use plain language so it can be understood by all members of the UREC, especially those who are not necessarily experts in the particular discipline. To that effect ensure that you fully explain / define any technical terms or discipline-specific terminology (use the space provided in the box).

The purpose of this quantitative correlational study is to examine and evaluate relationships between existing investment support mechanism and resulting private sector investment levels in solar energy through a three prong interrogation of financial incentives for investors; fiscal incentives in form of tax related benefits such as exemptions and deferments and also non-monetary incentives such as investment environment and availability of supporting infrastructure and concessions relating to investment locations.

The study's underlying rationale is that Zambia as a third world country, needs sustainable energy for its developmental agenda to mitigate prevailing energy deficits and also to comply with carbon emissions guidelines by driven by the Paris Agreement and Intergovernmental Panel on Climate Change (IPCC). Low levels of solar utilisation, existing energy deficits and existing literature gaps on appropriate application of solar sector investments incentives necessitates further examination to facilitate scaling up of investment levels in the sector. Accordingly sustainable development demands green, clean energy.

Questions arising from the purpose of this study are; (1) Are existing financial incentives and corresponding access levels contributing to investment outcomes for private solar firms? (2) Are existing fiscal incentives levels affecting investment levels for private solar organisations? (3) Are existing non-monetary incentives positively affecting solar sector investments levels in the country?

Anticipated findings are will help improve policies and in effective deployment of investment incentives in the country's solar sector. This will help enhance solar energy utilisation through increased investment levels in the sector and reduce energy deficits in the country. Solar energy is clean energy which has ability to hence can help reduce use of polluting fossil fuel products to ultimately reduce the carbon footprint. Anticipated results will reveal inefficient and ineffective investment policies regarding investment incentives responsible for the impediment of solar sector growth in Zambia



3.b. Significance of the Proposed Research Study and Potential Benefits:

Outline the potential significance and/or benefits of the research (use the space provided in the box).

With an installed electricity generation capacity of approximately 3,030 MW, Zambia's government targeted to achieve 500 MW of installed photovoltaic solar by 2023. However, only about 91 MW of solar capacity was installed by 2023, indicating slow growth. The country remains heavily dependent on hydro-power accounting for nearly 85% of electricity generation, while national energy access is only approximately 40%. Limited access contributes to underdevelopment underscoring the significance of alternative energy sources to enhance access.

Hydropower shortfalls due to erratic rainfall patterns have exposed of Zambia's vulnerability in electricity capacity, but with 3,000 annual sunshine hours, Zambia solar potential is substantial. This study's significance is therefore its ability to avert energy deficits through optimised deployment of financial, fiscal, and non-monetary incentives to improve private investments.

Anticipated findings will help provide evidence-based insights for policy and practices relating to solar investments. The study will inform strategies to improve investment outcomes in the solar sector and also contribute to the body of knowledge on solar energy investments in Zambia.

4. **Project execution:**

4.a. The following study is an:

☑ experimental study (primary research)

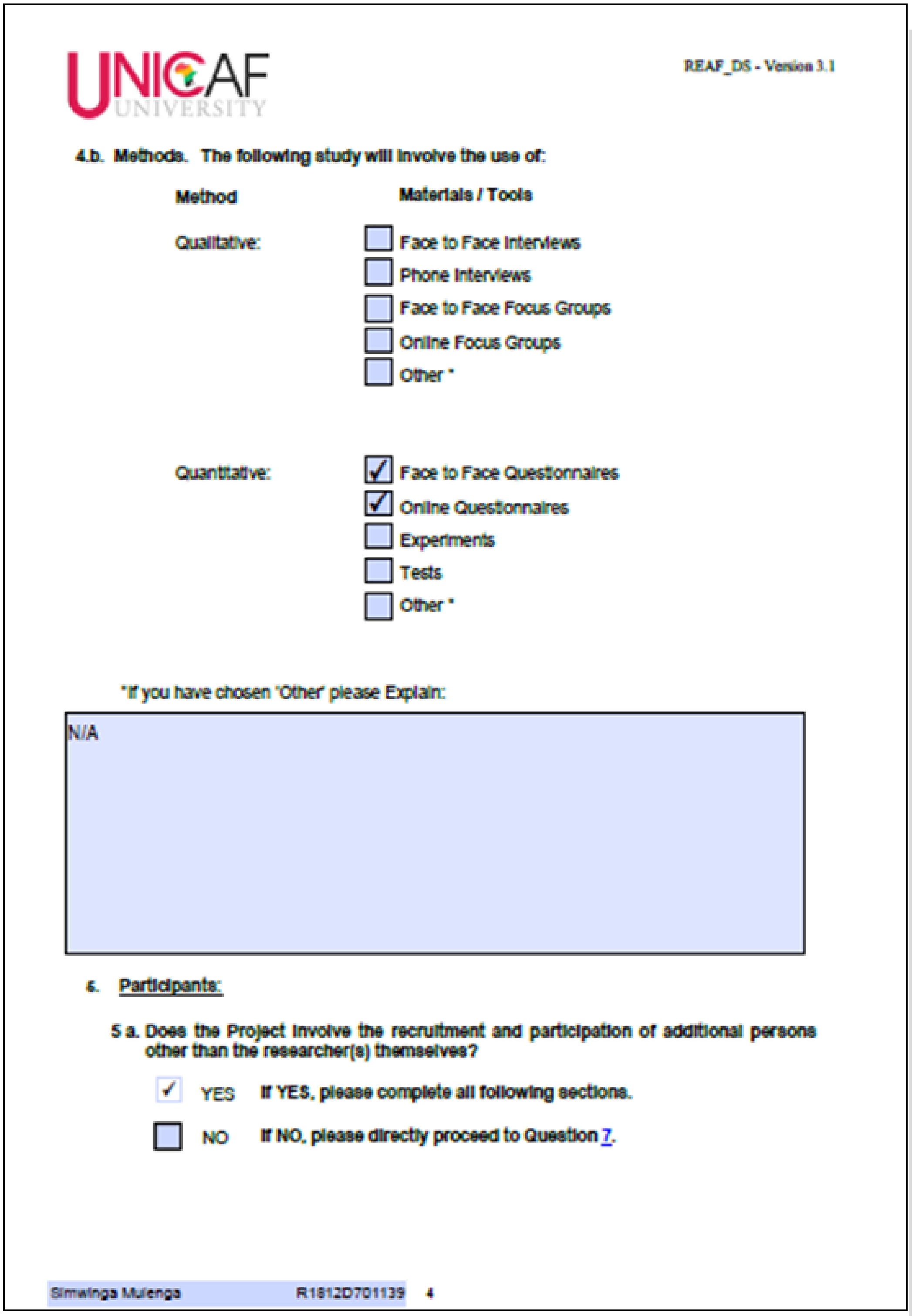
☐ desktop study (secondary research)

☐ desktop study using existing databases involving information of human/animal subjects

☐ Other

If you have chosen 'Other' please Explain:

N/A



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4.b. **Methods. The following study will involve the use of:**

Method	**Materials / Tools**
Qualitative:	☐ Face to Face Interviews ☐ Phone Interviews ☐ Face to Face Focus Groups ☐ Online Focus Groups ☐ Other *
Quantitative:	☑ Face to Face Questionnaires ☑ Online Questionnaires ☐ Experiments ☐ Tests ☐ Other *

*If you have chosen 'Other' please Explain:

N/A

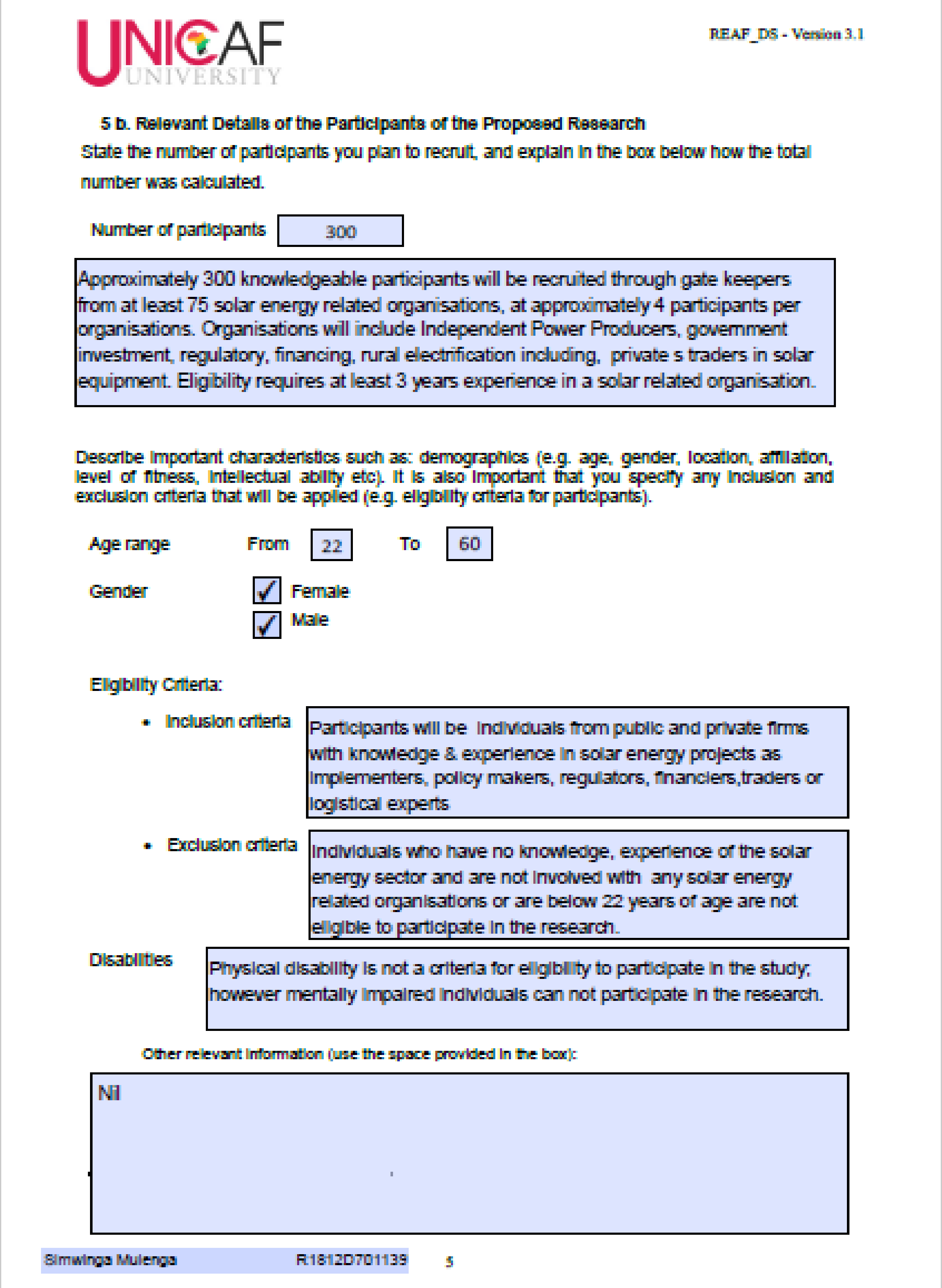
5. **Participants:**

5 a. Does the Project involve the recruitment and participation of additional persons other than the researcher(s) themselves?

☑ YES **If YES, please complete all following sections.**

☐ NO **If NO, please directly proceed to Question 7.**

Simwinga Mulenga R1812D701139 4



5 b. Relevant Details of the Participants of the Proposed Research

State the number of participants you plan to recruit, and explain in the box below how the total number was calculated.

Number of participants: 300

Approximately 300 knowledgeable participants will be recruited through gate keepers from at least 75 solar energy related organisations, at approximately 4 participants per organisations. Organisations will include Independent Power Producers, government investment, regulatory, financing, rural electrification including, private s traders in solar equipment. Eligibility requires at least 3 years experience in a solar related organisation.

Describe important characteristics such as: demographics (e.g. age, gender, location, affiliation, level of fitness, intellectual ability etc). It is also important that you specify any inclusion and exclusion criteria that will be applied (e.g. eligibility criteria for participants).

Age range From 22 To 60

Gender ☑ Female
☑ Male

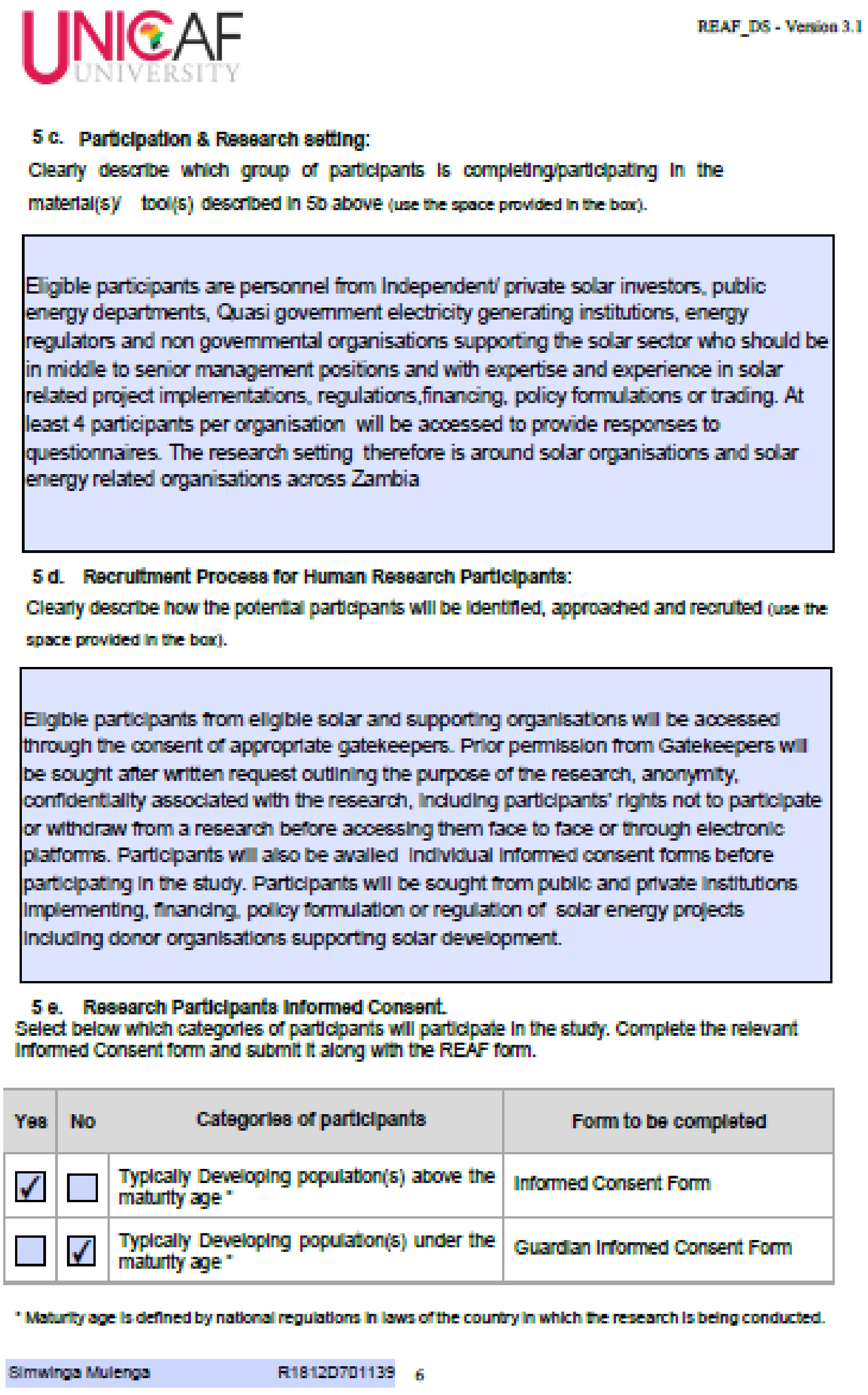
Eligibility Criteria:

- Inclusion criteria: Participants will be individuals from public and private firms with knowledge & experience in solar energy projects as implementers, policy makers, regulators, financiers,traders or logistical experts
- Exclusion criteria: Individuals who have no knowledge, experience of the solar energy sector and are not involved with any solar energy related organisations or are below 22 years of age are not eligible to participate in the research.

Disabilities: Physical disability is not a criteria for eligibility to participate in the study; however mentally impaired individuals can not participate in the research.

Other relevant information (use the space provided in the box):

Nil



5 c. Participation & Research setting:

Clearly describe which group of participants is completing/participating in the material(s)/ tool(s) described in 5b above (use the space provided in the box).

Eligible participants are personnel from Independent/ private solar investors, public energy departments, Quasi government electricity generating institutions, energy regulators and non governmental organisations supporting the solar sector who should be in middle to senior management positions and with expertise and experience in solar related project implementations, regulations,financing, policy formulations or trading. At least 4 participants per organisation will be accessed to provide responses to questionnaires. The research setting therefore is around solar organisations and solar energy related organisations across Zambia

5 d. Recruitment Process for Human Research Participants:

Clearly describe how the potential participants will be identified, approached and recruited (use the space provided in the box).

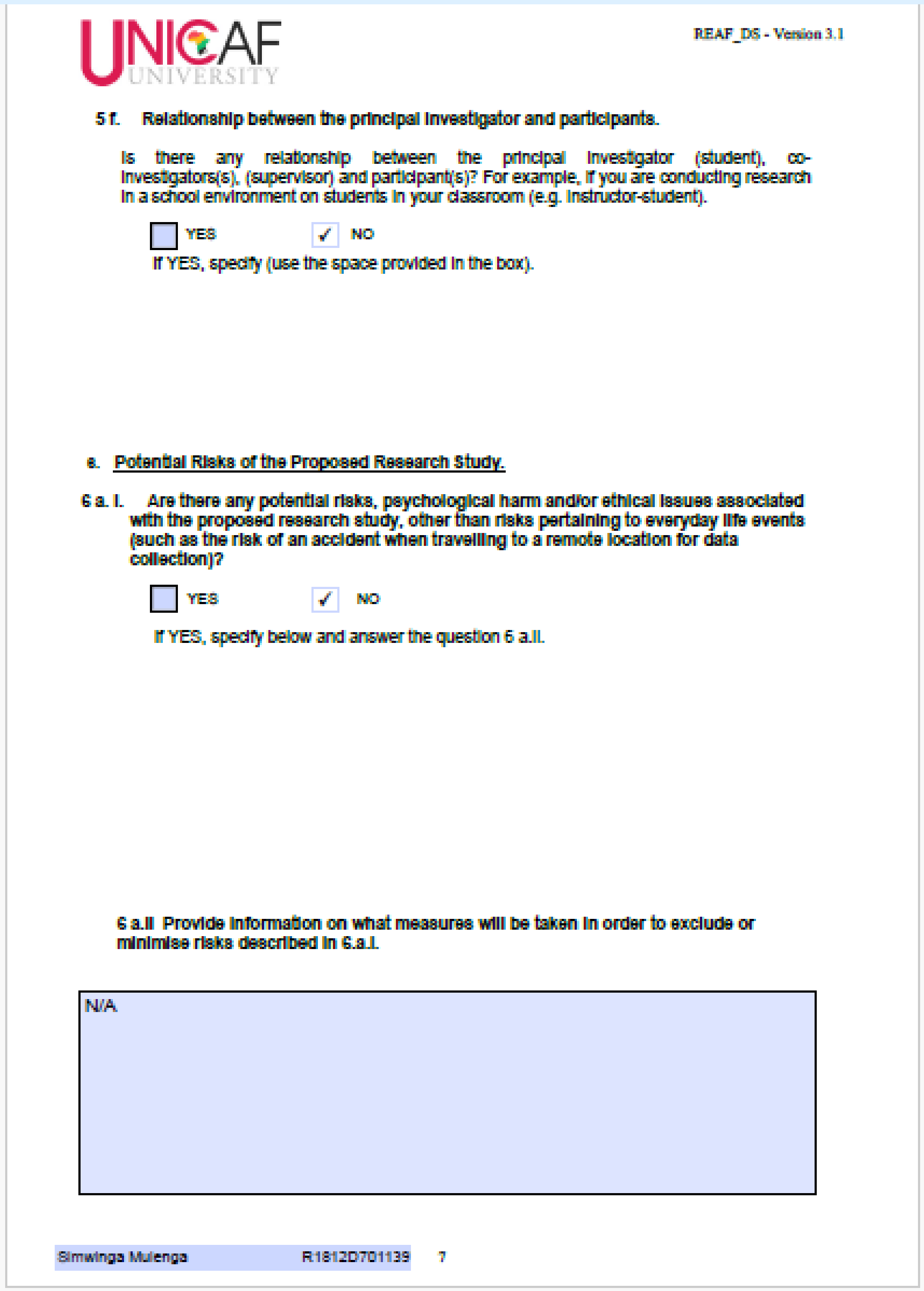
Eligible participants from eligible solar and supporting organisations will be accessed through the consent of appropriate gatekeepers. Prior permission from Gatekeepers will be sought after written request outlining the purpose of the research, anonymity, confidentiality associated with the research, including participants' rights not to participate or withdraw from a research before accessing them face to face or through electronic platforms. Participants will also be availed individual informed consent forms before participating in the study. Participants will be sought from public and private institutions implementing, financing, policy formulation or regulation of solar energy projects including donor organisations supporting solar development.

5 e. Research Participants Informed Consent.

Select below which categories of participants will participate in the study. Complete the relevant Informed Consent form and submit it along with the REAF form.

Yes	No	Categories of participants	Form to be completed
☑	☐	Typically Developing population(s) above the maturity age *	Informed Consent Form
☐	☑	Typically Developing population(s) under the maturity age *	Guardian Informed Consent Form

* Maturity age is defined by national regulations in laws of the country in which the research is being conducted.



5 f. Relationship between the principal investigator and participants.

Is there any relationship between the principal investigator (student), co-investigators(s), (supervisor) and participant(s)? For example, if you are conducting research in a school environment on students in your classroom (e.g. instructor-student).

☐ YES ☑ NO

If YES, specify (use the space provided in the box).

6. Potential Risks of the Proposed Research Study.

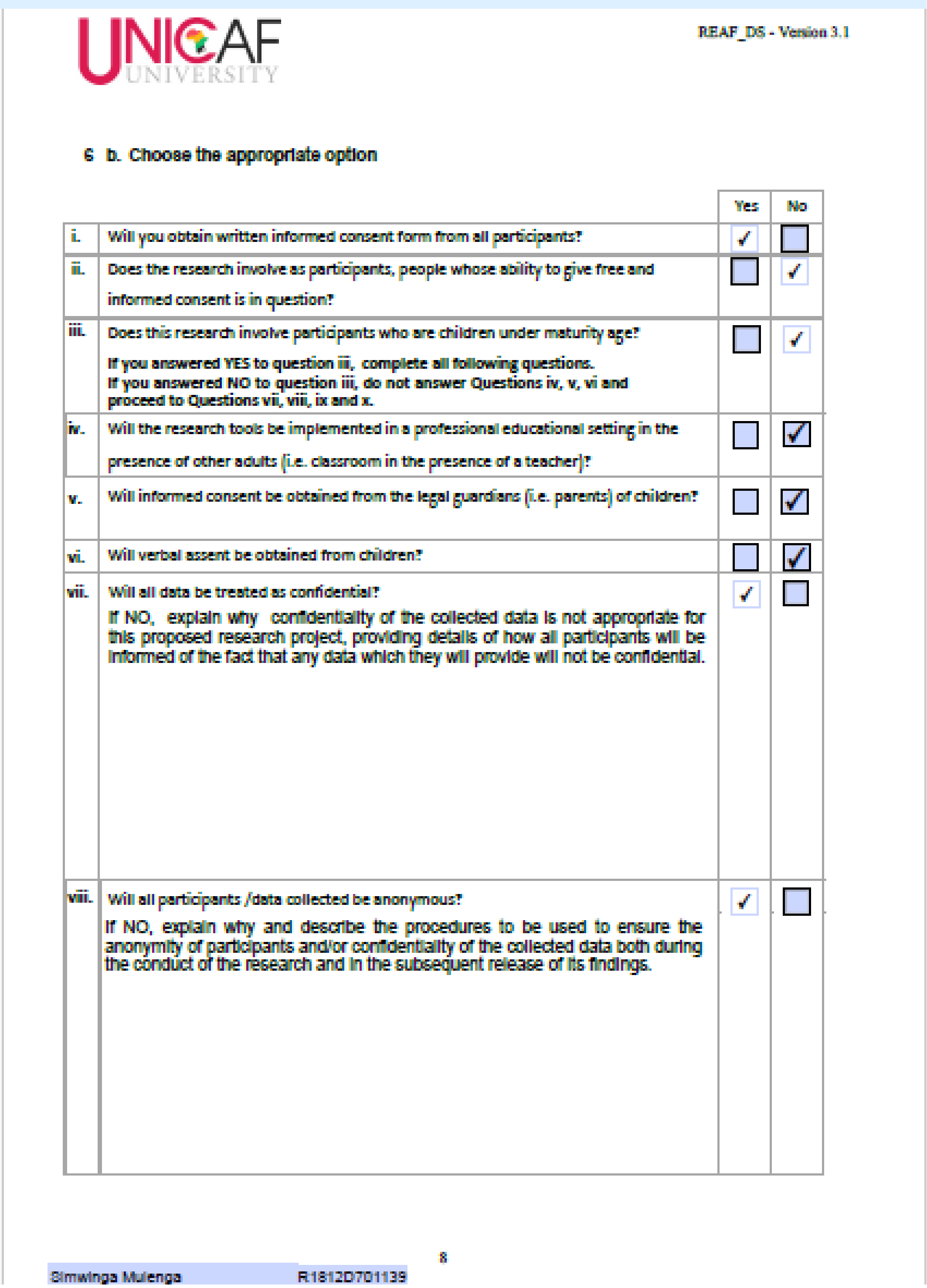
6 a. i. Are there any potential risks, psychological harm and/or ethical issues associated with the proposed research study, other than risks pertaining to everyday life events (such as the risk of an accident when travelling to a remote location for data collection)?

☐ YES ☑ NO

If YES, specify below and answer the question 6 a.ii.

6 a.ii Provide information on what measures will be taken in order to exclude or minimise risks described in 6.a.i.

N/A



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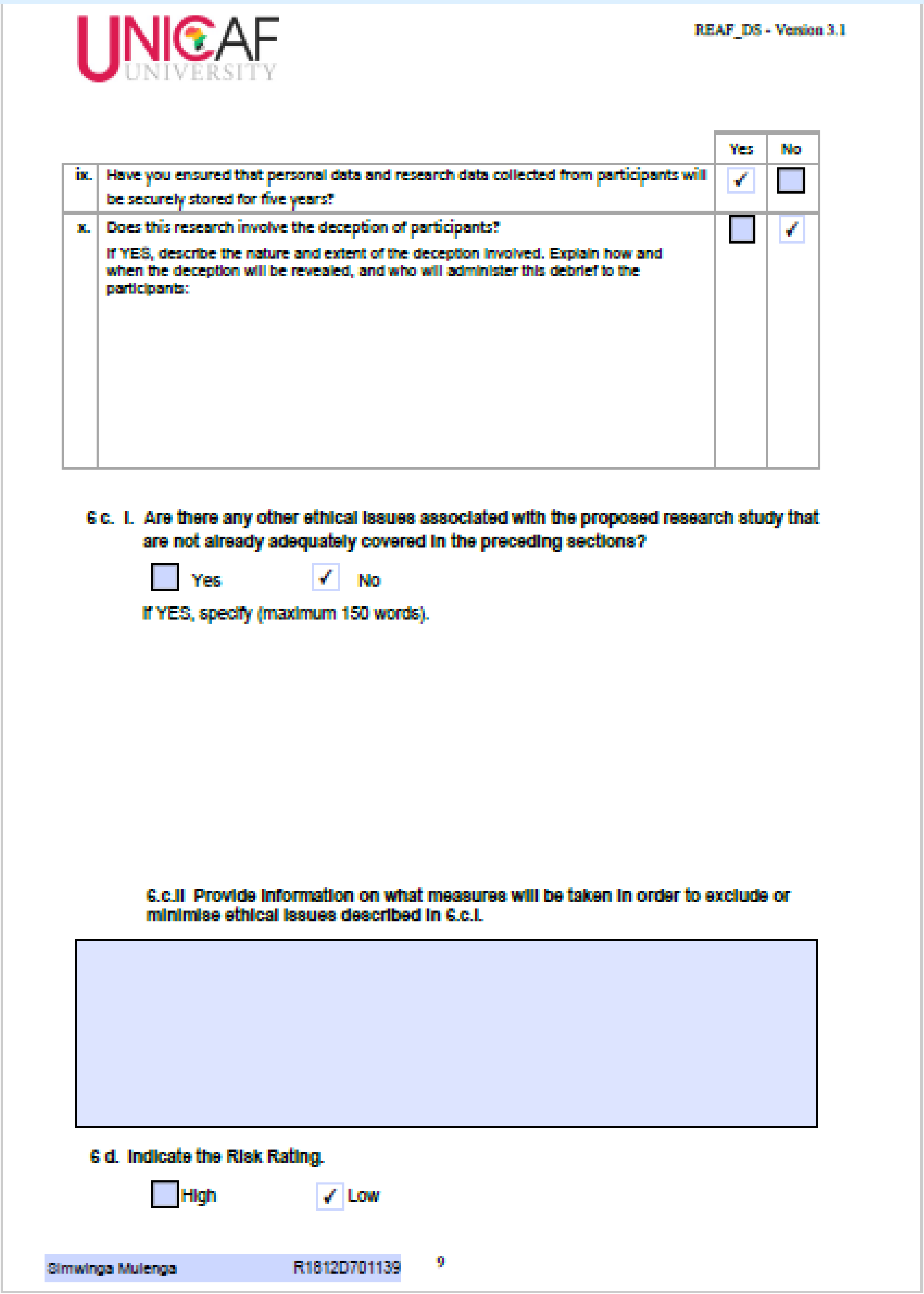
6 b. Choose the appropriate option

		Yes	No
i.	Will you obtain written informed consent form from all participants?	✓	☐
ii.	Does the research involve as participants, people whose ability to give free and informed consent is in question?	☐	✓
iii.	Does this research involve participants who are children under maturity age? **If you answered YES to question iii, complete all following questions.** **If you answered NO to question iii, do not answer Questions iv, v, vi and proceed to Questions vii, viii, ix and x.**	☐	✓
iv.	Will the research tools be implemented in a professional educational setting in the presence of other adults (i.e. classroom in the presence of a teacher)?	☐	☑
v.	Will informed consent be obtained from the legal guardians (i.e. parents) of children?	☐	☑
vi.	Will verbal assent be obtained from children?	☐	☑
vii.	Will all data be treated as confidential? If NO, explain why confidentiality of the collected data is not appropriate for this proposed research project, providing details of how all participants will be informed of the fact that any data which they will provide will not be confidential.	✓	☐
viii.	Will all participants /data collected be anonymous? If NO, explain why and describe the procedures to be used to ensure the anonymity of participants and/or confidentiality of the collected data both during the conduct of the research and in the subsequent release of its findings.	✓	☐

8

Simwinga Mulenga R1812D701139



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		Yes	No
ix.	Have you ensured that personal data and research data collected from participants will be securely stored for five years?	☑	☐
x.	Does this research involve the deception of participants? If YES, describe the nature and extent of the deception involved. Explain how and when the deception will be revealed, and who will administer this debrief to the participants:	☐	☑

6 c. i. Are there any other ethical issues associated with the proposed research study that are not already adequately covered in the preceding sections?

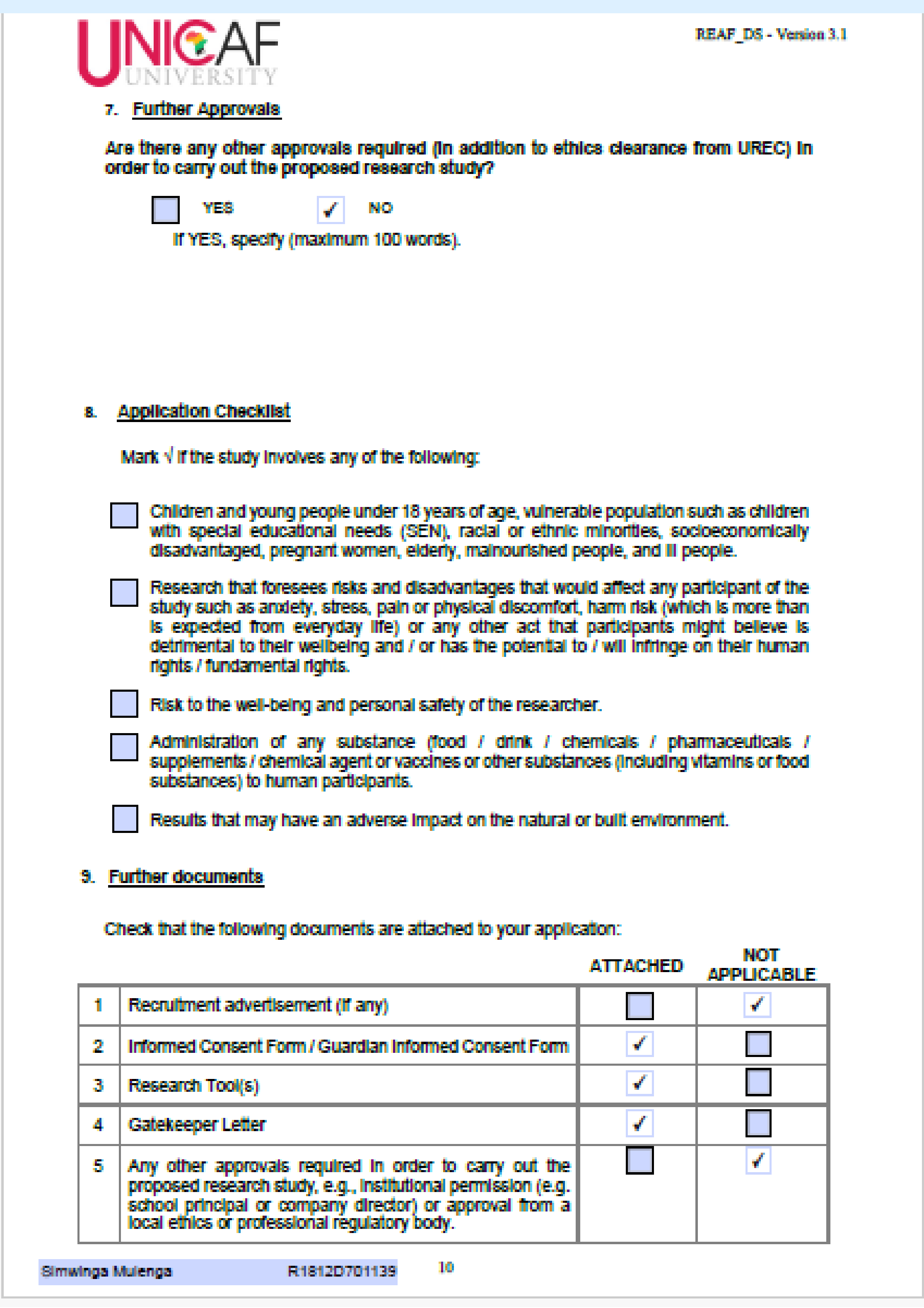
☐ Yes ☑ No

If YES, specify (maximum 150 words).

6.c.ii Provide information on what measures will be taken in order to exclude or minimise ethical issues described in 6.c.i.

6 d. Indicate the Risk Rating.

☐ High ☑ Low



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7. Further Approvals

Are there any other approvals required (in addition to ethics clearance from UREC) in order to carry out the proposed research study?

☐ YES ☑ NO

If YES, specify (maximum 100 words).

8. Application Checklist

Mark √ if the study involves any of the following:

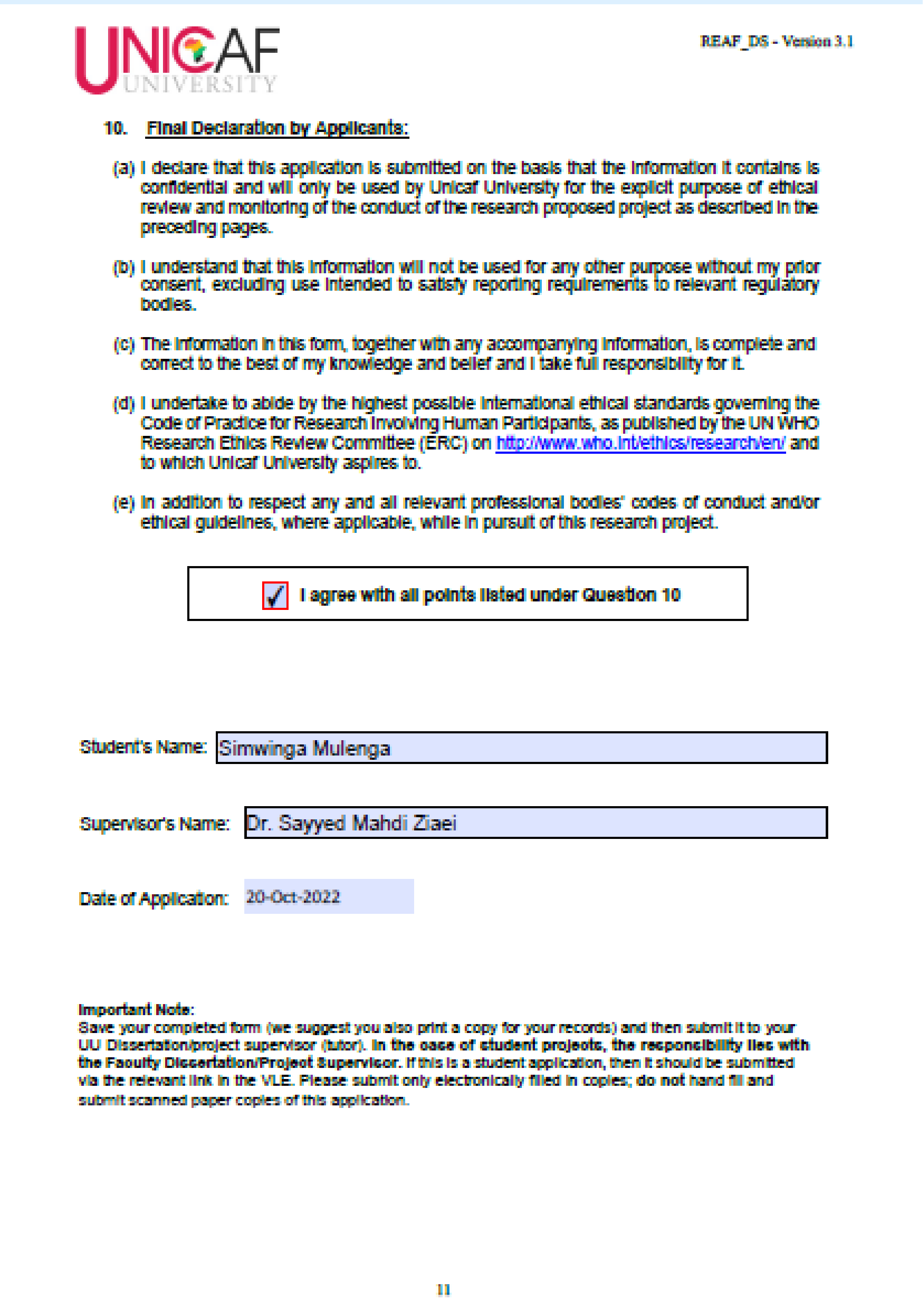
- ☐ Children and young people under 18 years of age, vulnerable population such as children with special educational needs (SEN), racial or ethnic minorities, socioeconomically disadvantaged, pregnant women, elderly, malnourished people, and ill people.
- ☐ Research that foresees risks and disadvantages that would affect any participant of the study such as anxiety, stress, pain or physical discomfort, harm risk (which is more than is expected from everyday life) or any other act that participants might believe is detrimental to their wellbeing and / or has the potential to / will infringe on their human rights / fundamental rights.
- ☐ Risk to the well-being and personal safety of the researcher.
- ☐ Administration of any substance (food / drink / chemicals / pharmaceuticals / supplements / chemical agent or vaccines or other substances (including vitamins or food substances) to human participants.
- ☐ Results that may have an adverse impact on the natural or built environment.

9. Further documents

Check that the following documents are attached to your application:

		ATTACHED	NOT APPLICABLE
1	Recruitment advertisement (if any)	☐	☑
2	Informed Consent Form / Guardian Informed Consent Form	☑	☐
3	Research Tool(s)	☑	☐
4	Gatekeeper Letter	☑	☐
5	Any other approvals required in order to carry out the proposed research study, e.g., institutional permission (e.g. school principal or company director) or approval from a local ethics or professional regulatory body.	☐	☑

Simwinga Mulenga R1812D701139 10



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10. Final Declaration by Applicants:

(a) I declare that this application is submitted on the basis that the information it contains is confidential and will only be used by Unicaf University for the explicit purpose of ethical review and monitoring of the conduct of the research proposed project as described in the preceding pages.

(b) I understand that this information will not be used for any other purpose without my prior consent, excluding use intended to satisfy reporting requirements to relevant regulatory bodies.

(c) The information in this form, together with any accompanying information, is complete and correct to the best of my knowledge and belief and I take full responsibility for it.

(d) I undertake to abide by the highest possible international ethical standards governing the Code of Practice for Research Involving Human Participants, as published by the UN WHO Research Ethics Review Committee (ERC) on http://www.who.int/ethics/research/en/ and to which Unicaf University aspires to.

(e) In addition to respect any and all relevant professional bodies' codes of conduct and/or ethical guidelines, where applicable, while in pursuit of this research project.

☑ **I agree with all points listed under Question 10**

Student's Name: Simwinga Mulenga

Supervisor's Name: Dr. Sayyed Mahdi Ziaei

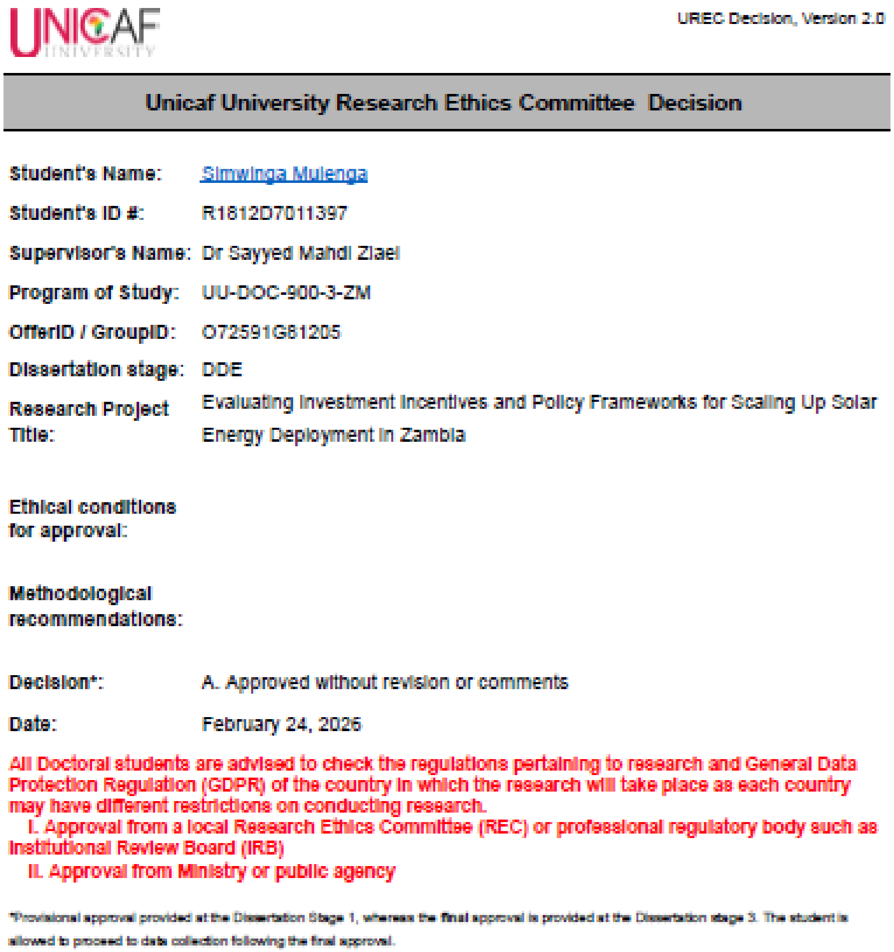
Date of Application: 20-Oct-2022

Important Note:
Save your completed form (we suggest you also print a copy for your records) and then submit it to your UU Dissertation/project supervisor (tutor). **In the case of student projects, the responsibility lies with the Faculty Dissertation/Project Supervisor.** If this is a student application, then it should be submitted via the relevant link in the VLE. Please submit only electronically filled in copies; do not hand fill and submit scanned paper copies of this application.

11

Appendix F

UREC Approval



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UREC Decision, Version 2.0

Unicaf University Research Ethics Committee Decision

Student's Name:	Simwinga Mulenga
Student's ID #:	R1612D7011397
Supervisor's Name:	Dr Sayyed Mahdi Ziaei
Program of Study:	UU-DOC-900-3-ZM
OfferID / GroupID:	O72591G81205
Dissertation stage:	DDE
Research Project Title:	Evaluating Investment Incentives and Policy Frameworks for Scaling Up Solar Energy Deployment in Zambia
Ethical conditions for approval:	
Methodological recommendations:	
Decision*:	A. Approved without revision or comments
Date:	February 24, 2026

All Doctoral students are advised to check the regulations pertaining to research and General Data Protection Regulation (GDPR) of the country in which the research will take place as each country may have different restrictions on conducting research.

I. Approval from a local Research Ethics Committee (REC) or professional regulatory body such as Institutional Review Board (IRB)

II. Approval from Ministry or public agency

*Provisional approval provided at the Dissertation Stage 1, whereas the final approval is provided at the Dissertation stage 3. The student is allowed to proceed to data collection following the final approval.

Appendix G:

Research Instrument

The study employed a structured questionnaire to examine solar sector investment incentives and performance outcomes in Zambia under the title; Evaluating Investment Incentives and Policy Frameworks for Scaling up Solar Energy Deployment in Zambia. The instrument was designed to collect quantitative data on the relationships and effects of financial, fiscal, and non-monetary incentives on investment performance outcomes, measured in terms of private sector investment rates and returns on investment (ROI).

The questionnaire was distributed face to face, targeting participants with professional experience in solar sector financing, policy formulation, implementation, regulation, investment promotion, and trading in Zambia.

Within the study's framework, the Private Sector Investment Rate (PSIR) is specified as an endogenous variable. PSIR is modelled as an explanatory variable in the financial incentives versus return on investment (ROI) equation and as a dependent variable in relationship tests and regression models assessing the effects of some of the fiscal and non-monetary investment incentives.

Measurement scale

Responses were measured using a five-point Likert scale, adapted to reflect the nature of each construct, as outlined below.

Scale	Agreement	Effect	Level	Suitability	Affordability
1	Strongly disagree	Very Negative	Very Low	Very Unsuitable	Very Unaffordable
2	Disagree	Negative	low	Unsuitable	Un Affordable
3	Neutral	Moderate	Average	Moderate	Moderate
4	Agree	Positive	High	Suitable	Affordable
5	Strongly Agree	Very Positive	Very High	Very Suitable	Very Affordable

Note. Likert Scale indicating various measured response attributes

Section A: Respondent and Organisational Profile

This section captured demographic and professional characteristics of respondents.

1. What is your gender?

(Male; Female; Other; Prefer not to say)

2. Which age group do you belong to?

(22–30; 31–40; 41–50; 51–60; above 60 years)

3. What is your highest level of education? *(Trade certificate; Diploma; Bachelor's degree; Master's degree; PhD)*

4. How long have you worked in the renewable energy sector?

(1–2; 3–4; 5–6; above 6 years)

Section B: Financial Incentives

This section assessed financial incentive conditions and investment performance outcomes.

5. On a scale of 1 to 5, how would you rate the level of private sector investment rates in solar energy in Zambia in the past five years?

(1 - Very low; 2 – Low; 3 - Moderate; 4 - High; 5 - Very high)

6. On a scale of 1 to 5, how would you rate the levels of financial access to government loans, guarantees and bank loans for solar sector investments in Zambia?

(1 - Very low; 2 – Low; 3 - Moderate; 4 - High; 5 - Very high)

Section C: Fiscal Incentives

This section examined the influence of fiscal incentives on private sector investment rates.

7. On a scale of 1 to 5, rate the suitability of existing fiscal incentives in form of reduced corporate tax, dividends, import duty and VAT for private investments in solar energy in Zambia?

(*1 -Very unsuitable; 2- Unsuitable; 3 – Moderate; 4 – suitable; 5- Very Suitable)*

8. On a scale of 1 to 5, rate the effect of existing fiscal incentives in reduced corporate tax, dividends, import duty and VAT for solar investments in Zambia?

(1- Very low; 2 –Low; 3 – Moderate; 4 – High; 5 -Very high)

This subsection assessed how non-monetary conditions influence private sector investment rates.

9. On a scale of 1 to 5, how would you rate initial cost of investing in solar energy in Zambia?

(1- Very low; 2 - Low 3 - Moderate; 4 - High; 5 - Very high)

10. On a scale of 1 to 5, how would you rate the affordability of solar energy services in Zambia?

(1 - Very unaffordable; 2 - Unaffordable; 3 -Moderate; 4 - Affordable; 5- Very Affordable)

11. On a scale of 1 to 5, how would you rate the effect of ‘Type, Value and Location' based structured fiscal incentives on solar sector investments in Zambia?

(1 - Very negative; 2 - Negative; 3- Moderate; 4 - Positive; 5 - Very positive)

12. On a scale of 1 to 5, How do you rate how bankability of Power Purchase Agreements (PPAs) for Independent Power Producers (IPP) in Zambia?

(1- Very negative; 2- Negative; 3- Moderate; 4- Positive; 5- Very positive)

13. On a scale of 1 to 5, rate the effect of Investment Promotions and Protection Agreements (IPPA) on levels of investment in Zambia's solar sector.

(1- Very negative; 2- Negative; 3- Moderate; 4- Positive; 5- Very positive)

14. On a scale of 1 to 5, rate the improvement resulting from investments policies structured according to Value, Location and Type of investment in the solar for the past five years in Zambia?

(1- Very negative; 2- Negative; 3- Moderate; 4- Positive; 5- Very positive)

Section D: Outcome Variables

This section captured the study’s primary outcome measures.

15. On a scale of 1 to 5 how would you rate levels of Return on Investment (RoI) for solar power producers in Zambia (Criterion Variable)?

(1 - Very positive; 2 – Positive; 3- Moderate; 4- Negative; 5 - Very negative)

16. On a scale of 1 to 5, how would you rate the level of private sector investment rates in solar energy in Zambia in the past five years?

(1 - Very low; 2 – Low; 3 - Moderate; 4 - High; 5 - Very high)

Appendix H

Table

Variable Category	Variable	Indicators	Questionnaire Items gauging (Likert Scale)	Section
Independent Variable (IV- 1)	Financial Incentives	Access to Govt loans, guarantees, & bank loans	Access to Govt/ bank-supported loans for solar investments.	Section A
		Effect of financial access on solar investments	Influence on investments from existing financial loan schemes.	
		Private sector investments rates	Private-sector investment rates in solar energy have grown consistently in recent year	
Independent Variable (IV-2)	Fiscal Incentives	Suitability of reduced corporate tax, dividend tax, import duty, and VAT	Current tax reductions suitable for promoting solar investments.	Section B
		Effect of fiscal incentives on solar investments	Existing fiscal incentives significantly influence private-sector investment decisions in solar energy.	
Independent Variables (IV-2)	Non-Monetary incentives	Bankability of PPAs for IPPs	Current PPAs are bankable and supportive of solar energy investments."	Section C
		Effect of Investment Promotion and Protection Agreements (IPPAs) on investment levels	Existing (IPPAs) encourage private-sector solar investment."	
		Effect of location- and value-based concessions	Location- and value-based concessions encourage investment in solar energy projects."	

		Effect of affordability of solar services	Affordability of solar energy services contributes to increased sector investment.”	Section C
Dependent Variable (DV)	Investment Performance	Return on Investment (ROI)	Solar energy investments provide competitive returns compared to other sectors.	Section D
		Private solar investments Rates	The current rate of private-sector investments in solar energy reflects sector growth.	

Classification of Questionnaire by Variables

Note. Breakdown and classification of questionnaire items according to variables

Appendix I

Research Tool Alignment with Theoretical Framework

Table 2: Alignment with Technological Innovation Systems Theory)

Section	**Variable**	**Alignment to Theoretical Framework (TIS Theory)**
Section A	Financial Incentives (IV1)	Monetary inputs supports the concepts of the Technological innovation systems by financially supporting novel investments
Section B	Fiscal Incentives (IV2)	Supports TIS advocacy to have support structures and policy instruments strengthening innovation pathways alongside financial inputs
Section C	Non-monetary Incentives (IV3)	Conducive investment environment supporting are highlighted in the TIS theory as a requisite for investment growth and stable system functionality
Section D	Investment Performance (DV)	Technological innovation systems Theory emphasises investment returns and investment rate as indicators of system growth

Note. Summarised layout of alignment of the variables to TIS

Appendix J:

Data Coding Process and Simple Random Sampling (SRS)

Random Code Generation	Sample Frame (Institutions)	Sample Frame (Numbers)	Random Sample Selection (First 244)	Sample Sorting
0.003319	UNIVERSITY OF ZAMBIA	301	275	2
0.012892	ZAMGRID LTD	254	2	5
0.021155	SOLERA ELSEWEDY	37	173	7
0.023728	WID ENERGY AFRICA	239	283	8
0.024562	CHLORIDE (Z) KABWE	169	5	9
0.039607	BARGAIN SYNERGY	212	272	10
0.040349	SNV	45	7	11
0.040371	ZECTEC BUSINESS SOLUTIONS	140	8	12
0.042285	CAMCO ZAMBIA LTD	152	9	13
0.045054	DS SOLAR LTD	144	10	14
0.049116	MUHANYA SOLAR LTD	277	11	15
0.055131	MUHANYA SOLAR LTD	280	13	16
0.063417	MYSOL SOLAR CO	162	14	17
0.065139	CHLORIDE (Z) LTD KITWE	54	15	18
0.065935	KASUBA POWER SOLUTION	82	17	19
0.068467	ZDA	33	18	20
0.070033	VITALTE SOLAR LTD	181	19	21
0.070036	DAMUNGU SOLAR	217	20	22
0.070735	MUSIKA DEV INITIATIVE LTD	179	21	23
0.075872	DAVIES AND SHIRTLIFF	266	22	24

0.078702	ZAMGRID LTD	257	23	25
0.079516	MYSOL SOLAR CO	156	24	26
0.080003	MUSIKA DEV INITIATIVE LTD	174	26	28
0.085567	RENWASAL RENEWABLE EN	99	28	29
0.08715	CHLORIDE (Z) KABWE	168	33	35
0.087402	SARO AGRO ZAMBIA LTD	72	35	36
0.088748	SNV	43	36	37
0.090467	MUSIKA DEV INITIATIVE LTD	175	38	38
0.091514	CHLORIDE (Z) LTD KITWE	51	39	39
0.095903	WID ENERGY AFRICA	242	40	40
0.09617	NAMENE SOLAR	7	41	41
0.104502	SUNTECH LTD	200	42	42
0.105398	WID ENERGY AFRICA	245	43	43
0.110745	KAZANG SOLAR LTD	63	44	44
0.112783	BARGAIN SYNERGY	209	45	45
0.113404	RURAL ELECT AUTHORITY	295	46	46
0.118601	DAMUNGU SOLAR	213	47	47
0.122827	UNIVERSITY OF ZAMBIA	307	48	48
0.123442	UNIVERSITY OF ZAMBIA	313	49	49
0.127888	VITALTE SOLAR LTD	184	50	50
0.13094	SUNRAY POWER CO LTD	130	51	51
0.133803	SARO AGRO ZAMBIA LTD	70	52	52
0.134984	KASUBA POWER SOLUTION	78	53	53
0.136484	MUSIKA DEV INITIATIVE LTD	172	54	54
0.140528	SOLAR MACS ENERGY	18	57	57
0.14331	GIZ	22	58	58
0.145719	AK SOLAR LTD	60	60	60
0.146262	CAMCO ZAMBIA LTD	149	61	61

0.148474	BARGAIN SYNERGY	205	62	62
0.150433	CHLORIDE (Z) KABWE	164	63	63
0.156181	SUNRAY POWER CO LTD	134	66	66
0.162456	ZAMBEZI AMIGO ENERGY LTD	117	67	67
0.163124	RENWASAL RENEWABLE EN	95	68	68
0.168251	DAVIES AND SHIRTLIFF	265	69	69
0.17475	SUNRAY POWER CO LTD	132	70	70
0.177702	COPPERBELT ENERGY CORP	284	72	72
0.178803	SU HWANG LTD	89	73	73
0.187649	ENERGY REGULATION BOARD	236	74	74
0.188961	UNIVERSITY OF ZAMBIA	304	75	75
0.192867	COPPERBELT ENERGY CORP	286	76	76
0.198583	CHLORIDE (Z) LTD KITWE	53	78	78
0.208654	SOLAR MACS ENERGY	14	80	80
0.211575	SARO AGRO ZAMBIA LTD	73	81	81
0.212313	CHLORIDE (Z) KABWE	167	82	82
0.217682	SUNTECH LTD	199	84	84
0.220877	CHLORIDE (Z) KABWE	166	179	88
0.229547	MUSIKA DEV INITIATIVE LTD	176	88	89
0.234945	MUHANYA SOLAR LTD	275	89	90
0.237678	ENGIE (Z) LTD KABWE	194	90	93
0.25145	RURAL ELECT AUTHORITY	297	25	95
0.255002	BARGAIN SYNERGY	208	93	97
0.258276	VITALTE SOLAR LTD	186	95	99
0.261308	ENERGY REGULATION BOARD	234	97	101
0.262909	KAZANG SOLAR LTD	65	99	102
0.265166	KAZANG SOLAR LTD	69	101	104
0.270776	SUNTECH LTD	197	102	106

0.275083	WID ENERGY AFRICA	238	106	113
0.277221	ZECTEC BUSINESS SOLUTIONS	135	37	114
0.277498	GIV	26	287	115
0.278337	NAMENE SOLAR	12	110	117
0.281737	KASUBA POWER SOLUTION	84	244	118
0.290908	ZAMGRID LTD	260	113	119
0.291464	SUNRAY POWER CO LTD	131	114	123
0.294628	NAMENE SOLAR	13	115	124
0.295733	CHLORIDE (Z) LTD KITWE	52	117	126
0.298681	ZECTEC BUSINESS SOLUTIONS	138	118	127
0.300944	BARGAIN SYNERGY	211	119	128
0.304942	DAVIES AND SHIRTLIFF	267	123	129
0.313074	SUPCO SUPPLY & CONSTR	109	124	130
0.317865	ENGIE (Z) LTD KABWE	189	126	131
0.322216	SOLERA ELSEWEDY	40	127	132
0.325393	SOLAR MACS ENERGY	16	128	133
0.338164	SNV	46	129	134
0.339501	NAMENE SOLAR	11	130	135
0.341503	KASUBA POWER SOLUTION	81	131	138
0.341801	COPPERBELT ENERGY CORP	289	132	139
0.345927	DAMUNGU SOLAR	215	133	140
0.347854	SNV	49	134	141
0.350159	SARO AGRO ZAMBIA LTD	74	135	142
0.351131	SWITCH AC-DC	249	255	144
0.351688	RURAL ELECT AUTHORITY	291	16	145
0.357523	WID ENERGY AFRICA	240	138	148
0.368557	UNIVERSITY OF ZAMBIA	310	140	150

0.370007	SU HWANG LTD	90	141	151
0.370167	ZAMGREAT SOLAR LTD	228	142	152
0.371849	COPPERBELT ENERGY CORP	283	144	155
0.378835	MUHANYA SOLAR LTD	278	145	156
0.381399	MUHANYA SOLAR LTD	274	206	157
0.38239	ENERGY REGULATION BOARD	237	148	159
0.38263	RENWASAL RENEWABLE EN	93	149	160
0.383334	CHLORIDE (Z) LTD KITWE	50	150	161
0.396453	SOLAR MACS ENERGY	15	151	162
0.401924	ZAMGRID LTD	255	152	163
0.404165	ERB	235	219	164
0.405737	SWITCH AC-DC KITWE	248	155	165
0.406143	SWITCH AC-DC LUSAKA	252	156	166
0.407188	SOLERA ELSEWEDY	41	157	167
0.409876	KAZANG SOLAR LTD	67	159	168
0.416152	COPPERBELT ENERGY CORP	288	160	169
0.4181	BATTERY KING	127	161	170
0.429952	UNIVERSITY OF ZAMBIA	311	162	171
0.436225	CHLORIDE (Z) KABWE	170	163	172
0.436411	GIV	25	164	173
0.436578	WID ENERGY AFRICA	241	165	174
0.449173	DS SOLAR LTD	145	166	175
0.45247	DAMUNGU SOLAR	219	167	176
0.4528	RURAL ELECT AUTHORITY	299	168	179
0.454011	DAVIES AND SHIRTLIFF	268	169	180
0.458887	UNIVERSITY OF ZAMBIA	315	171	183
0.460899	RDG COLLECTIVE LTD	2	172	184
0.461212	SNV	48	174	186

0.468096	MYSOL SOLAR CO	157	175	188
0.475934	ZAMGRID LTD	253	176	189
0.47729	DAMUNGU SOLAR	220	180	194
0.486698	ZECTEC BUSINESS SOLUTIONS	141	181	196
0.498121	RURAL ELECT AUTHORITY	296	183	197
0.505342	NAMENE SOLAR	9	184	198
0.507276	SUPCO SUPPLY & CONSTR	113	186	199
0.507721	VITALTE SOLAR LTD	180	188	200
0.514056	SOLAR MACS ENERGY	20	189	201
0.52094	GIZ	24	12	203
0.524182	ZAMBEZI AMIGO ENERGY LTD	114	298	204
0.531163	SWITCH AC-DC	247	194	205
0.531347	RURAL ELECT AUTHORITY	300	196	206
0.534089	SOLERA ELSEWEDY	36	197	208
0.534827	ZAMGREAT SOLAR LTD	225	198	209
0.538073	BATTERY KING	123	199	210
0.538273	COPPERBELT ENERGY CORP	290	200	211
0.539565	UNIVERSITY OF ZAMBIA	308	201	212
0.542169	MUSIKA DEV INITIATIVE LTD	173	203	213
0.543871	SOLERA ELSEWEDY	38	204	215
0.543999	SU HWANG LTD	88	205	216
0.547073	ZAMGREAT SOLAR LTD	223	208	217
0.553104	MUHANYA SOLAR LTD	279	209	219
0.56024	WID ENERGY AFRICA	244	211	221
0.562368	DAMUNGU SOLAR	216	212	223
0.565026	ZDA	29	213	224
0.568538	SUNRAY POWER CO LTD	128	215	225
0.570679	MBS INDUSTRIES LTD	104	216	226

0.572249	ZAMGRID LTD	261	217	227
0.573449	ENGIE (Z) LTD KABWE	188	220	228
0.580632	SARO AGRO ZAMBIA LTD	76	221	229
0.583606	ZAMGREAT SOLAR LTD	227	296	231
0.589366	AK SOLAR LTD	61	223	232
0.594937	SUNTECH LTD	203	224	233
0.596556	UNIVERSITY OF ZAMBIA	305	225	234
0.599238	ZAMGREAT SOLAR LTD	221	226	235
0.601614	SWITCH AC-DC	251	227	236
0.601762	BARGAIN SYNERGY	206	228	237
0.604675	AK SOLAR LTD	58	229	238
0.608782	KAZANG SOLAR LTD	68	231	239
0.609685	CHLORIDE (Z) KABWE	171	232	240
0.61465	GIZ	23	233	241
0.626849	NAMENE SOLAR	8	234	242
0.627178	MYSOL SOLAR CO	161	235	244
0.627795	UNIVERSITY OF ZAMBIA	303	236	245
0.628762	CAMCO ZAMBIA LTD	150	237	246
0.629082	MUHANYA SOLAR LTD	272	238	247
0.632869	SUNTECH LTD	196	239	248
0.63887	RENWASAL RENEWABLE EN	97	240	249
0.64929	MUHANYA SOLAR LTD	273	242	251
0.649551	NAMENE SOLAR	10	245	252
0.653853	SOLERA ELSEWEDY	39	246	253
0.661053	SUPCO SUPPLY & CONSTR	110	247	254
0.662434	SUNTECH LTD	201	248	255
0.66295	ERB	231	249	257
0.663307	RDG COLLECTIVE LTD	5	250	258

0.665954	BARGAIN SYNERGY	210	251	259
0.666009	DS SOLAR LTD	148	252	260
0.668552	AK SOLAR LTD	57	253	261
0.670718	CAMCO ZAMBIA LTD	155	254	262
0.671187	COPPERBELT ENERGY CORP	287	257	263
0.672424	MBS INDUSTRIES LTD	102	258	264
0.675036	DS SOLAR LTD	142	259	265
0.68947	ZAMBEZI AMIGO ENERGY LTD	119	260	266
0.690403	VITALTE SOLAR LTD	183	261	267
0.692746	RURAL ELECT AUTHORITY	292	262	268
0.693535	SWITCH AC-DC	246	263	271
0.694098	CAMCO ZAMBIA LTD	151	264	272
0.694157	SOLERA ELSEWEDY	35	265	273
0.709633	DAVIES AND SHIRTLIFF	263	266	274
0.711972	MBS INDUSTRIES LTD	106	267	275
0.713554	SUNRAY POWER CO LTD	129	268	277
0.717893	ENERGY REGULATION BOARD	229	271	278
0.718045	UNIVERSITY OF ZAMBIA	312	273	279
0.719041	RURAL ELECT AUTHORITY	298	274	280
0.725034	UNIVERSITY OF ZAMBIA	314	278	284
0.72521	ZAMGREAT SOLAR LTD	224	279	285
0.725465	COPPERBELT ENERGY CORP	285	280	286
0.727989	ENERGY REGULATION BOARD	232	284	287
0.728221	ZAMGREAT SOLAR LTD	226	285	288
0.72917	MYSOL SOLAR CO	160	286	289
0.730613	ZECTEC BUSINESS SOLUTIONS	139	288	290
0.733285	ZDA	28	289	291
0.738733	SOLAR MACS ENERGY	17	290	292

0.740419	UNIVERSITY OF ZAMBIA	302	291	293
0.749321	ZAMBEZI AMIGO ENERGY LTD	115	292	294
0.752408	DAVIES AND SHIRTLIFF	264	293	295
0.759417	DAVIES AND SHIRTLIFF	262	294	296
0.760373	SNV	47	295	297
0.763311	KAZANG SOLAR LTD	66	297	298
0.77559	SUNTECH LTD	204	299	299
0.777309	MYSOL SOLAR CO	163	300	300
0.781137	RURAL ELECT AUTHORITY	293	301	301
0.78524	KASUBA POWER SOLUTION	80	302	302
0.789354	GIZ	21	303	303
0.790753	SUNTECH LTD	198	304	304
0.793871	RURAL ELECT AUTHORITY	294	305	305
0.796723	SOLERA ELSEWEDY	42	307	307
0.798422	BATTERY KING	124	308	308
0.800825	ZAMGRID LTD	259	310	310
0.810464	DAVIES AND SHIRTLIFF	271	311	311
0.813483	SUNRAY POWER CO LTD	133	313	313
0.816021	ZAMBEZI AMIGO ENERGY	118	314	314
0.817866	SWITCH AC-DC	250	315	276
0.8229	KAZANG SOLAR LTD	64	Random Selection of the first 244 Sample	
0.825428	SARO AGRO ZAMBIA LTD	71		
0.826392	BATTERY KING	122		
0.827173	SU HWANG LTD	85		
0.828942	ZDA	30		
0.829384	KASUBA POWER SOLUTION	83		
0.83107	DS SOLAR LTD	143		

0.833268	ENGIE (Z) LTD KABWE	191
0.834221	MBS INDUSTRIES LTD	101
0.835001	MBS INDUSTRIES LTD	105
0.840257	VITALTE SOLAR LTD	185
0.841759	UNIVERSITY OF ZAMBIA	309
0.842243	RDG COLLECTIVE LTD	6
0.847136	ZDA	34
0.848538	KASUBA POWER SOLUTION	77
0.857249	MUHANYA SOLAR LTD	276
0.857471	DS SOLAR LTD	146
0.857477	SUPCO SUPPLY & CONSTR	111
0.859444	ENGIE (Z) LTD KABWE	195
0.860974	ZAMBEZI AMIGO ENERGY	116
0.862563	SU HWANG LTD	86
0.863452	CHLORIDE (Z) LTD KITWE	55
0.864571	SUPCO SUPPLY & CONSTR	107
0.873403	UNIVERSITY OF ZAMBIA	306
0.87445	SUPCO SUPPLY & CONSTR	112
0.874841	ENGIE (Z) LTD KABWE	193
0.876593	SU HWANG LTD	91
0.876833	RENWASAL RENEWABLE EN	96
0.877799	BATTERY KING	121
0.87905	KASUBA POWER SOLUTION	79
0.881614	DAVIES AND SHIRTLIFF	270
0.887258	SU HWANG LTD	92
0.889367	RDG COLLECTIVE LTD	3
0.900335	MUSIKA DEV INITIATIVE LTD	178
0.909277	SUNTECH LTD	202

0.913067	ZAMGREAT SOLAR LTD	222
0.913968	SUPCO SUPPLY & CONSTR	108
0.919504	CAMCO ZAMBIA LTD	153
0.922044	ZAMGRID LTD	256
0.924759	DAVIES AND SHIRTLIFF	269
0.924866	RDG COLLECTIVE LTD	4
0.925099	ZAMBEZI AMIGO ENERGY	120
0.925664	DS SOLAR LTD	147
0.927012	AK SOLAR LTD	59
0.930861	MBS INDUSTRIES LTD	103
0.931761	CAMCO ZAMBIA LTD	154
0.936083	GIZ	27
0.940311	ZECTEC BUSINESS SOLUTIONS	136
0.941968	RENWASAL RENEWABLE EN	98
0.946149	DAMUNGU SOLAR	214
0.946612	MBS INDUSTRIES LTD	100
0.946642	ZECTEC BUSINESS SOLUTIONS	136
0.948908	ENERGY REGULATION BOARD	230
0.949365	COPPERBELT ENERGY CORP	282
0.951766	VITALTE SOLAR LTD	182
0.951884	MYSOL SOLAR CO	158
0.961218	VITALTE SOLAR LTD	187
0.965211	MUSIKA DEV INITIATIVE LTD	177
0.972046	COPPERBELT ENERGY CORP	281
0.974604	ENGIE (Z) LTD KABWE	190
0.974674	RENWASAL RENEWABLE EN	94
0.982402	ZDA	32
0.985135	WID ENERGY AFRICA	243

0.985485	RDG COLLECTIVE LTD	1
0.985863	AK SOLAR LTD	56
0.986612	BATTERY KING	125
0.994436	DAMUNGU SOLAR	218
0.997406	ENGIE (Z) LTD KABWE	192
0.99917	ZDA	31

Note. Outline of the research sample selection through Simple random sampling. *Source:* Excel Sheet RAND Function

Appendix K:

Cronbach Alpha Test for of Pilot Study questionnaire

Table 1

Case Processing Summary

		N	%
Cases	Valid	12	48.0
	Excluded [a]	13	40.0
	Total	25	100.0

Note. [a.] Listwise deletion based on all variables in the procedure. Processing summary indicating total number of cases in the dataset - 25 and number of question tested being 12. *Source*: IBM SPSS outputs

Table 2

Reliability Statistics -Pilot Cronbach alpha test results

Constructs (Variables)	**No. of Items**	**Cronbach's α (Pilot)**	**Cronbach's α (Final)**	**Remarks**
Financial	3	0.62	0.73	Refined
Fiscal	3	0.64	0.71	Refined
Non -Monetary	6	0.68	0.75	Refined
Collectively	12	-	0.72*	Accepted

Note. * The final Cronbach alpha level for 12 items tested from 25 cases in the dataset is at 0.72. Individual items refined to acceptable level through adjustments and exclusions. *Source*: IBM SPSS outputs

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Appendix L:

Checklist of Data Preparation – Cleaning and Coding Steps

Action	Purpose
Screening for Missing Data	Checked for incomplete responses and handled missing values appropriately (removal or imputation).
Detection of Outliers	Identified and reviewed extreme or inconsistent values.
Data Entry Verification	Cross-checked entered responses against original survey forms to minimize typographical errors.
Coding of Responses	Assigned numerical codes to categorical and Likert-scale items to enable statistical analysis.
Labelling of Variables	Applied clear, standardized labels for all variables to ensure interpretability in SPSS.
Scale Verification	Confirmed measurement levels (ratio and ordinal), for appropriate statistical tests.
Randomization	Used the RAND function in Microsoft Excel to randomly distribute and select cases.
Standardization	Ensured uniform formatting of variable names, response categories, and data structures.
Final Consistency Check	Reviewed dataset for completeness, logical consistency, and readiness for import into SPSS.

Note. Steps taken during data cleaning and coding, demonstrating methodological rigor to ensure replicability of the study. Source (Fadele & Rocha, 2025). Design by Author