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Institute of Water and Energy Sciences

MASTER'S DISSERTATION

Submitted in partial fulfillment of the requirements for the award of a Master of Science degree in

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Presented by

Bakengana PADDY

Challenges and way forward for using the Multi-Tier Framework for bottom-up Tracking of progress towards SDG7, a case of selected clean energy companies in Uganda

Defended on 17th/11/ 2021, before the following committee,

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Pan African University
Institute of Water
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INSTITUTE FOR WATER AND ENERGY SCIENCES

(Including CLIMATE CHANGE)

Challenges and Way forward for Using the Multi-Tier Framework for Bottom-up Tracking of progress towards SDG7.

A Case of selected clean energy companies in Uganda.

A Master's thesis submitted to the Pan African University Institute of Water and Energy Sciences, including Climate Change (PAUWES) in partial fulfillment of the requirements for the award of the degree of Master of Science in Energy (Policy option).

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DISSERTATION APPROVAL PAGE

CHALLENGES AND WAY FORWARD FOR USING THE MULTI-TIER FRAMEWORK FOR BOTTOM-UP TRACKING OF PROGRESS TOWARDS ACHIEVING SDG 7,

A CASE OF SELECTED CLEAN ENERGY COMPANIES IN UGANDA.

Submitted by		**20th October 2021**
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DEDICATION

To my brother Nguru Julius (1979-2020), who lovingly taught me essential things that are rarely taught in school.

STATEMENT OF THE AUTHOR

I, Bakengana Paddy, declare that this dissertation titled, the challenges and ways forward for using the Multi-tier Framework for bottom-up Tracking of progress towards SDG7, A case of selected clean energy companies in Uganda' has never been submitted to any institution of higher education. I have followed all Pan African University (PAU) Scholarship regulations and recognized scholarly matters through proper citation and references. I affirm that I have made every effort within my means to avoid plagiarism.

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BIOGRAPHICAL SKETCH

Bakengana Paddy is one of the few Ugandan youths who have secured a fully paid Pan African University Scholarship under the African Union Commission. He was born and raised in Kaghorwe Village, Kyondo Sub County in Kasese District, Uganda. He holds a post-graduate certificate in administrative law from Bugema University, (Uganda) and a bachelor's degree in Public Administration from Gulu University (Uganda). He also holds a certificate in French from the University of Tlemcen, (Algeria) a certificate in Advanced entrepreneurship and leadership from the Sustainability Institute (South Africa), and certificate in Energy economics, environment and policy from the Asian Development Bank Institute (Philippines). Paddy has served as a volunteer-Child protection officer with compassion international from July 2017 to August 2018. He served as Projects Officer at Irrisol Engineering Limited in 2019. He did a three-months internship with the West African Science Center for Climate Change and Adapted Land Use (WASCAL) based in Ouagadougou, (Burkina Faso). From May 2021 to November 2021, Paddy did an internship with HEDERA Sustainable Solutions GmbH based in Berlin, (Germany).

Paddy strongly believes he will be a valuable asset to Uganda and Africa in designing actionable policies and setting necessary regulations towards scaling up electricity and clean cooking technologies. He is currently involved in the green energy research under the Impact-Driven and Action Based Research (IMPACT-R) in Uganda and he wishes to pursue a PhD as soon as possible while lecturing other students.

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ACRONYMS AND ABBREVIATIONS

AGECC Advisory Group on Energy and Climate Change
BECS Bundibugyo Electricity Cooperative Society
CREEC Centre for Research Energy Efficiency and Conservation
ERA Electricity Regulatory Authority
ESMAP Energy Sector Management Assistance Program
IEA International Energy Agency
IPPs Independent Power Producers
IRENA International Renewable Energy Agency
KIL Kilembe Investments Limited
KPI Key Performance Indicators.
LPG Liquefied Petroleum Gas
MDG Millennium Development Goals
MEPI Multidimensional Energy Poverty Index
MEMD Ministry of Energy and Mineral Development
MTF Multi-Tier Framework
NPA National Planning Authority
PACMES Padir Abim Community Multipurpose Electric Cooperative Society
REA Rural Electricity Agency
REB Rural Electricity Board
RECF Renewable Energy Capital Fund
SDG7 Sustainable Development Goal 7
SE4ALL Sustainable Energy for All
TEA Total Energy Access
UBOS Uganda Bureau of Statistics
UEB Uganda Electricity Board
UEDCL Uganda Electricity Distribution Company Limited
UNACC Uganda National Alliance for Clean Cooking
UNCDF United Nations Capital Development Fund
UNCDF United Nations Capital Development Fund

UEGCL	Uganda Electricity Generation Company Limited
UETCL	Uganda Electricity Transmission Company Limited
UNDP	United Nations Development Program
USEA	Uganda Solar Energy Association
WEO	World Energy Outlook
WENRECO	West Nile Rural Electricity Company
WHO	World Health Organisation.

ABSTRACT

Energy access remains a global challenge despite the interventions by national and international organizations. This challenge is more evident in Sub-Saharan Africa, where more than two-thirds of the population lack electricity. In Uganda, the government has introduced various measures to increase access to energy, but energy poverty is still a significant challenge. Again, the binary measurement of energy access has proven insufficient to reflect Uganda's actual energy poverty level. It defines energy access based on the Population with electricity and those without electricity, leaving some crucial components of energy access such as affordability, reliability, and safety. Still, the United Nations Sustainable Development Goal SDG-7 seeks to ensure affordable, reliable, sustainable, and modern energy for all by 2030. Through the Energy Sector Management Assistance Program (ESMAP), the World Bank proposed the Multi-Tier Framework (MTF) as an ideal tool for measuring energy access. It captures the multiple aspects of energy in line with SDG7. 17 energy developing countries have been adopted as pilot case studies for this MTF which has proven quite complex for reporting\tracking energy access because of the multiple data it requires.

With a mixed-method design, this research investigates the challenges of using the Multi-Tier Framework utilizing a sample of 12 solar and hydro-based energy companies and eight clean energy companies in Uganda. Results suggest that the MTF is intricate, yet, an ideal tool for tracking progress towards SDG7 because of its multi-dimensional nature spread on energy access tiers. This study also showed that MTF could be used for impact reporting by clean energy companies in Uganda because data collection is digitalized, and customers are sensitized to provide all information needed by energy companies. Further, the results show that the contribution of private energy companies to- energy access upscaling was outstanding despite their huge tax obligation. The study recommends using the multi-tier framework by both government and private-owned energy companies better to measure the trends of energy access in Uganda. Better policies, programs, and projects should be designed to enhance energy access in Uganda, with the ultimate goal of achieving affordable, reliable, sustainable, and modern energy for all.

RÉSUMÉ

L'accès à l'énergie continue d'être un défi mondial malgré les interventions pour que la question soit traitée de manière durable. En outre, le problème est plus visible en Afrique subsaharienne, où plus des deux tiers de la population n'ont pas l'électricité. Le gouvernement ougandais a proposé diverses mesures pour améliorer l'accès à l'énergie, mais la pauvreté énergétique reste un défi important. Pour relever tout défi, il faut commencer par le comprendre et y accéder de manière critique. La mesure binaire de l'accès à l'énergie s'est avérée insuffisante pour refléter le niveau réel de pauvreté énergétique en Ouganda. Elle définit l'accès à l'énergie sur la base de la population disposant de l'électricité et de celle qui n'en dispose pas, laissant de côté les composantes cruciales de l'accès à l'énergie telles que le caractère abordable, la fiabilité et la sécurité. Pourtant, l'ODD7 vise à garantir une énergie abordable, fiable, durable et moderne pour tous d'ici 2030. Dans le cadre du programme d'aide à la gestion du secteur de l'énergie (ESMAP), la Banque mondiale a proposé le cadre multi-niveaux (MTF) comme outil idéal pour mesurer et suivre l'accès à l'énergie. Il prend en compte les multiples aspects de l'énergie, conformément à l'ODD7.

De plus, après l'avoir piloté dans plus de 17 pays pauvres en énergie, le MTF s'est avéré assez complexe à utiliser pour le reporting/suivi de l'accès à l'énergie en raison des multiples données qu'il requiert. En utilisant une méthode mixte, la recherche examine les défis de l'utilisation du cadre multi-niveaux en utilisant l'expérience de 12 entreprises d'énergie solaire et hydroélectrique et huit entreprises d'énergie propre en Ouganda. Les résultats confirment que le MTF est un outil complexe mais idéal pour suivre les progrès vers l'ODD7 en raison de sa nature multidimensionnelle répartie sur les niveaux d'accès à l'énergie. Il peut être utilisé pour les rapports d'impact par les entreprises d'énergie propre en Ouganda, à condition que la collecte des données soit numérisée et que les clients soient sensibilisés pour fournir toutes les informations nécessaires aux entreprises d'énergie. Les résultats ont montré que la contribution des entreprises privées d'énergie à l'amélioration de l'accès à l'énergie était sous-estimée par le gouvernement, car elles paient des impôts élevés et le gouvernement n'a pas adopté de lois pour les protéger. L'étude recommande l'utilisation du cadre multi-niveaux par les compagnies d'énergie publiques et privées pour suivre l'accès à l'énergie en Ouganda de manière exhaustive. Des politiques, des programmes et des projets meilleurs et applicables seront alors conçus pour améliorer l'accès à l'énergie en Ouganda afin d'obtenir une énergie abordable, fiable, durable et moderne pour tous.

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CHAPTER 1.

1 INTRODUCTION

1.1 Introduction

This chapter presents the general introduction of the research topic under investigation. It discusses the background of the study, problem statement, research objectives, and questions. It also highlights the significance of the study and briefly discusses the scope.

1.2 Background of the study.

Energy is often referred to as the bedrock to the development of any nation (International Energy Agency, 2014). Access to efficient, reliable, affordable, and sustainable energy may offer an easy path to prosperity (Bazilian et al., 2010). Modern energy has steered industrial growth and other Singapore, Malaysia, and South Korea sectors (NPA, 2007). Moreover, universal access to energy would sustainably reduce poverty as the poor can set up small and large enterprises and escape poverty (Practical Action, 2012).

Globally, at least 700 million people still live without electricity. Yet, the covid-19 pandemic has worsened the situation as about 90 million people from Africa and developing Asia could not afford to pay for electricity despite being connected at the beginning of 2019 (International Energy Outlook 2021).

In regard to clean cooking, 2.6 billion people globally still use substandard solid fuels, and the challenge deepened between 2019 and 2021. Many people could not pay for modern fuels, and traveling to refill Liquidified Petroleum Gas was suffocated by financial shock and lockdowns. Additionally, more people were exposed to air pollution and associated health conditions because of spending more time at home due to the Covid-19 pandemic (International Energy Outlook, 2021).

Unfortunately, the current energy system cannot meet the global Population's demands to escape the ravaging poverty since energy poverty affects services like health, education, and building sustainable cities. While there has been a global increment in energy access, Sub-Saharan Africa still lags, accounting for one-third of the populace without power**.** Yet, the region has abundant energy resources that can meet its energy needs if fully harnessed (International Energy Agency, 2014).

Uganda is featuring the countries with the least energy access rates despite the quest by the

government to increase electricity access by investing in hydroelectricity and opening up investments in solar and geothermal energy. Electricity demand is growing yearly at a scooping rate of 10-12 percent, and this calls for more investment and planning for the energy sector to achieve sustainable energy for all. The country envisions a 22 percent rural electrification rate by 2022 (Mokveld, Kees, 2018).

According to IEA 2018, only 42.65% of the Population in Uganda has access to electricity. Whereas electricity access in urban areas stands at 57.5%, access to electricity in rural areas is still at 38%. Clean cooking adoption in Uganda stands at 10% (MEMD, 2018b).

These statistics are far below the global electricity rate of 89.5% (World Bank 2018). However, the above energy access statistics are based on a binary measurement that considers people with access to electricity and those without electricity, neglecting fundamental energy access attributes like affordability, reliability, health, quality, and safety. There is a significant gap in understanding the complexity of the existing energy problem in Uganda as access is not well measured.

Moreover, the country envisions expanding household access to electricity from 21 percent by 2020 to 60 percent by 2060 (National Planning Authority, 2020).

Achieving these targets calls for proper definition and measurement of energy access to better handle the challenge.

To address the gaps in measuring energy access, the World Bank introduced the multi-tier framework through the Energy Sector Management Assistance Program that incorporates several attributes in measuring energy access.

The Multi-Tier Framework (MTF) was initiated by the Energy Sector Management Assistance Programme under World Bank to measure and track energy access. It was declared recently as a standard framework for measuring progress towards SDG7. It has been conceived as a novel methodology to overcome the challenges of binary approaches (Koo et al., 2018). However, besides publicly funded implementation of the Multi-Tier Framework at the country level, its applicability in the private sector is still limited, making the MTF approach not entirely successful. Launching this novel methodology by the ESMAP entailed objectives to pursue its dissemination and integration in the energy sector.

Nonetheless, its complexity has limited and restrained the private sector from adopting the metrics. The study will investigate possible ways to use the Multi-Tier Framework to track energy access in a bottom-up approach by enabling private, clean energy companies working in Uganda to

implement the framework quickly. The study will investigate the ability of the small, clean energy companies in Uganda to collect comprehensive energy data to guide business growth. Moreover, when the data is shared with the government, it can inform energy planning, policy formulation, and investment planning

1.3 Problem Statement.

Energy access is considered an incentive towards socio-economic development (Day et al., 2016). According to IEA 2018, only 42.65 percent of the Population in Uganda has access to electricity. Whereas electricity access in urban areas stands at 57.5 percent, access to electricity in rural areas is still at 38%. These statistics are far below the global electricity rate of 89.5 percent (World Bank 2018). Moreover, the definition and measuring access is still a challenge. The above energy statistics are based on the binary measure of energy access in short terms. For example, a household using a small Solar Home system is counted as connected even though it does not meet all essential energy services. In addition, a home connected to the grid is counted as having access even if backouts existed or the electricity is unaffordable for users (Koo et al., 2018).

According to (Practical Action, 2012), the business as usual scenario would leave about 900 million people without electricity globally by 2030. In comparison, at least 3 billion people will use predominant fuels for cooking, and thirty million people, especially women, will lose lives to smoking-related diseases due to poor cooking conditions.

According to (International Energy Outlook, 2021), electricity demand increases as countries recover from the ravaging Covid-19 economic shocks. The Population is also multiplying, and setting the pace to energy access for all will require more holistic and actionable interventions.

The new direction to achieve universal access in Uganda deserves proper measurement of energy access to understand the challenge well and provide feasible solutions. Yet, the binary measure proves insufficient as it considers Population with electricity and those without electricity leaving important attributes like affordability, durability, quality of service, health, and other aspects. Under the World Bank, the Energy Sector Management Assistance Program introduced the Multi-Tier Framework as an ideal and comprehensive measure of energy access.

The Multi-Tier Framework is considered an ideal measure of energy access as it is comprehensive than the binary measurement. It has been piloted in 17 energy-poor countries, including Ethiopia, Muammar, Rwanda, and others. However, its applicability has proven not easy because of its

complexity (Bhatia & Angelou, 2015b).

Moreover, most recent studies on the Multi-Tier Framework for tracking progress towards energy for all have focused on government neglecting the private sector, which plays a part in increasing energy access (Bhatia & Angelou, 2015a)(Koo et al., 2019)(Koo et al., 2018).

This study analyzed the challenges of using the Multi-Tier Framework for reporting and tracking energy access. The study captures data collection methods of private, clean energy companies to assess their possibility of reporting using the MTF. In the long run, detailed energy data from the government combined with data from private energy service providers can provide a holistic report that depicts the energy situation in Uganda. The study analyzed the complex attributes of the Multi-tier Framework to identify what is done and what can be done to inform policy interventions, energy investments, and necessary technology needed to close the energy poverty gap and achieve SDG7 by 2030.

1.4 Main Objective

To investigate the challenges of using the Multi-tier Framework for bottom-up Tracking of progress towards SDG7 based on the experience of private, clean energy companies in Uganda.

1.5 Specific objectives.

1. To examine the challenges of using the multi-tier framework for tracking energy access progress.
2. To identify the incentives needed by clean energy companies in Uganda to use the Multi-tier Framework.
3. To access the value of energy data to clean energy companies in Uganda.

1.6 Research Questions.

1. What are the challenges/barriers of using the Multi-Tier Framework for tracking energy access?
2. What incentives private, clean energy companies in Uganda to report with Multi-Tier Framework??
3. What impacts do energy access data have on private, clean energy companies in Uganda?

1.7 Working Hypothesis.

1. The Multi-Tier Framework can be used by private, clean energy companies to track energy access.
2. Clean energy companies need incentives to use the Multi-Tier Framework.
3. Energy access data is very important to clean energy companies.

1.8 Significance of the study

The binary method used to measure energy access in most countries has proven insufficient to show the complexity of energy access and tracking progress towards achieving SDG7. The Multi-tier Framework offers more comprehensive and logical attributes of energy access that give details on the advancement towards achieving sustainable energy for all by 2030.

Moreover, (IRENA & Bank, 2019) noted that the current interventions are likely to lag us behind our global targets within SDG7 by 2030. At least 660 million will not have electricity by 2030 if the contemporary interventions are not increased significantly. One of the improvements that could shape our struggle towards achieving the targets of SDG7 is shifting from the binary measurement of energy access to a multi-dimensional measure such as the Multi-Tier Framework.

According to (Net Zero by 2050, 2021), electricity demand will double by 2050. There is a need for a holistic approach towards increasing electricity access as quickly as possible. Increasing energy access requires a holistic approach by governments, international bodies, and private players, and both must understand the underlying tracking measures. The Multi-tier framework is a new idea that the governments and private energy players must understand and use so that the progress towards SDG7 is easily tracked and reported. The study will examine the challenges and Way forward for utilizing the multi-tier Framework for bottom-up Tracking of Progress towards SDG7 using the experience of private, clean energy companies in Uganda. The results shall provide a realistic view and guidance to private, clean energy companies to report their impact using the Multi-tier Framework. Moreover, the previous studies on Multi-Tier Framework have all focused on its use by the government neglecting the private sector, which contributes to energy access in Africa. This study fills this gap.

Reporting using the Multi-tier Framework captures valuable attributes of capacity, affordability, quality, health, safety, reliability, and formality, which the binary method neglects.

The results shall guide decision-making on how private, clean energy companies can be empowered to track progress towards SDG7 by understanding the current challenges of collecting customer data. The study also offers a basis for government intervention towards achieving SDG7 by 2030.

1.9 Scope of the Study.

1.9.1 Content Scope.

The study was based on a deep analysis of the Multi-tier Framework and identifying the framework's challenges. The study also looked at how Ugandan clean energy companies can easily use the multi-tier framework to track progress in energy access based on their experience collecting comprehensive data from their customers. The study also looked at how the energy access data is helpful to the energy companies to boost their businesses.

1.9.2 Geographical Scope.

This research was carried out in Uganda, located in East Africa, Africa. The country has about 50 registered clean energy companies that provide primarily solar home systems, wind energy institutional solar systems, clean cooking fuels and technologies, solar lamps and lanterns, and other renewable energy services throughout the whole country. Most energy companies have head offices in Kampala city but have branches across the country.

1.9.3 Time Scope

According to the university calendar, the research period commenced on 10th May 2021 to 1st November 2021.

1.9.4 Structure of the Thesis

The report contains five chapters which are described below.

Chapter 1

This chapter presents the introduction of the subject under investigation, the problem statement and Research objectives. It also presents the research questions and the significance of the study. The chapter briefly describes the scope of the study.

Chapter 2

This chapter presents the theoretical analysis of the subject under investigation. It highlights a comprehensive look of literatures, theories and frameworks of measuring energy access and indicates how the Multi-tier Framework is used to track progress towards the SDG7. It also gives highlights of Uganda’s energy situation and the global future of energy in the face of covid19 pandemic.

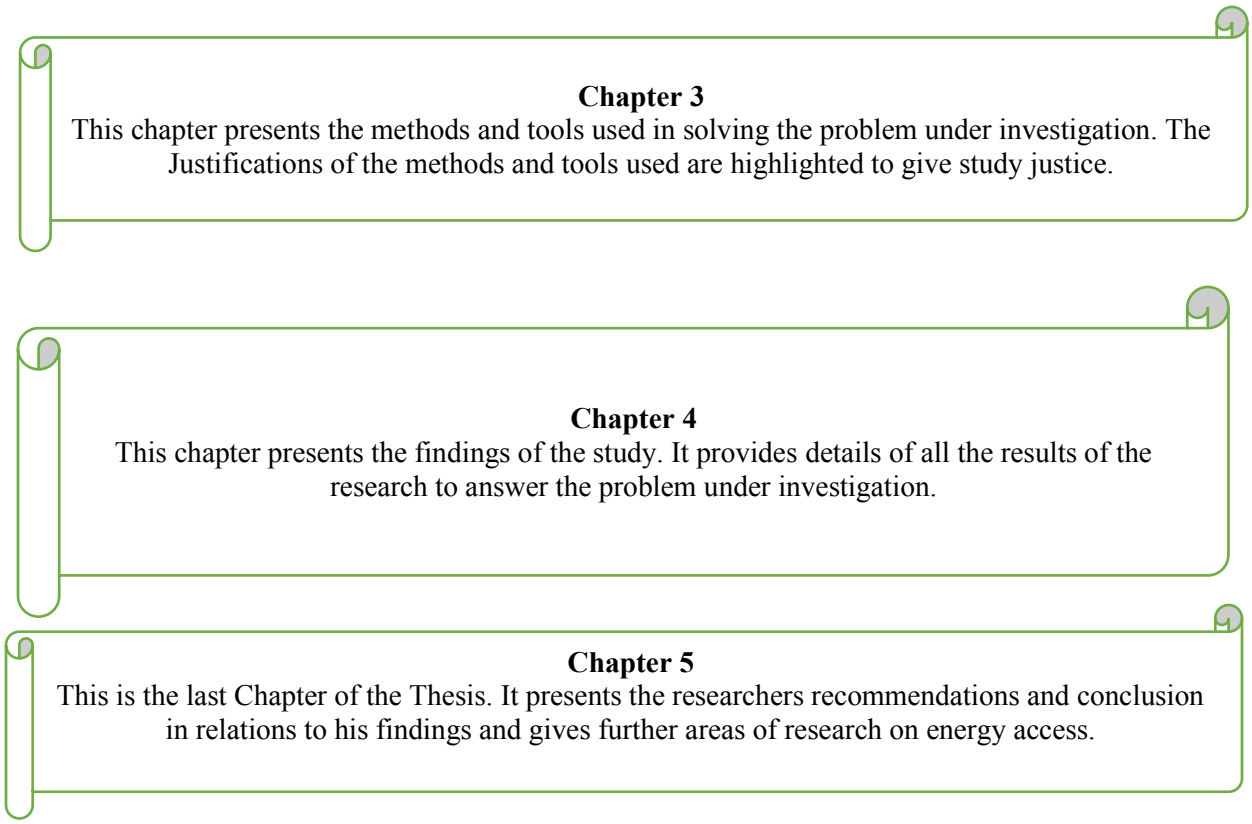

Figure 1:1 Flow of the master's thesis document

Source: Authors creation, 2021.

1.9. 5 Limitations of the research study.

The covid-19 pandemic has been the most significant challenge. The movement restrictions imposed by the Ugandan government to control the spread of the disease delayed data collection by almost 50 days. Also, some energy companies laid off some workers who would have been potential respondents for the study. The researcher had few study trips because of the frequent lockdowns caused by the Covid-19 pandemic.

Furthermore, the frequent power outages in my residential area delayed the writing process.

CHAPTER TWO

2 Literature Review.

2.1 Introduction

The literature review presents the theory and applicability of the multi-Tier Framework in measuring energy access. It also offers a detailed discussion of other frameworks that different authors and international bodies have suggested. A brief study of Uganda's energy situation is captured as the case study area. The chapter also provides the business-as-usual scenario for achieving SDG7, specifying the situation in Sub-Saharan Africa and in the face of the Covid-19 pandemic. The proceeding chapters will base on this chapter.

2.2 Definition of Terms and Concepts.

Energy poverty is the deficiency of access to sustainable modern energy services and products. Energy poverty exists where there is a lack of adequate, affordable, reliable, quality, safe, and environmentally sound energy services to support development (World Economic Forum, 2010).

Energy Access refers to a household having reliable and affordable access to clean cooking facilities and electricity, which is enough to supply an essential bundle of energy services initially and then an increasing level of electricity over time to reach the regional average (IEA, 2020). Although this definition may be criticized for not being comprehensive, it covers somewhat a clear view of energy access.

The Multi-Tier Framework is a multi-dimensional measure of energy access introduced by the Energy Sector Management Assistance program under the World Bank as a standard framework for measuring progress towards achieving SDG7 (World Bank 2016). It was developed in consultation with a cluster of sustainable energy for all stakeholders, including Lighting Africa.

Impact refers to 'positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly intended and unintended'. The definition rests on the need for any intervention to have an effect compared to the pre-existent situation (Roger Bymolt, 2015).

Sustainable Development Goal 7 (SDG7). One of the seventeen Sustainable Development Goals that the United Nations General Assembly developed in 2015 depicts the world's targets by 2030.

SDG7 intends to '*Ensure access to affordable, reliable, sustainable and modern energy for all"* (World Bank, 2016). SDG7 came with targets that present the yardsticks for measuring success. 7.1 calls for universal access to electrification and clean fuels and technologies for cooking, 7.2 calls for an increase in energy consumption from renewable sources. Target 3 calls for doubling improvements in energy efficiency. Each target was given an indicator and responsible agency to achieve these targets quickly, as shown below.

Table 2:1 Overview of SDG7, targets, indicators, and Responsible agencies adopted from (IEA et al., 2018).

SDG7 targets	**Indicators**	**Responsible Agencies**
7.1 By 2030, ensure universal access to affordable, reliable, and modern energy services.	Fraction of Population with access to electricity	World Bank (WB)
	Fraction of Population with primary reliance on clean fuels and technologies	World Health Organisation (WHO)
7.2 By 2030, increase the share of renewable energy in the global energy mix substantially	Renewable energy share in total final energy consumption	International Energy Agency (IEA), International Renewable Energy Agency (IRENA), UN Statistics Division (UNSD)
7.3 By 2030, double the global rate of improvement in energy efficiency	Energy intensity measured in terms of primary energy and GDP	International Energy Agency (IEA), UN Statistics Division (UNSD)

2.3 Study Area. (Uganda)

The research was carried from Uganda, a landlocked country located in East Africa. Kenya in the East borders Uganda, South Sudan in the North, Tanzania in the South, Rwanda in the South West, and Democratic Republic Congo in the West. It is also called 'the pearl of Africa. It receives

tropical climate and lies between coordinates 1°00′N 32°00′E.

The country's economy depends on Agriculture (Agriculture, 2013) The main crops are coffee, cotton, maize, and the main export is gold, coffee, fish, and fish products. The currency is shillings and is used within the borders exchanged for any other money that comes in.

According to (World Bank 2020), Uganda's Population is 45.74 million, with 22.5 million males and 23.1 million females. In comparison, the GDP is US$ 37.37Billion.

(World Bank 2019) puts electricity access in Uganda at 41.3%. While only 31.7% of the rural Population have access to electricity, 70.8% of the people in urban areas have electricity indicating a significant gap in electricity access between rural and urban dwellers.

According to (UBOS, 2018), literacy rates for persons of 10 years and above are 76%, with 81% for males and 72% for females. Meaning at least 8 in every ten persons can read and understand one language. Healthwise, at least one in every five persons reported an illness per month, most malaria-related. Four in every ten households, about 47% in urban areas, are food poor compared to 22% in every ten families living in the rural areas. Karamoja Acholi and Bukedi regions were most affected.

Uganda's economy had dropped slightly due to the impact of Covid-19, but it is recovering significantly. At least 2.6 million Ugandans will become poor because of the effects of covid-19. Many people lost jobs, the market for their goods due to the pandemic. Moreover, the pandemic dragged a lot of people to small-scale agriculture increasing vulnerability to poverty (World Bank, 2021.

Uganda is blessed with various energy resources ranging from solar, wind, geothermal, hydro, and biomass. The country also has oil deposits that are under exploitation process. However, recent expansion in rural electrification is attributed to hydro and solar sources (MEMD, 2018a).

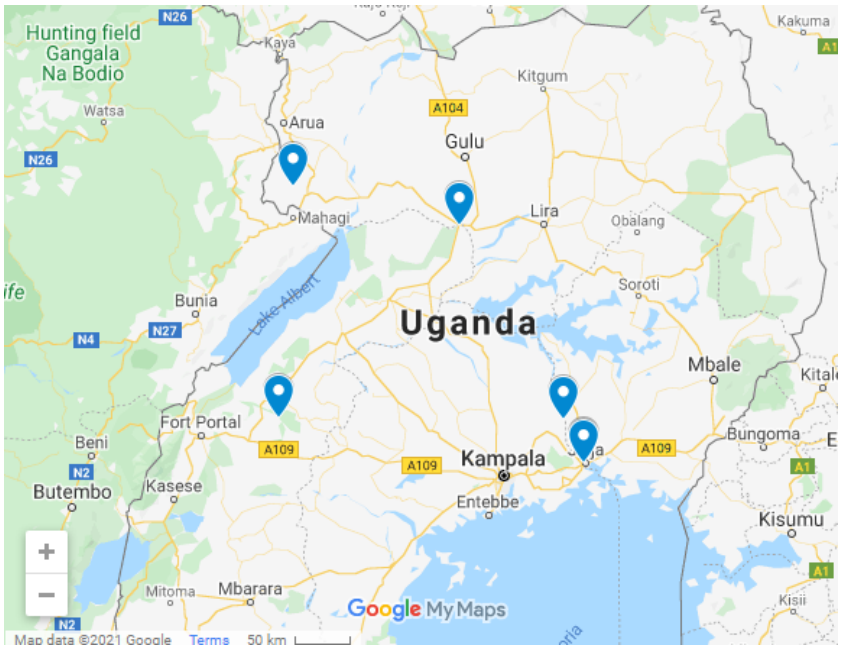

Figure 2:1 Electricity generation facilities in Uganda

Source: Uganda Electricity Generation Company Limited UEGCL, 2021

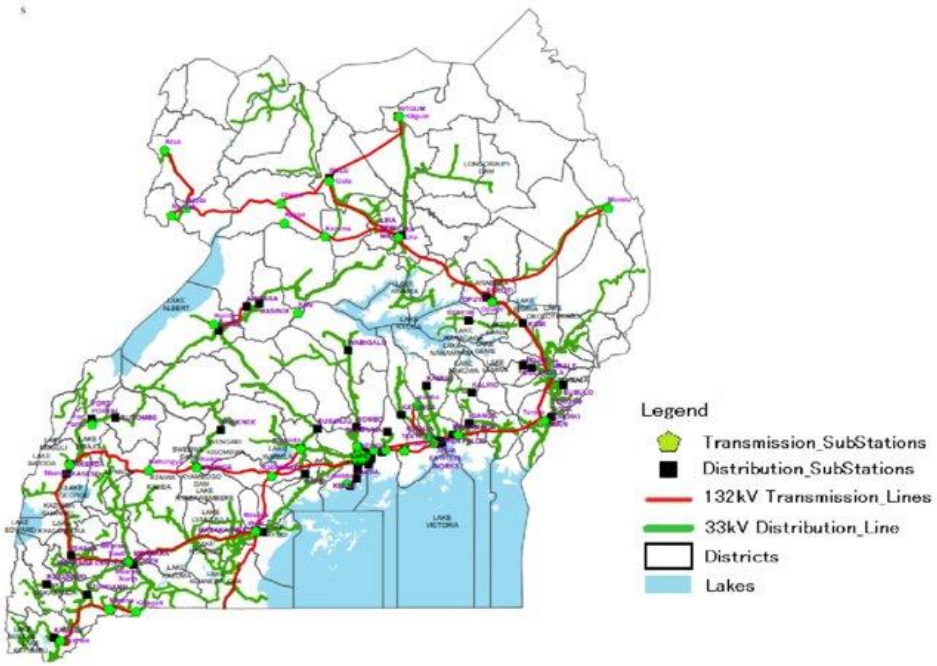

Figure 2:2 Map of Uganda showing electric grid and sub stations

Source: (Miito & Banadda, 2017)

2.4 Energy Actors in Uganda.

The energy sector is driven by the Ministry of Energy and Mineral Development (MEMD). It has the mandate to establish, promote, and protect minerals and energy resources for sustainable development. The ministry gives policy guidelines, including designing necessary policies that drive the energy sector. It also supervises, monitors, and evaluates privately-owned companies in the energy sector. The ministry undertakes supervisory roles in the petroleum, energy resource development, and geological surveys through the different ministerial departments. The head of the ministry is appointed by the president and confirmed by the Parliament of Uganda. Due to the complexity of the energy sector, the government of Uganda, through the Parliament, created support agencies from the Uganda Electricity Board to undertake different responsibilities for the smooth implementation of programs and projects. These were provided for under the Electricity Act 1999. These agencies are discussed below.

2.4.1 Generation.

The Government of Uganda does generation through its owned power plants. The private, public partnerships (PPPs), and independent power producers (IPPs) all generate electricity under the monitoring of the Electricity Regulatory Authority. The government-owned electricity generation plants are under the Uganda Electricity Generation Company Limited. (UEGCL)

2.4.2 Transmission.

Transmission of electricity is costly, and the government of Uganda solely did it through the Uganda Electricity Transmission Company Limited. (UETCL)

2.4.3 Distribution.

The distribution segment is liberalized. It has private-public partnerships and the government of Uganda through the Uganda Electricity Distribution Company Limited. (UEDCL)

2.4.4 Umeme Limited.

Umeme is the leading distributor of electricity in Uganda. Since 2005, Umeme has had a distribution contract awarded by the government of Uganda on 1st March 2005 for 20 years. Umeme is licensed to distribute electricity to all households; the contract involves operation, maintenance, and upgrading the electricity distribution structure. The Uganda Electricity

Transmission Company Limited is a sole supplier of Umeme limited. The Electricity Regulatory Authority regulates Umeme's activities. (ERA)

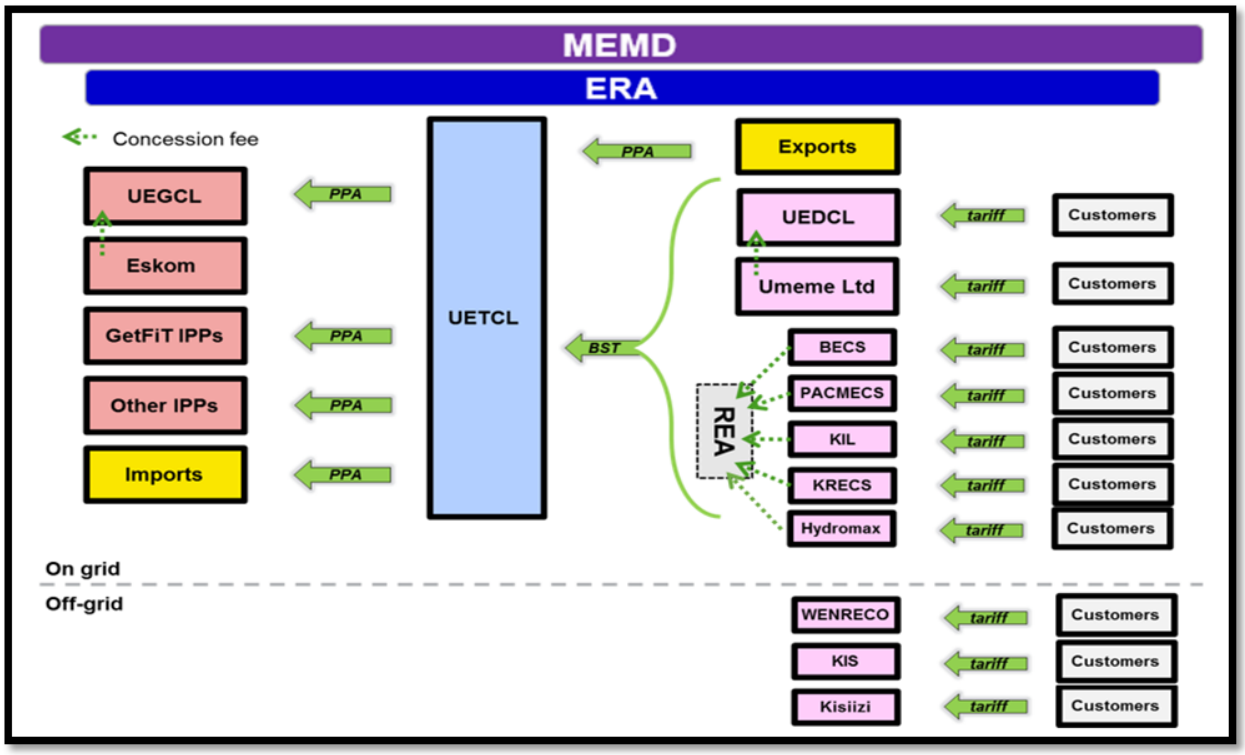

Figure 2:3 shows the electricity supply market structure of Uganda

Source: Electricity Regulatory Authority, 2021.

The Electricity Regulatory Authority is mandated to supervise the electricity supply market in Uganda. It was introduced in 2000 as an autonomous organ of government, and it sets tariffs and approves other charges on electricity. It issues electricity generation, transmission, distribution, sale, import, and export licenses (Authority, 1999).

2.4.5 Rural Electrification Agency (REA)

The Rural Electrification Agency is a semi-autonomous body that Parliament set up. It operates under the Rural Electrification Board (REB), which provides guidance and advice specified by the Electricity Act 1999. The Rural Electrification Agency supports private electricity supplies in taking electricity to the villages. Other agencies participating in rural electricity include Kilembe Investments Limited (KIL), Bundibugyo Electricity Cooperative Society (BECS), Padir Abim

Community Multipurpose Electric Cooperative Society (PACMES), West Nile Rural Electrification Company (WENRECo), and Umeme. These companies are operating in upcountry areas and supplying electricity to different regions.

2.4.6 Contribution of Clean Energy Companies on Energy Access in Uganda.

2.4.6.1 Solar Companies.

Uganda, like other East African Countries, has enormous renewable energy resources. Besides biomass, the region has solar, wind, geothermal, and hydroelectricity capacity (USEA, 2019).

To increase energy access in Uganda, the government of Uganda liberalized the renewable energy sub-sector by allowing different private players to provide clean energy services to the households. There has been an extension of grid connection, free grid connection policy, and supporting off-grid solutions (Uganda Solar Energy Association, 2018).

According to (UBOS 2018), 27% of households used solar kits, and 11% used solar home systems, indicating a slightly increased uptake of solar power due to the availability of various solar energy companies. A deep study showed that 93% of households in the Kampala region were using grid electricity compared to the 1% in Karamoja. The many licensed private solar companies are trying to close this electricity access gap by taking solar kits and solar home systems to upcountry regions. On interrogation on why they do not use grid electricity, 66% of the households in rural areas pointed at the non-availability of grid electricity in their localities. In comparison, 35% of the urban dwellers cited the high initial connection cost as a barrier to grid electricity.

According to (Solar & Companies, n.d.), 23 off-Grid solar companies under Uganda Solar Energy Association reached 1.3 million customers in 2018, indicating a significant impact on energy access in Uganda. According to (Uganda Solar Energy Association, 2018), Solar companies under the association contributed 8.18 Megawatts of newly installed capacity. However, all companies are still struggling to take off. Pay Go's business model was more evident than cash sales, which increased the chances of accessing solar systems even by poor households. Many Off-grid solar companies started struggling when Covid-19 emerged as most customers on PayGo were not capable of paying in instalments. Some solar companies at the forefront of expanding electricity access in Uganda are Solar Now, Mkopa Solar, All in Trade Limited, Anuel energy, Village Energy, Bright life, Power Trust Limited, and Fenix International.

2.4.6.2 Clean Cooking Companies

According to (UBOS 2018), 73% of households in Uganda use firewood for cooking, and 20% use charcoal. Yet, it causes health challenges to primarily women and girls who participate in the cooking. The air quality is destroyed, leading to health complications. 57% of households in urban areas used charcoal compared to 9% in rural areas. Summarily, most Ugandans use unprocessed biomass for cooking.

The government of Uganda recognizes the need for increased access to clean energy, including clean cooking, and has liberalized the sub-sector to support adoption (National Planning Authority, 2020) (NPA, 2007) Uganda embraced the global alliance for clean cooking model and united all companies dealing in clean cooking in the Uganda National Alliance for Clean Cooking (UNACC). UNACC is a joint body leading Uganda towards clean cooking for all. They envisioned reaching five million households by 2020. The Uganda LPG association with 13 companies imagined getting 20% of households by 2020. Through the Uganda Electricity scale-up project, the government is scaling up clean cooking in public and private institutions. The project targets schools, prisons, universities, health centres, and other public institutions. Recent studies show that clean cooking adoption in Uganda stands at 10%. Moreover, some clean cooking stoves in circulation are substandard and still health challenges (MEMD, 2018b).

(Alliance, 2019) surveyed clean cooking companies, investment in clean cooking had increased in 2019, although it is still low to achieve energy for all by 2030. Most companies highlighted the need for tax exemption to boost the operations of the clean cooking companies. However, East African-based companies raised more capital than other companies in African regions. Whereas (Mapping, 2012) cited the need to increase regulations and testing and awareness as key factors to foster adoption and environmental sustainability. On the supply side, they proposed improving designs of the stoves, good quality production, and extensive sales and marketing as critical parameters to boost clean cooking in Uganda. There is a significant influx of clean cooking companies in Uganda and Africa in general. However, they have been hit by the side effects of Covid-19. Most companies registered fewer sales by the end of 2019, and others closed operations temporarily. The survey also showered a fear that funding to private companies would reduce due to the impacts of Covid-19 (Alliance, 2019).

Table 2:2 Ongoing clean cooking initiates in Uganda.

Project	Developer	Activities	Financial Opportunities
Energy Efficient Stoves	Impact Carbon	Disseminate domestic and institutional cookstoves	Stove subsidies
Up Energy Project	Up Energy	Disseminate Domestic wood stoves	Stove subsidies
Improved Cook stoves for East Africa	Uganda Carbon Bureau	Disseminate domestic wood stoves and develop voluntary carbon credits	Stove subsidies
Uganda Domestic Biogas Program	Heifers/Hivos	Disseminate 12000 digesters	30% subsidy on the construction of biogas plant
Energy Efficient Cookstoves	Church of Sweden	50,000 Households	Revolving fund

Source: Uganda sustainable energy for all Agenda (Agenda, 2015).

2.5 Tracking Progress to SDG7

There has been some progress in achieving targets set out in SDG7, although it has been more visible in some regions and specific countries**.** Asia has made tremendous progress regarding the targets while Sub-Saharan Africa still lags. Moreover, between 2010 and 2019, central and southern Asia had reduced the electricity access deficit from 440 million to 103 million. They increased access to clean cooking and energy intensity compared to any part of the developing world. This tremendous progress by Asia is attributed to large financial inflows and the implementation of policies (IRENA, 2020).

On the other hand, Sub-Saharan Africa is not doing well as planned, and the 20 least electrified countries are in this region. The progress in energy access and efficiency has not been proportional to the increase in population growth. Although the area has registered good progress in the share of renewable energy in energy consumption, it still lags as 570 million still lacked electricity by 2018 (IRENA, 2020). As for clean cooking, Sub-Saharan Africa is doing poorly and accounts for the most significant percentage of the population without access to clean fuels and technology for cooking.

Moreover, the problem is worsening instead of reducing. Although there has been some progress in energy intensity, the annual improvement rates in Sub-Saharan Africa are at 1.4 percent, far below the global average of 2.0 in 2020 and 3.0 needed to achieve the SDG target. The challenge is likely to worsen as the region struggles to tight the deadly coronavirus disease. There is a need for more funding, sensitization, and policy formulation and implementation to further align the Sub-Saharan part to the targets of the SDG7.

To further close the energy poverty gap, (IRENA 2020) proposed using renewables and doubling energy efficiency in all regions. They argue that achieving targets of SDG7 requires access to minimal Energy and sufficient Energy for business and productive use to trigger development in all sectors. Furthermore, that energy must come from clean sources if growth is holistic and without long-run costs. There has been some progress in investment in renewable energy, especially solar and wind. However, biomass has been the most used energy source for cooking in

Sub-Saharan Africa, yet it causes health problems. The figure below depicts the current and future situation concerning the SDG7 goal.

2.6 SDG7 targets in the face of the Covid19 Pandemic.

Given the current progress, about 660 million people will not have electricity by 2030, and global electricity access will be 92 percent by 2030, away from 90 percent in 2019. Before the pandemic, there was already slow progress in achieving targets, but the covid19 pandemic is likely to worsen the situation. Moreover, most Sub-Saharan countries concentrate on improving their health sector rather than other sectors. The struggle for energy access for all has been halted because funds are diverted to fight against coronavirus (IRENA, 2020). According to IEA (2020), World Energy Outlook 2020, IEA, Paris, 20 million people did not afford to pay for electricity bills in 2020 because of the impacts of the covid19 pandemic. The problem could escalate if the pandemic continues beyond 2021. There is a need to increase political and financial commitment towards energy investments, especially in renewable energy and energy efficiency, to achieve the global targets under SDG7. Reaching the targets also requires shared responsibility on government, private sector, international agencies to come on the drawing and do everything possible within their means to close the energy poverty gap and set the world towards sustainable energy for all by 2030.

2.3 Review of Existing Approaches to measuring Energy Poverty

For many years, measuring energy poverty has been a developing phenomenon. (Bensch, 2014).

It gave rise to different suggestions brought by other scholars. Both approaches have gotten strengths and weaknesses, as presented below.

2.6.1 Binary Measurement of Energy Access.

Up to date, energy access is mainly measured by comparing people who have electricity connections with those without connections. It concerns access to electricity and access to clean fuels and technology for cooking. However, this measurement proves insufficient as it does not give details of the access. A household might be connected to the grid yet cannot afford the electricity bill. Another home would have an illegal connection that is not healthy and safe for inhabitants. One can have a connected house, but the electricity is not reliable. They receive light 4hours a day or even less. It could also be possible that the connection cannot run a refrigerator or another appliance. A household might have access to clean fuel, which is not affordable, and they

might not use it often. The binary measurement neglects the complexity of energy access. The idea is short of details such as the quality and quantity of service. (Bhatia & Angelou, 2014) was quoted '*Would the SE4ALL goal be deemed achieved if every household had electric lighting? Or should every home own a television as well? What about a refrigerator? Is energy access defined by round-the-clock power, or are four hours per day of electricity sufficient? Likewise, what would qualify a household as having access to modern cooking solutions? Should every household be cooking with nonsolid fuels such as LPG or electricity? What about improved cookstoves that use solid fuels as clean and efficient as those using nonsolid fuels? Is any amount of time and effort involved in collecting fuel considered acceptable? How do tariffs figure in the equation? In other words, does energy have to meet an affordability standard before being counted toward universal access? How should energy access be measured in productive enterprises or community institutions?*

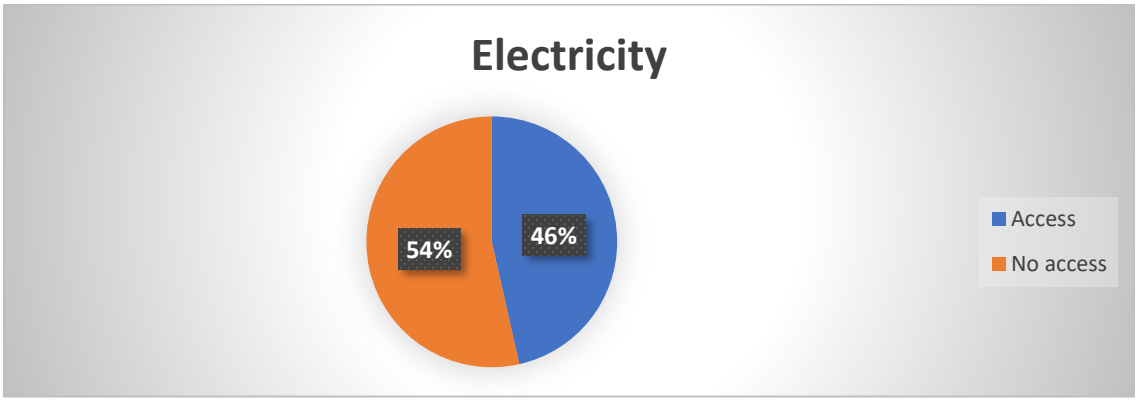

Figure 2:4 Binary measurement of energy access.

Source: (Bhatia & Angelou, 2014).

2.6.2 Incremental levels of energy access.

According to (AGECC 2010)**,** energy is a critical item for global prosperity. Moreover, the United Nations Secretary General's Advisory Group on Energy and Climate Change (AGECC) acknowledged energy as a driver to development but the most significant contributor to greenhouse emissions and advised that energy must be made clean. They also argue that there is no clear definition of energy access but instead classifies levels of energy access into three (IRENA, 2020 classes, namely, basic human needs, productive uses, and modern energy needs. In contrast, modern society needs the third level. Summarily, they analyzed Access to Energy at an incremental

basis based on affordability while considering the impact of energy consumption on the environment.

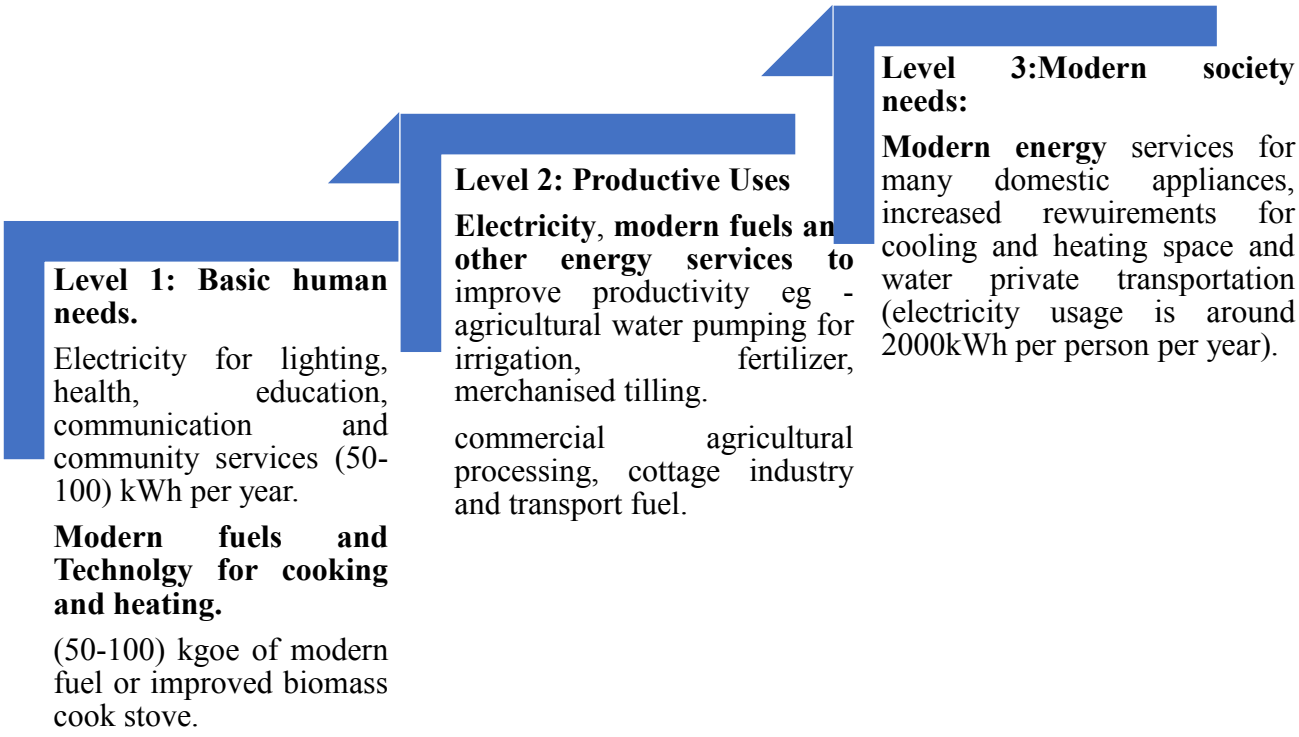

Figure 2:5 Incremental levels of energy access.

Source: Adapted from AGECC, 2010.

2.6.3 Dashboard of Indicators.

The United Nations Development Programme and World Health Organisation drafted several indicators to guide energy access situations in developing countries. The data collected from different countries was put together in a single document for better study and analysis using indicators. The joined publication was used to assess the energy situation, propose interventions and help in understanding the health impacts of air pollution from household use of fuels for cooking and heating**.** The joint reports helped to know which countries have targets and how far they were going over them to achieve the Millennium Development Goals (Bhatia & Angelou, 2015b).

The metric details various modern energy forms, but energy access is broader than this framework defines. This framework is therefore not comprehensive enough to be used to measure energy access. It does not give attention to attributes such as affordability, quality, quantity, health, and

safety of the energy service. These are essential aspects of energy access; therefore, any energy access metric that neglects them is inadequate and not the best method to track progress towards achieving SDG7.

Table 2:3 Indicators used to measure Energy Access

The Modern form of energy	**Indicator**
Access to Electricity	Percentage of people with a household electricity connection
Access to modern fuels	Percentage of people who use electricity/liquid fuels/gaseous fuels as their primary fuel to satisfy their cooking needs
Access to cooking fuels	Percentage of people who use different types of cooking fuels as their primary cooking fuel, including both modern and solid forms of energy
Access to improved cooking stoves	Percentage of people relying on solid fuels (traditional biomass and coal) who use improved stoves for their cooking needs.
Access to mechanical power	Percentage of people who use mechanical power for productive, nonindustrial applications, such as water pumping, agricultural mechanization, and small-scale agro-processing (e.g., grinding, milling)

Source: Adapted from (Bhatia & Angelou, 2015b)

2.6.4 Multidimensional Energy Poverty Index (MEPI)

Multi-dimensional indices are pertinent in tracking energy poverty to achieve sustainable energy for all. The Multi-dimensional Energy Poverty Index captures the prevalence and severity of energy poverty. The metric assesses services that modern energy provides based on a multi-

dimensional approach (Nussbaumer et al., 2013).

(Bensch, 2014), acknowledged the necessity of multi-dimensional measurements of energy poverty as it cannot be presented in a particular denomination but rather a variety of indices. However, some indices can be simplified into simple indicators. He recognized the general challenge with the multi-dimensional indicators' applicability due to various data dimensions that cannot be easily analyzed. He proposed using composite indices that combine data from different measurements into one number and dashboards that present results from poverty measurements independently to solve the complexity of the multi-dimensional indicators.

Howells et al (2010) recognized the need to use a simple, politically achievable, and complete index to measure energy poverty so that energy planning can be accessible and actionable. Whereas (Nussbaumer et al., 2013) proposed a hybrid method that combines composite indices and the corresponding indicators as the suitable option for comprehensive and precise results. Conclusively though, the MEPI is a pretty reasonable measure of energy poverty as it captures the energy services that people need most and emphasizes the poor. Moreover, MEPI exceeds the census of having or not having energy like the binary measure, providing a detailed account of the energy dilemma hence showing the structure of the energy poverty that informs tailored policy formulation. MEPI is a well-designed method and permits multiple analyses and dissemination for easy track of energy poverty.

Precisely, the Multi-dimensional Energy Poverty Index is structured to depict energy deprivations that influence a person or household. It reflects the dimensions showing the minimum energy services and six indicators of the underlying dimensions, as shown in figure 6 below.

Table 2:4 MEPI dimensions and respective indicators with cut-offs, including relative weights

Dimension	Indicator *(weight)*	Variables	Deprivation cut-off (energy poor if…)
Cooking	Modern Cooking fuel *(0.2)*	Type of cooking fuel	any fuel use besides electricity, LPG, kerosene, natural gas, or biogas
	Indoor pollution *(0.2)*	Food cooked on the stove or open fire (no hood/chimney), indoor, if using any fuel besides electricity, LPG, natural gas or biogas	true
Lighting	Electricity access *(0.2)*	Has access to electricity	false
Services provided by means of household appliances	Household appliance ownership *(0.13)*	Has a fridge	false
Entertainment/education	Entertainment/education appliance ownership *(0.13)*	Has a radio OR television	false
Communication	Telecommunication means *(0.13)*	Has a phone landline OR mobile phone	false

Source: Adopted from (Nussbaumer et al., 2013)

2.6.5 Total Energy Access (TEA)

According to (Practical Action, 2010)**,** Total Energy Access refers to 'energy access defined at the point of use in all its dimensions. They determine the exact needs of the energy poor and propose achievable targets based on the conditions. The minimum standards and indicators were developed. TEA identifies six vital energy services that are basic to people and have the right to get. Lighting, cooking and water heating, space heating, access to information and communication technologies, and energy for work. TEA reveals the exact energy needs at household, enterprise, and community levels, exceeding the familiar energy sources and electricity tracking.

However, after massive consultations and research coupled with practice (Practical Action, 2012) modified the TEA. The six initially invented vital energy services were revised and standardized.

They were later tested in three countries, namely Kenya, Peru, and Nepal, with promising results. The updated TEA looks more on the household needs and presents the enterprise and community access as an additional service. The updated TEA version also uses a TEA survey tool with fourteen yes/no questions relating to indicators reached. The questionnaire is simple that an ordinary person with minimal academic training can measure energy access.

Table 2:5 Energy services and minimum standards in TEA

Energy service		Minimum standard
Lighting	1.1	300 lumens for a minimum of 4 hours per night at the household level
Cooking and water heating	2.1	1 kg wood fuel or 0.3 kg charcoal or 0.04 kg LPG or 0.2 liters of kerosene or biofuel per person per day, taking less than 30 minutes per household per day to obtain
	2.2	Minimum efficiency of improved solid fuel stoves to be 40% greater than a three-stone fire in terms of fuel use
	2.3	Annual mean concentrations of particulate matter (PM2.5) < 10 µg/m3 in households, with interim goals of 15 µg/m3, 25 µg/m3 and 35 µg/m3
Space heating	3.1	Minimum daytime indoor air temperature of 18^0C
Cooling	4.1	Households can extend the life of perishable products by a minimum of 50% over that allowed by ambient storage
	4.2	Maximum apparent indoor air temperature of 30^0C
Information and communications	5.1	People can communicate electronic information from their household
	5.2	People can access electronic media relevant to their lives and livelihoods in their household

Source: (Practical Action, 2012)

A household that meets all the minimum standards is considered to have achieved total energy access. Where climatic conditions are favorable and services such as space heating are not

required, TEA assumes they are also met and done**.** Where a house meets some standards, the gaps are easily identified and strategies designed to bring the household on board. Policymakers can be guided after identifying the general gaps**.** Many technologies such as mini-grids can be proposed for rural areas instead of urban areas that can quickly get grid-connected. TEA looks simple and easy to use as it has just fourteen yes/no questions as the survey.

However, the TEA method neglects pertinent issues such as the safety of the power users. Moreover, it focuses on household access, yet SDG7 looks at sustainable energy for all, including enterprise, community, and public places. TEA lacks the multiple analysis of energy access such as quality, legality, and convenience of the energy services, which the multi-tier framework captures comprehensively. Though it tries to catch a few energy details, the TEA method is short-lived. The Multi-tier Framework offers better and comprehensive results that guide policy making towards increasing energy access.

2.7 The Multi-Tier Framework.

2.7.1 Background

According to (Koo et al., 2018), Multi-Tier Framework is an initiative of the Energy Sector Management Assistance Program (ESMAP), in consultation with international partners, especially World Bank under the Sustainable Energy for All (SEforALL) and Lighting Africa. The Multi-Tier Framework (MTF) was developed as an alternative measure of energy access that could close the gaps of the binary method. MTF is gaining recognition as the ideal approach used by World Bank as a tracking tool for SDG 7.1. The MTF was created to improve the measurement of energy access based on the multi-dimensional nature of energy access and capture the vast range of technologies and sources that can provide energy while considering the immense differences in user experience. It was launched in 17 energy-poor countries and gave comprehensive results in Rwanda, Ethiopia, Cambodia, and Myanmar.

2.7.2 Measuring Energy Access using Multi-tier Framework.

(Padam et al., 2018) noted that the use of the Multi-Tier Framework to measure energy access was piloted in 17 countries across Africa, Latin America, and Asia. The framework's objective was to provide comprehensive data on energy access, including access to electricity and clean cooking solutions. The Multi-Tier Framework captures the multi-dimensional nature of energy

access and various technologies and sources that can provide energy while considering the vast differences in user experience. The Multi-Tier Framework approach measures energy access supplied by any technology or fuel-based on attributes that capture critical characteristics of the energy supply. Based on those attributes, the Multi-Tier Framework contemplates six access tiers ranging from tier 0 to tier 5. Tier 0 defines no access, while tier 5 defines complete access. Each attribute is assessed separately, and the overall tier for a household's access to electricity is the lowest attained across the attributes.

According to (Bhatia & Angelou, 2015b), the Multi-Tier Framework captures three areas of energy use: households, productive engagements, and community institutions. The framework looks at access to electricity, clean cooking fuels and technologies, and access to energy for household use space heating. For productive use, the framework captures energy supply against critical energy applications. It is because there are various energy applications, and the size of enterprises varies. The multi-tier Framework considers educational facilities, street lighting, government offices, health facilities, and public buildings for community institutions. Energy has to reach these facilities to facilitate holistic development.

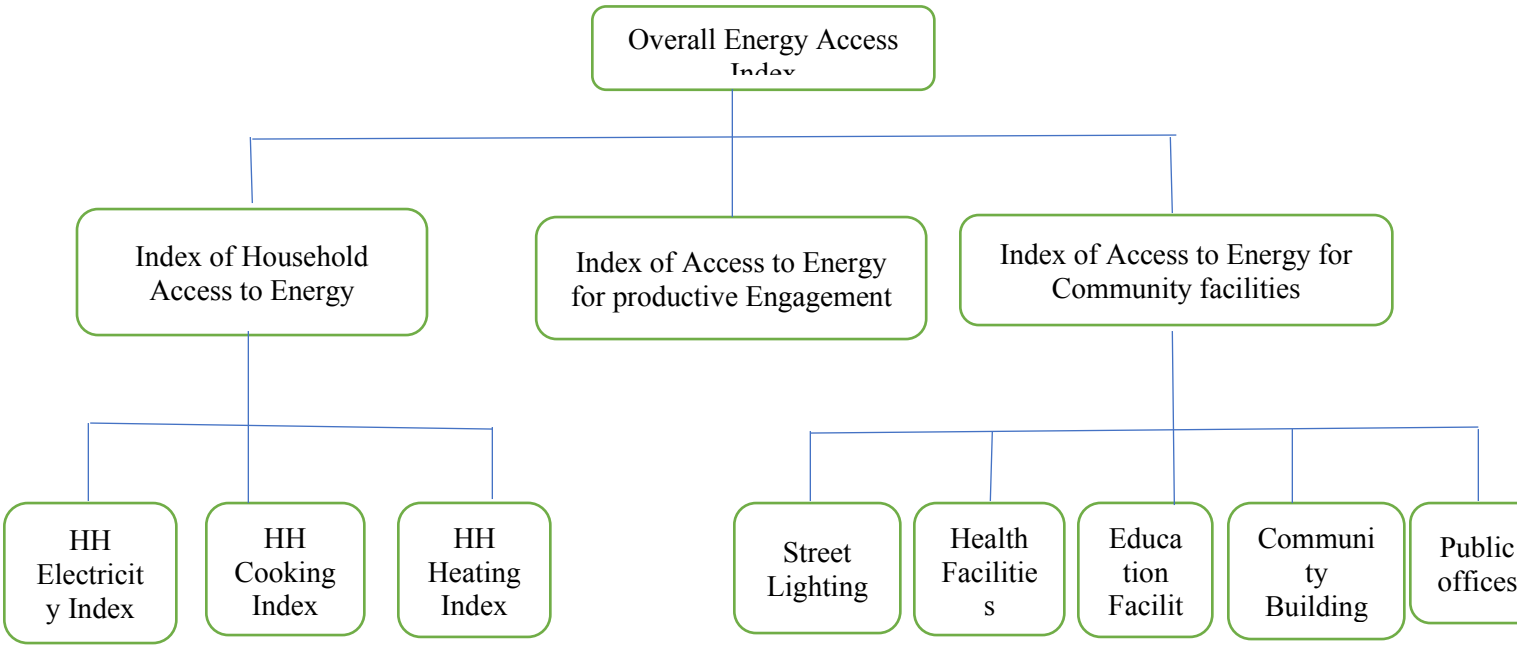

Figure 2:6 Flow of Energy Access Indices (HH-Household

Source: Adapted from (Bhatia & Angelou, 2015b).

2.7.3 The attributes of the Multi-Tier Framework

The seven attributes on which electricity access is defined in the application of the Multi-Tier Framework are,

Capacity refers to the system's ability to provide a certain amount of electricity to run various appliances, ranging from a few watts for light-emitting diodes and mobile phone chargers to several thousand watts for space heaters or air conditioners.

Availability refers to the amount of time during which electricity is available. 24hours for day and 6-8 evening hours during which electricity is available.

Reliability refers to the degree of reliability of the supply of electricity that is measured by interruptions of electricity supply**.**

Quality is the absence of frequent voltage fluctuations that can damage a household's appliances.

Affordability is the ability of the household to quickly pay the electricity bill without affecting their lifestyle throughout the year, usually measured by less than 5% or more of the annual household income.

Health and safety refer to the severity of electrical injuries ranging from minor burns to severe shocks and death.

Formality, a connection is considered formal if it was made by a certified technician and under the permission of an electricity supplier**.** Each attribute is matched with a tier according to a level of service defined by its thresholds. The lowest tier value determines a household's level of access the home obtains among the attributes.

2.7.4 Measuring electricity access using Multi-tier Framework.

According to (Koo et al., 2019)**,** access to electricity is measured based on seven attributes: Capacity, Availability, Reliability, Quality, Affordability, Formality, and Health and Safety. Tier 0 defines households that receive electricity for less than four hours a day and less than one hour per evening or that have a primary energy source with a capacity of fewer than 3 watts. Tier 1 defines households with limited access to small quantities of electricity provided by any

technology. For example, a small solar lighting system light for a few hours a day and meets simple electric lighting and phone charging. Services Tier 2 defines households that receive electricity for at least four hours a day, including at least two hours per evening and capacity is sufficient to power low-load appliances as needed during that time. Devices used in this tier2 might include a television and a fan. Rechargeable batteries, solar home systems, a mini-grid, and the national grid can provide such power. Tier 3 gives more attributes as the household gets power at least 8 hours in the day and 3 hours in the evening. Capacity must be enough to power medium load appliances such as a refrigerator, freezer, food processor, water pump, rice cooker. Additionally, the household should afford a basic consumption package of 365 kilowatt-hours per year, and a mini-grid, national grid, or a solar home system can provide such power (Padam et al., 2018).

Tier 4 defines a household that can access electricity at least 16hours a day plus 4 hours in the evening. The capacity should be enough to run high-load appliances as needed during that time, such as a washing machine, iron, hairdryer, toaster, and microwave. Additionally, all these services should be enjoyed without long or frequent unscheduled interruptions, and the supply must be safe. The grid connection is legal, and there are no voltage issues. The national grid, mini-grid can provide such power (Padam et al., 2018).

Tier 5 is the ultimate and most comprehensive tier where the world wishes to reach by 2030. It is defined by access to electricity for at least 23 hours a day, including 4 hours per evening. The capacity is sufficient to power very high load appliances as needed during that time, such as air conditioners, space heaters, vacuum cleaners, and electric stoves. The most likely source for meeting these requirements is the national grid and a high-capacity generator or mini-grid (Koo et al., 2018).

Besides measuring access to electricity against tiers, the multi-tier framework survey also gathers data on energy access technologies ranging from small solar lanterns to the national grid and from 3 stone technology to Liquified petroleum gas (LPG.) The survey considers differences in experience to the users of the above technologies based on the performance of the energy solution. The solar lantern may do only lighting, while the national grid may provide enough power to run many appliances and activities. The 3stone technology can emit a lot of heat and smoke, which inconveniences the user and may cause health challenges while the LPG is convenient. Such

differences are key in determining access to clean cooking fuels and technology and are classified in tiers 0 -5 along with the Multi-Tier Framework survey (UNECA, 2018).

The Multi-Tier Framework goes beyond just attributes and gathers data about customer willingness and perceptions to pay for grid connection, Solar Home system, and improved cookstove. It also considers consumption rates, appliance ownership, energy expenditures compared to monthly household income, and backup options for the users. Economic data, gender, and household income flows are also captured, and the survey can capture the user's location, for example, urban or rural. This data is vital for planning, especially in target intervention (UNECA,2018). The Multi-Tier Framework exceeds household energy access and considers community institutions and enterprises. Energy does not stop at the household level, and it is needed in all walks of life, including running enterprises and community services. The multi-tier framework considers energy access to public institutions such as schools, hospitals, and government offices to drive socio-economic development. The framework employs tiers to measure energy access at both enterprise and community institutions like the household level. Access to reliable, affordable, and good quality electricity aids enterprise growth as improved services like refrigeration, and communication are introduced. People's incomes and standard of living improve (Bhatia & Angelou, 2014). More than ever, the world needs increased energy access to community institutions to livelihood and manage the global crisis of covid19. Health institutions need energy for cold chain services to store drugs and vaccines to the required temperature in rural and urban areas to improve health services. The prevention against Covid19 requires frequent handwashing, and this means good access to water. Energy access drives water access; therefore, the world needs sustainable energy to reduce the spread and impact of covid19 and other related illnesses.

Multi-tier Matrix for Measuring Household Electricity Consumption

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Annual consumption levels, in kWhs		≥4.5	≥73	≥365	≥1,250	≥3,000
Daily consumption levels, in Whs		≥12	≥200	≥1,000	≥3,425	≥8,219

Table 2:6 multi-tier matrix for measuring Access to Household Electricity Services

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Tier Criteria		Task Lighting and phone Charging	General Lighting and phone charging and Television and fan (if needed)	Tier 2 and other medium power appliances	Tier 3 and other high-power appliances	Tier 2 and any other high-power appliances

Source: Adopted from (Bhatia & Angelou, 2015b)

2.7.5 Measuring access to modern energy cooking solutions Using MTF

Access to modern energy cooking solutions is still deficient compared to reaching 100% by 2030. Yet, poor cooking services are responsible for the deaths of many people due to indoor air pollution. (Padam et al., 2018). As the access to electricity, clean cooking is complex. The multi-tier Framework analyses clean cooking across five tiers, tier 0 to tier 5 basing on six attributes, and addresses the question of how cookstoves and their use restrains a household from moving from a lower tier to a higher one.

Access to Clean cooking is based on six attributes: Cooking Exposure, Cookstove Efficiency, and Safety of Primary Cookstove. For matters of specialty, four stove categories are used, namely, three-stone stove, traditional biomass stove, improved biomass stove, and a clean fuel stove. Cooking Exposure defines the personal Exposure to pollutants from cooking activities which depends on stove emissions, ventilation structure, and time spent in the cooking environment. Cookstove Efficiency establishes the performance of the stove in terms of thermal efficiency. Convenience measures the time spent acquiring fuel and preparing fuel and the stove for cooking. Safety of Primary Cookstove analyses the Safety in using the most used cookstove within the household. Affordability analyses the household's ability to pay for both the cooker and fuel. Fuel

Availability is defined by the availability of fuel when needed for cooking purposes. Homes that use three-stone technology without good ventilation are in Tier 0, which means no access to modern cooking energy solutions; those that use a three-stone stove with good ventilation are placed under Tier 1. Households with a self-built or manufactured biomass stove are placed under Tiers 1–3, and homes with a clean fuel stove are in Tier 5. Convenience is measured as time spent acquiring and preparing fuel and lies under Tiers 2–5 while affordability is measured in the percentage of one's income used on fuel or cooking technology, and Fuel Availability calculated in the ability to get fuel quickly, are placed in tiers 4 and 5 (Bhatia & Angelou, 2015a).

The use of attributes is comprehensive and gives a promising avenue for measuring access to clean cooking. However, measuring some details is problematic. For instance, cooking exposure should be measured by direct Exposure to pollutants by the cook. However, it is not easy to measure in large-scale surveys. Some models have been proposed to measure cooking Exposure. For example, simulation mathematical-based models that consider indoor air quality are under development. Secondly, using proxy indicators classifies real-life occurrences whether they contribute less or more to Exposure, although its use needs to be within World Health Organisation rules (Padam et al., 2018).

Determining tiers based on cooking Exposure depends on three factors. Firstly, is to determine the tier for emissions for a household depending on its primary stoves. Every stove that the home uses is classified based on a combination of the primary stove design and the primary fuel used with that stove. Secondly, assess the ventilation for the cooking area, categorized by the location of the cooking activity. Households that prepare meals from indoor regions with less than two doors and windows have poor ventilation. Finally, the contact time is also incorporated. It refers to the exposure to cooking activities someone faces. To promote health, one has to spend less time in a cooking place (Padam et al., 2018).

In contrast, households that prepare meals indoors in an area with more than two openings or a good chimney or hood are said to have average ventilation. Families that cook from open places have good ventilation. Ventilation reduces indoor air pollution that a household is exposed to by diluting the emissions from polluting fuels and releasing the pollutants from the cooking area, creating clean air. Homes in Tier 0 for stove emissions remain in Tier 0 for Cooking Exposure if

they have poor or average ventilation but move to Tier 1 if they have good ventilation. Households that use a self-built or manufactured biomass stove are in Tier 1, 2, or 3, regardless of ventilation structure. Homes in Tier 4 for emissions remain in Tier 4 for Cooking Exposure if they have poor or average (Padam et al., 2018).

2.7.6 Using Multi-Tier Framework for policy and Investment Decisions.

The Multi-Tier Framework is a metric that accesses energy access based on attributes and tiers. In its multi-dimensional nature, the surveys gather information of energy supply dynamics and energy demand, mainly household data that highlights people's capacity to pay, the willingness to pay for energy services, the technologies they are using, and other personal details. Such data guides policymakers in deciding the nature and level of intervention that can move households to higher tiers of energy access (Bhatia & Angelou, 2015a).

Data from MTF Surveys help in assessing the impact of projects. Every energy project comes to fill a specific gap that has been identified. The data gathered through MTF surveys also help access the effects of energy projects based on the project targets. A country can access the impact of a recently constructed mini-grid using the multi-tier framework through surveys. It helps identify if the project has moved a specific group of people from one tier to a higher tier (Padam et al., 2018).

Moreover, additional data on gender, financial status, education level, and energy expenditure guide policymakers in energy planning. Policymakers can understand the socio-economic status of the people they are planning for to reach the right interventions. The surveys also specify the location of users, either rural or urban dwellers, so the necessary intervention is designed. For example, low-income earners who are rural dwellers in a sparse population network can be given Solar Home Systems instead of extending the grid since the latter can be more expensive (Padam et al., 2018).

MTF data helps governments to set achievable country targets. The data helps to understand existing energy access levels and guide policymakers on where the country can reach in a specific period basing on the available resources and support. The data also helps in predicting the particular date for universal access. Moreover, upon gathering all country data, the international agencies can use the general data to predict regional energy access levels, guide investment priorities, and support specific countries (Padam et al., 2018).

The data gathered from the MTF surveys is always rich and comprehensive that policymakers base on to reach different decisions. However, collecting the MTF data is tiresome and expensive. The data is based on the attributes of the Multi-Tier Framework, yet each attribute is broad, and collecting data for each may not be easy for countries. The questions are many, and the energy users are unwilling to share their data, primarily financial related. Some may not have data on expenditure and willingness to pay, which poses a significant challenge to the MTF surveys. Specific electronic-based surveys should be developed based on MTF to reduce the time spent with documentation while collecting data. There is also a need to sensitize energy users to provide the correct information whenever needed so that appropriate and specific interventions can be reached to achieve sustainable energy for all by 2030.

2.7.7 Review of impact Reporting and Measurement.

The need for progress towards social and environmental development has triggered an improvement in measuring impact. The whole idea is premised on the need for any intervention to result into a positive and lasting effect to the beneficiaries. The call to improve impact measurement got more attention in the early 2000s when many countries worked hard to achieve the Millennium Development Goals. It has since gained more recognition in both government and private ventures. Upon the great urge for impact measurement, many development practitioners developed metrics to measure impact. The Global Impact Investment Network (GIIN) came in and drew Impact Reporting and Investment Standards (IRIS), which comprise the standard guidelines for impact reporting. Moreover, each standard comes with indicators that measure the target (Roger Bymolt, 2015).

The significant challenges of energy poverty and climate change call for appropriate measurement frameworks to draw necessary interventions to combat the global challenges. Many metrics to report energy access have been invented over time, including the incremental levels of energy access, dashboard of indicators, Total Energy Access, multi-dimensional Energy poverty index, and multi-tier framework. Solving energy poverty requires a framework that captures the whole energy situation getting all the access details incorporating all technologies.

According to (IMWG, 2014) there are specific guidelines for proposal impact measurement practice as discussed below.

- Goal setting. The process of impact measuring is based on the expected output. It shows the purpose of the intervention and where you want to reach it. There is a global target of achieving SDG7, and the Multi-Tier Framework seeks to measure energy poverty comprehensively so that interventions can be tailored towards the identified challenge.

- Develop a framework and select metrics. In this stage, a company or organization selects a standard framework based on the data it requires. The multi-tier framework requires detailed data from customers and it rated as an ideal tool.

- Collect and store data. It requires that you identify all the data needed to measure your impact. The data collection procedures have to be made in a way that is convenient and cheap, and data integrity must exist. Tools for data collection have to be easy to use and other resources like human resources and capital incorporated. In reporting using the multi-tier framework, all these have to be considered.

- Validate data. Cross-examine the data for authenticity and validity.

- Analyze data. Data analysis offers a clear view of the situation, and it helps the company management compare targets and outcomes. Comprehensive data gathered through the Multi-Tier Framework needs to be analyzed, and marks cross-checked.

- Report data. Report the analyzed data to the respective authority or body to evaluate if the organization achieves its objectives. The data needs to be presented comprehensively and coherently for easy analysis and decision-making. In the case of energy access, the government players and private energy companies should all report impact so that significant decisions are made based on actual and comprehensive data.

- Make data-driven investment decisions. Decisions based on data are always legit and set the pace for company growth. They guide to change and any decisions that the company seeks to implement. The best framework must capture all the above guidelines for impact reporting to be complete and sufficient.

CHAPTER THREE

3 METHODOLOGY

3.1 Introduction.

This chapter provides a detailed discussion of the data collection techniques and research methods the study used in gathering relevant data. The chapter also presents the general context of the study area. It gives the energy situation of Uganda, with details of population, economy, and energy resources.

3.2 Data Collection.

3.2.1 Literature study

A comprehensive literature study was done to understand the energy situation in Uganda and how the multi-tier Framework can work better in measuring access to energy while assessing progress to achieving SDG7. The reviewed literature includes reports from the World Bank, the government of Uganda, the International Renewable Energy Agency, the International Energy Agency, and other published articles from renowned experts. Also studied were reports about the progress of the Multi-Tier Framework based on experiences in Ethiopia, Rwanda, Cambodia, and Myanmar.

3.2.2 Primary Data Collection.

The researcher adopted the HEDERA Impact tool kit, as a standard tool for efficiently managing, analyzing, and reporting data. HEDERA sustainable Solutions GmbH developed this tool mainly to collect high-quality data used to measure the impact of Organizations and progress towards Sustainable Development Goals (SDG). The survey questionnaire was developed based on the Multi-Tier Framework. It provides detailed questions that gather information about customers' energy needs, electric appliances used, technology, income, gender details, and other information based on the attributes of the Multi-Tier Framework. The tool kit gathered experiences from company staff to collect data, report, and measure their impact. Reports are easily generated based on field data and can be used anywhere, both online and offline. The toolkit is so flexible that it can create graphs for easy readability of the report. Some local energy companies use the same tool to collect data from customers, mainly during the sale of products. Customized questions were developed and added to the HEDERA toolkit to suit the researcher's needs.

3.2.3 Testing Survey Questionnaire.

Two web-based survey questionnaires were developed to gather detailed and comprehensive data answering the investigated problem. One was for testing, and another was for actual interviews with staff from energy companies. Several tests were made, and results were gathered before rolling out the survey to the energy companies. Both questionnaires were developed by the HEDERA sustainable solutions adapted from the HEDERA Impact tool kit tailored to the Multi-Tier Framework.

3.2.4 Face to Face Interviews.

Using the structured questionnaires, the researcher interacted face to face with staff from the sales department of energy companies to understand in detail the process of capturing comprehensive data from customers. Each face-to-face interview took between 55 minutes and 70 minutes, depending on the willingness of the interviewee to elaborate further and explain situations deeply. The researcher took at least two weeks while visiting different companies and interacting with staff on how data collection based on the attributes of the Multi-Tier Framework can be done.

According to (Dykema et al., 2012), face-to-face surveys provide data for complex situations and are considered the best internationally. They offer a platform for giving extra data depending on the subject under investigation. To give interviewees confidence and reduce doubts, the researcher made official appointments to meet the team and introduced himself as a student and researcher before beginning each interview session. The researcher assured the interviewees of utmost secrecy and anonymity in the booking email and at the start of each interviewing session.

3.2.5 Direct Observations.

The researcher went to the field with the marketing teams from different companies to get the experience of gathering detailed data from customers. On-site visits and observations confirmed data from the surveys. The researcher got the experience of selling energy products, assessing customers to determine affordability, and assessing the cooking places for different customers to evaluate their safety and health. The researcher also got a chance to interact with customers on the convenience of other technologies, especially clean cooking, to assess their difficulties accessing different fuels and technologies. According to (Ciesielska & Jemielniak, 2017), observation allows for interactions and conclusions. Direct Observations provide actual gestures of how serious the

issue is as it provides an avenue to analyze body language and gesture.

Figure 3:1showing researcher at the store and in the field selling stoves and briquettes

Source: Author's Fieldwork, 2021.

3.2.6 **Renewable Energy Laboratory and Testing Centre.**

The researcher visited the regional Renewable Energy laboratory to ascertain how clean cooking fuels are tested to ensure the safety of the users. The researcher visited the center for Research in Energy and Energy conservation at Makerere University, Kampala, Uganda, to see how stoves and briquettes are tested to get the right quality. All clean cooking companies take samples of their products to this laboratory and testing center to get the certificate of quality. The laboratory has the mandate to ensure good quality products are produced for sale by all clean cooking companies. The center has various samples of stoves and briquettes from different companies. The laboratory also tests solar panels to check standards and quality before they are released for sale. Consumer safety and protection are enhanced.

Figure 3:2 shows the researcher at the testing and Knowledge center, Makerere University, Uganda.

Source: Image from author's fieldwork, 2021).

3.3 Ethical Consideration

For purposes of ethics and trust, the researcher first made appointments with the interviewees using the personal, institutional email and got positive feedback. He met the interviewees conveniently, presented himself with a PAUWES student identity card, and assured all participants of confidentiality and anonymity. The researcher also requested permission from participants before starting to record the conversations. The data collection tool also has a statement that assures the respondent of his privacy, and it shows the purpose of the interview as being solely for academic research purposes. When the researcher wanted pictures, he sought permission from the responsible people. Additionally, the researcher did not indicate the names and job titles of people he quoted during the interview.

CHAPTER FOUR

4 RESULTS, INTERPRETATION, AND DISCUSSION

4.1 Introduction.

This chapter showcases details of the survey conducted with clean energy companies, including solar and clean cooking companies**.** The chapter presents the results from the study concerning challenges faced by clean energy companies in using the Multi-tier Framework for reporting and how the challenges can be reduced. The proposed incentives by clean energy companies are also presented. A detailed discussion of the results based on the researcher's perspective is also presented.

4.2 Results

4.2.1 Respondent Company Details.

The research focused on solar and clean cooking companies in Uganda. Respondents were managers, marketing officers, and data analysts from the selected companies. The results are presented below.

Table 4:1 Number of respondents from energy companies

Clean Energy Companies	**Number of respondents**	**Percentage**
Solar Energy Companies	12	60%
Clean Cooking Companies	8	40%
Total	**20**	**100%**

Source: Author's field survey 2021.

From table 4.1 above, it is seen that the researcher interviewed staff from twenty energy companies; 60% of the respondents were staff from solar energy companies, whereas 40% were from clean cooking companies. Most of these respondents were marketing officers and data

officers who collect data on behalf of the companies. The selection of the above officers was to capture the exact people that face customers, collect data from them and make company decisions. The different officers provided reach experience in ensuring service delivery to the last man while tracking progress towards sustainable energy for all by 2030.

4.2.2 Years of Existence

To expeditiously access and understand the contribution of the energy companies, the survey captured the years of existence of the companies**.** Long service is a crucial measure of a company's handout to energy access. The survey revealed the following results.

Table 4:2 Showing the years of existence of energy companies.

Clean Energy Companies	**Years of Existence of Companies**		
	1-5 (Years)	6-10 (Years)	11-15 (Years)
Solar Companies	2	7	3
Clean Cooking Companies	1	5	2
Total	**3**	**12**	**5**

Source: Author's survey 2021.

From Table 4.2 above, it is seen that three (3) energy companies from the ones surveyed, including two (2) solar companies and one (1) clean cooking company, had existed for 1-5 years. In contrast, ten (12) companies, including seven (7) solar companies and five (5) clean cooking companies, had existed for 6-10 years. In the same vein, five (5) companies, including three (3) solar companies and two clean cooking companies, had existed for 11-15 years. The above statistics indicate that clean energy companies were very few compared to the current number. At least sixty percent (12 companies) of the surveyed clean energy companies were formed 6-10 years ago, while

only twenty-five percent (5) were formed 11-15 years ago. Fifteen percent of the companies started 1-5 years back, indicating that very few companies had been developed in the most recent years.

1.1.3 Products Clean energy Companies Deal in

Clean energy companies deal in various products that they provide to their customers. The solar companies sell solar home systems, lanterns, water heating systems, mini-grids, solar fridges, solar saloon equipment, solar refrigeration, and solar milling. However, not all solar companies were providing these services or products. In comparison, the clean cooking companies sold charcoal briquettes, improved cookstoves, Liquified Petroleum Gas, and ovens.

Table 4:3 shows the products companies sell.

Products and services offered	**Number of companies offering service**
Solar Home Systems and solar lanterns	9
Solar water heating and solar fridges, saloon equipment	3
Solar mini-grids	2
Solar milling	2
Improved cook stoves and Briquettes	6
LPG	2

Source: Author's field survey, 2021.

From Table 4.3 above, it is observed that most companies (9) sold solar home systems and solar lanterns. In contrast, three solar companies sold solar water heating systems and solar fridges in addition to the solar home systems. Two solar companies had solar mini-grids that offer electricity to many households far from the national grid, whereas two companies offered solar milling systems. Six clean cooking companies sold improved cookstoves and briquettes for home and institutional use. Two of the surveyed clean cooking companies offered Liquified Petroleum Gas (LPG) sold on a cash basis to customers.

Figure 4:1 shows some solar products and improved cookstoves sold at Anuel Energy and Josa Green Technologies Limited respectively.

Source: Author's field survey, 2021.

1.1.4 The number of employees, youth, and women highlighted.

All companies had several employees. Some people worked with clean energy companies as commission agents, but this study focused on full-time employees. However, the researcher investigated the percentage of youth and women employed in clean energy companies. The results help analyze the youth and women's involvement in driving sustainable energy for all. The results are presented below.

Table 4:4 shows employees in companies (youth and women highlighted)

Total number of employees in surveyed companies	Number and Percentage of youth employees (less than 30 years)	Number and Percentage of women Employees
2432	1371 (56.3%)	651 (26.8%)

Source: Author's field survey, 2021.

From Table 4.4 above, it is shown that the surveyed twenty clean energy companies employed 2432 people. One thousand three hundred seventy-one of the employees, 56.3%, were youth below 30 years of age, and (651), 26.8% of the employees, were women. Youth are significantly leading the clean energy sector; moreover, the youth population in Uganda is over seventy percent. The proportion of women employed in the clean energy sector is still low, evidenced by 26.8%. However, there is a need to hire more women in the clean energy sector since they are highly affected by poor cooking methods that cause them smoke-related illnesses.

Furthermore, women can be better salespeople in clean cooking companies due to demonstration while selling stoves, briquettes, and LPG. Moreover, increasing energy access requires proper advocacy. Women can perform it well as they fight for their health and safety since they are directly affected by unclean cooking fuels and technologies.

4.3 Tracking Progress Towards SDG7

In this section, there is a presentation of results about data collection habits, methods by the clean energy companies, and how data is helpful to them and the government

4.3.1 Types of Data energy companies collect from customers.

The survey revealed that clean energy companies collect household data, energy consumption data, level of customer satisfaction, personal details, future energy demand, and assess customers' willingness to pay. The detailed results are presented below

Table 4:5 showing types of customer data collected by energy companies

Type of data collected by companies	Number of companies interested in the data set		
	Solar Companies	**Clean cooking companies**	**Total number of companies**
Household data	8	3	11
Energy consumption data	10	4	14
Customer satisfaction	10	4	14
Future Energy demand	6	1	7
Willingness to pay	6	3	9
Customer Details (Personal and Gender)	12	4	16
Others	5	3	8
Do not collect data	0	0	0

Source: Author's field survey, 2021.

From Table 4.5 above, it is vividly seen that 11 companies, including eight solar companies and three clean cooking companies, were interested in household data. In comparison, fourteen companies, including ten solar companies and four clean cooking companies, were interested in

energy consumption data. It is observed that (10) 83% of solar companies are interested in energy consumption data related to system sizing and design. It is meant to ensure that the companies size suitable solar home systems for their customers. Four clean cooking companies were very interested in energy consumption data for primarily institutional customers. One respondent emphasized the need to know the number of students before designing an institutional stove for a school. The respondent noted that student enrolment determines energy consumption.

Furthermore, it is clear that all solar companies collect customer details/personal data that helps them to know their customers better and enroll them on the installment-based payment system. Only four clean cooking companies were interested in customer details. Most of the clean cooking companies sold briquettes, LPG, and improved stoves on a cash basis from door-to-door delivery and did not have the arrangement to have customer details. All companies collected at least one or more data sets from their customers although solar companies were more interested in collecting data than clean cooking companies.

4.3.2 Reasons why clean energy companies collect energy data

The surveyed clean energy companies highlighted various reasons for collecting comprehensive data from customers. The results are shown below.

Table 4:6 showing reasons why private clean energy companies collect data

Reasons for data collection	**Number of Companies (out of 20 surveyed).**
Assess periodic performance	9
Benchmarking purposes	8
Customer Registration	13

Accountability	6
Customer satisfaction survey	8
Impact reporting	13
Legal Purchase contract	3
Financial Viability Survey	4
Guarantee Contract	3
Other reason	10

Source: Author's field results, 2021.

The information obtained in table 4.6 above indicates that most clean energy companies, 13, collected data for customer registration and impact reporting, nine clean energy companies collected data to assess periodic performance. Whereas eight clean cooking companies collected data for benchmarking purposes and customer satisfaction surveys. Six clean cooking companies collected data for accountability purposes, while four clean energy companies collected data for financial viability surveys. Three clean cooking companies collect data for legal purchase contract sealing and guarantee contracts. On average, at least every clean energy company was interested in collecting two data sets.

Finally, 50% of the clean cooking companies gave other various reasons for collecting data. Some respondents argued that data collection help in determining potential areas for investment to boost energy supply to targeted customers. At the same time, another respondent argued that data collection helps plan for financial needs at the company level and keep track of customers to

recover products supplied on credit to non-compliant customers. According to other respondents, data collection helps identify areas with more market and also aid follow-ups on customers. It also helps monitor its marketing patterns, understand the kind of people you serve, and know which products move faster. One respondent from a solar company is quoted saying, '*collecting data helps us to beat the competition because we speak to our clients often, know areas of improvement, and in the end, we get repeat customers.*

4.3.3 How clean energy companies collect data.

The study acknowledges that data collection is an integral part of the operations of clean energy companies to assess impact and monitor performance. The study investigated how clean energy companies collected data from customers, and the results are discussed below.

Table 4:7 showing how companies collect data.

Ways of data collection	**Number of Companies that use the mode**
Digital: Own App	8
Questionnaire	8
Receipt	11
Accountability/sales App	0
Collect App	1
Other	7
We do not collect data	0

Source: Author's field survey, 2021.

As depicted from Table 4.7 above, most companies (11) use receipts for data collection. The original copy of the receipt is given to the clients. The energy company retains a duplicate copy in the receipt book to get personal data and any other data a company wishes to gather. Eight companies have used digital applications and questionnaires for data collection from customers. Whereas only one company used a data collection app, the HEDERA collect App, the company reported delays caused by multiple questions to fill in the collect application that caused delays during the sale. Seven companies use other means of data collection: verbal, where they speak to customers and get data from them, while others use ledger cards. Some respondents said they visit customers and make observations, while others used telephone calls from customer care lines to gather feedback from customers. Moreover, all companies collected data, confirming that data is integral in company operations. It is important to note that most clean energy companies use more than one data collection mode. Most companies use a hard copy and a digital tool for data collection or observations/ conversations to get customer data, as shown in Table 4.7 above.

4.6. Times when Clean Energy Companies collect data

The study sought the duration when clean energy companies collect data from their clients. The investigation is based on the need to have up-to-date data to better measure impact or progress towards SDG7. The results of the survey are shown below.

Table 4:8 Showing when clean energy companies collect data.

Duration of data collection	**Number of clean energy companies that collect data in the duration**
At first visit	11
During the purchase of a product	11

When installing the product	4
Maintenance visit	3
Anytime	4
Others	6

Source: Author's field survey, 2021.

From the results displayed in Table 4.8 above, it is seen that eleven (11) clean energy companies collected data at the first visit and when selling a product. In contrast, four clean energy companies collected data when installing the product. Moreover, three companies collected data at maintenance visits, while four companies collected data anytime through customer service calls and any other means. Six clean energy companies collected data at intervals different from the above-discussed ones. On interrogation, respondents said they collected personal data like names and telephone contacts during the pitching of products to call people consistently and tell them more about their services and products. In addition, some respondents argued that they collected data before system installation, during the pre-feasibility survey period, and abruptly especially for customers with PayGo systems. From observing the above results, it is right to conclude that clean energy companies collect data at the first visit to the customer and any other time they deem it necessary.

4.3.4 **Importance of detailed household data to clean energy Companies.**

To answer the third research question, the survey investigated the benefits of detailed customer data to the clean energy companies. Such data include personal details such as gender, economic status, and other data such as energy consumption data, future energy demand, willingness to pay, and customer satisfaction. The responses from the clean energy companies are displayed in the table below.

Table 4:9 shows responses on the importance of detailed data to clean energy companies.

Use of data to Clean Energy Company	**Responses from clean energy Companies**	**Percentage (out of 20 companies surveyed)**
Data guides Planning	13	65%
Determines customers willingness to pay	11	55%
Helps to set sales targets	14	70%
Used to determine ability to pay	8	40%
Used to measure project impact	12	60%
Gathers customer feedback	11	55%
Help to discover areas of improvement	11	55%
Understand customer preferences	10	50%
Data guides change	7	35%
Other	3	15%

No, data is not relevant to my company	0	0

Source: Author's field survey, 2021.

The results displayed in Table 4.9 indicate 65% of the clean energy companies use detailed data for short-term and long-term planning. The exact data guides the company to set feasible plans basing on the reality that information presents. In contrast, detailed data guide 55% of the clean energy companies in determining customers' willingness to pay. In comparison, 70% of the clean energy companies set sales targets based on the detailed data they gather from the customers, as 40% of the clean energy companies use the detailed household data to determine customers' ability to pay primarily for those to be enrolled on the installment-based system. 60% of the respondents said they use data to measure project impact based on the number of customers reached or affected. These results confirm the argument of (Ridout & Keyte, 2016) that data is used to measure the positive and negative impact of a project.

Furthermore, 55% of the clean energy companies submitted that detailed data helps them gather customer feedback and identify areas of improvement. Respondents emphasized that such data is collected through telephone customer care calls direct to customers to inquire about the performance of the products. 50% of the clean energy companies lamented that they understand customer preferences through the detailed data they collect from them. In comparison, 35% of the companies used data to guide change in the marketing strategies and other decisions. 15% of the surveyed clean energy companies argued that detailed data helped track clients and detect areas to rely on. Respondents said detailed data also helped them determine the efficiency of products and gave them ground to improve service delivery. At the same time, one respondent noted that investors were interested in detailed customer data to assess the company readiness level before availing of financial support. Summarily, all respondents appreciated the value of comprehensive customer data to run their companies as none said it is irrelevant.

4.3.5 **The most relevant client information in transforming quality and business.**

The study investigated the most relevant client information to transform the quality and business growth at the company level to understand the relevance of client data to clean energy companies. The results are shown below.

Table 4:10 showing the most relevant client information to clean energy companies.

Client data	**Number of Companies it is most relevant (out of 20)**	**Percentage of relevancy**
Household data	3	15%
Energy consumption data	9	45%
Customer satisfaction	3	15%
Future Energy Demand	0	0%
Willingness to pay	1	5%
Customers details	3	15%
Others	1	5%
Total	**20**	**100%**

Source: Author's field survey, 2021

From Table 4.10 above, it is observed that 15% of the clean energy companies were very interested in household data to better align the products to the satisfaction of the people within the home. In

comparison, the majority, 45% of the respondents, argued that energy consumption data was the most relevant in improving quality and running the business well compared to other data. These respondents argued that energy consumption data helps them design/size suitable systems for a particular home or institution. Their argument is in with the works (Blechinger et al., 2016), who argued that proper system sizing must come from the energy consumption estimates from homes or communities to be installed.

Furthermore, 15% of the clean energy companies considered customer satisfaction data more relevant than any other. Only 5% upheld willingness to pay as the most pertinent data to boost quality and business growth. In comparison, 15% of the respondents attached more relevancy to customer details than any other as none of the respondents attached much value to future energy demand. However, one respondent highlighted the pertinence of location and contact of customers as the most critical data a company must get from clients. He was quoted, *'To us, the location and contacts of our clients are the big deals, and we can track customers when we have places and contacts' (Interviewed* on 30th September 2021).

4.3.6 **The challenges faced by clean energy companies in collecting data.**

The use of the Multi-Tier Framework for reporting or tracking impact depends on collecting comprehensive data. Unfortunately, they face many challenges in trying to gather all the data they need. The survey was conducted in 20 clean energy companies in Uganda, including solar companies and clean cooking companies dealing in briquettes, improved stoves, and LPG. The following were the challenges highlighted.

Table 4:11 shows the challenges energy companies face in data collection.

Challenges companies face in collecting data.	**Responses from Companies (out of 20)**
Customers are skeptical about sharing information	14

Expensive to collect data	7
Movement of long distances in areas	15
Time-consuming	11
Data collection requires much staff	6
Restrictions in movement due to covid-19	11
Data from surveys is unreliable with time	5
Customers do not know some specific information	8
Others specify	8

Source: Author's field survey, 2021

Results displayed in Table 4.11 above indicate that 14 clean energy companies noted that their customers are skeptical about sharing some information. Because companies require as detailed client data as possible, it becomes a great challenge for their functions. Insufficient data makes it difficult to determine the ability to pay for customers. Seven respondents argued that data collection is an expensive venture for them basing on their financial status. In comparison, 15 respondents (majority) said that data collection requires them to move long distances, which is tiresome and expensive, as 11 respondents said data collection is time-consuming. They argue that data is mainly collected when selling products, yet data takes time and causes delays.

Furthermore, six respondents said that data collection requires a lot of staff, yet hiring more staff would be expensive for the companies. Moreover, the movement restrictions due to Covid-19 were

unfortunate challenges to eleven (11) clean energy companies to freely collect data from their clients. Eight respondents argued that some customers do not know some specific information they would provide. Still, because of language barriers or ignorance, they cannot share with clean energy companies, leading to the inability to collect detailed data for planning at the company. Five respondents argued that data from surveys become unreliable with time making it of low value.

In comparison, eight respondents presented other challenges like the poor network in some parts of the country, yet the digital applications require good internet. Some areas are hard to reach, yet they have customers, while some clients share incorrect or exaggerated data which does not present their actual situation. In such cases, determining the affordability of such customers becomes so complex. Conclusively, most respondents showed many challenges they face in data collection, which means the solution must be robust and comprehensive.

4.4 Impact Reporting

The study sought the respondents' opinions about impact reporting to understand the contribution of the clean energy companies in tracking progress towards SDG7. The details are presented below.

Table 4:12 shows responses if energy companies should assess their impact

Responses	**Number of Companies**	**Percentage**
Yes	20	100%
No	0	0%
Total	**20**	**100%**

Source: Author's field survey, 2021.

From Table 4.12 above, 100% of the respondents said clean energy companies needed to assess their impact in communities/ countries. The effect is primarily reported in numbers and published

on websites.

4.4.1 The idea of sharing impact reports with third parties.

The study investigated the willingness of clean energy companies to share impact data with the government, academic institutions, and other third parties. The general tracking of progress towards achieving SDG7 calls for all stakeholders involved in supplying energy to report their impact so that countries can measure energy access easily. The results of the survey are expounded below

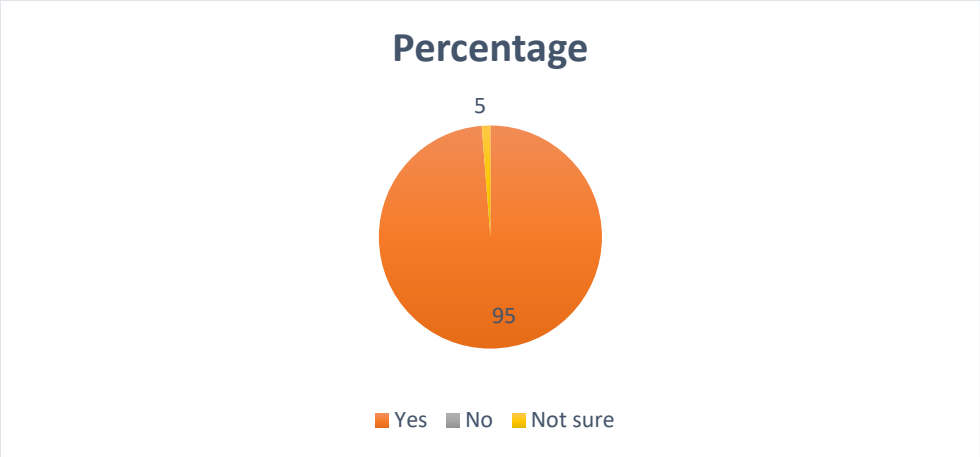

Figure 4:2shows the percentage of responses for companies sharing impact reports with third parties.

Source: Author's field survey, 2021.

From Figure 11 above, 95% of the respondents were ready to share impact reports with third parties, including the government and researchers. However, 5% of the respondents were not sure of sharing their impact reports with third parties. It is essential to mention that tracking progress towards SDG7 is dependent on the ability of the clean energy companies to share their impact data with the government. However, clean energy companies gave conditions under which they would willingly share their impact data with the government, and the reasons are summarized below.

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Condition	Responses from clean energy companies (Out of 20)
Funding	14
Subsidy	16
Share analyzed data	7
Others specify	6

Table 4:13 showing conditions under which respondents can share impact reports

Source: Author's field survey, 2021

As seen in Table 4.13 above, 14 respondents emphasized the need for government funding to share their data. They argued that they use their resources to collect data, requiring compensation to share data. In comparison, 16 respondents added the need for government to subsidize data collection to share detailed energy access data from their customers to the government. Seven (7) respondents were willing to share detailed data with the government on the condition that government shares its data. Besides the above conditions, the respondents also highlighted the need for tax exemption and enacting policies favoring their operations. Following an interview with the respondents, this was extracted from the conversation with one respondent. *'You see, we cannot share our data with the government. They tax us a lot. They should support us financially so that we can survive in this challenging business environment'* **(**Interviewed on 3rd September 2021).

4.4.2 The use of the Multi-Tier Framework for reporting

The key to the study is finding out the usability of the multi-tier framework by the private, clean energy companies to measure their impact. The survey results indicate a large awareness gap between the twenty surveyed clean energy companies in Uganda. The ten companies under the United Nations Capital Development Fund's Renewable Energy Challenge Fund project for the digitalizing impact reporting process aligned with the Multi-Tier Framework (MTF) and Progress Out of Poverty Index (MEPI) understood the MTF. In contrast, other clean energy companies did not know much about the framework. Moreover, most companies that understood the MTF did not report impact, citing its complexity and delay when making a sale. The survey investigated the number of clean energy companies currently using the Multi-tier Framework as a standard framework for measuring their impact. The results of the study are presented below.

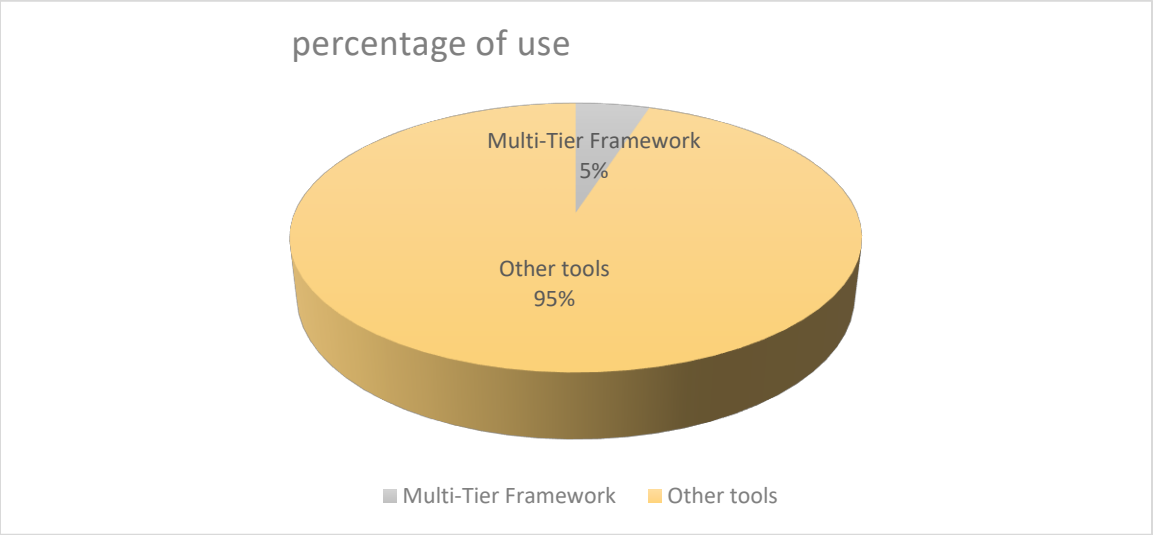

Figure 4:3 shows the percentage of use of standard frameworks for measuring impact.

Source: Author's field survey, 2021.

From Figure 4.3 above, it is observed that 95% of the respondents used other frameworks for measuring their impact. Most clean energy companies use internal or self-set Key performance Indicators and External key performance indicators set by their donors. In comparison, 5% of the respondents used the Multi-Tier Framework for measuring impact. Moreover, those who used the MTF reported the complexity of data collection based on the framework's attributes. One respondent said, '*that tool is too generic and fits the European companies'* (Interviewed on 26th

August 2021).

There is a need to sensitize the energy companies about the MTF. Otherwise, its use is minimal. In addition, the study investigated the reporting hierarchy of the impact from the clean energy companies. The researcher was interested in knowing if the local private, clean energy companies reported their impact directly to the government, which would form part of the energy access statistics. Tracking progress towards achieving SDG7 requires that all detailed energy access data be collected and analyzed to measure the reality of energy poverty in Uganda. The results of the survey are shown below.

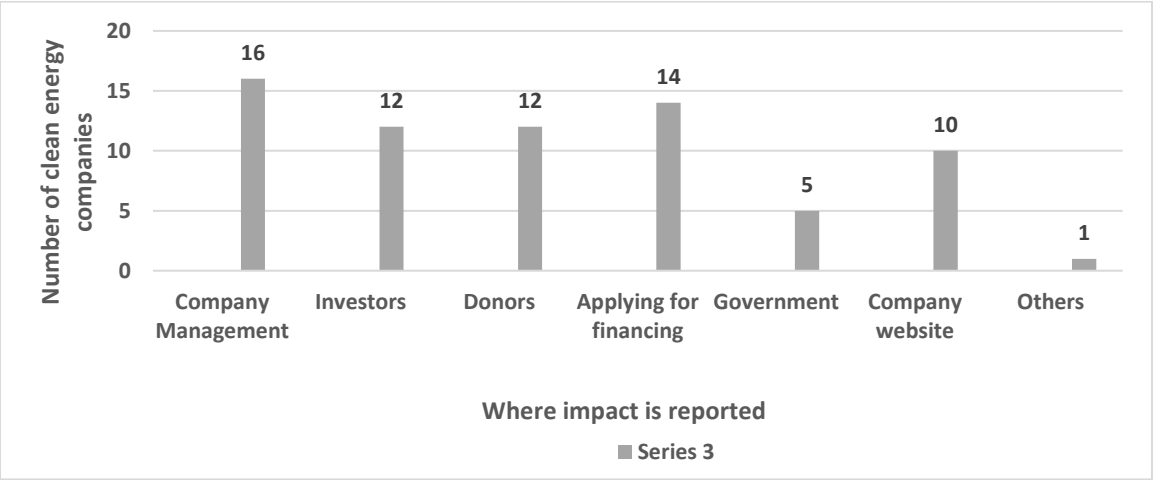

Figure 4:4 showing the impact reporting hierarchy for clean energy companies.

Source: Author's field survey, 2021.

From Figure 4:4 above, it is observed that sixteen (16) respondents reported their impact to the company board of directors, and twelve (12) respondents reported their impact to investors in their business. In comparison, twelve respondents (12) said they reported effect on donors, and fourteen (14) respondents reported their impact when funding to entice the donors to help them. However, only five (5) respondents reported their effect on the government, and ten (10) respondents displayed their impact on their company website. In contrast, one respondent asserted their implications for company employees to entice them to work hard. It is worth noting that at least each clean energy company reported effect to two or more destinations as detailed above.

Furthermore, the study investigated how often clean energy companies carried out impact surveys to measure their impact, and the following are results.

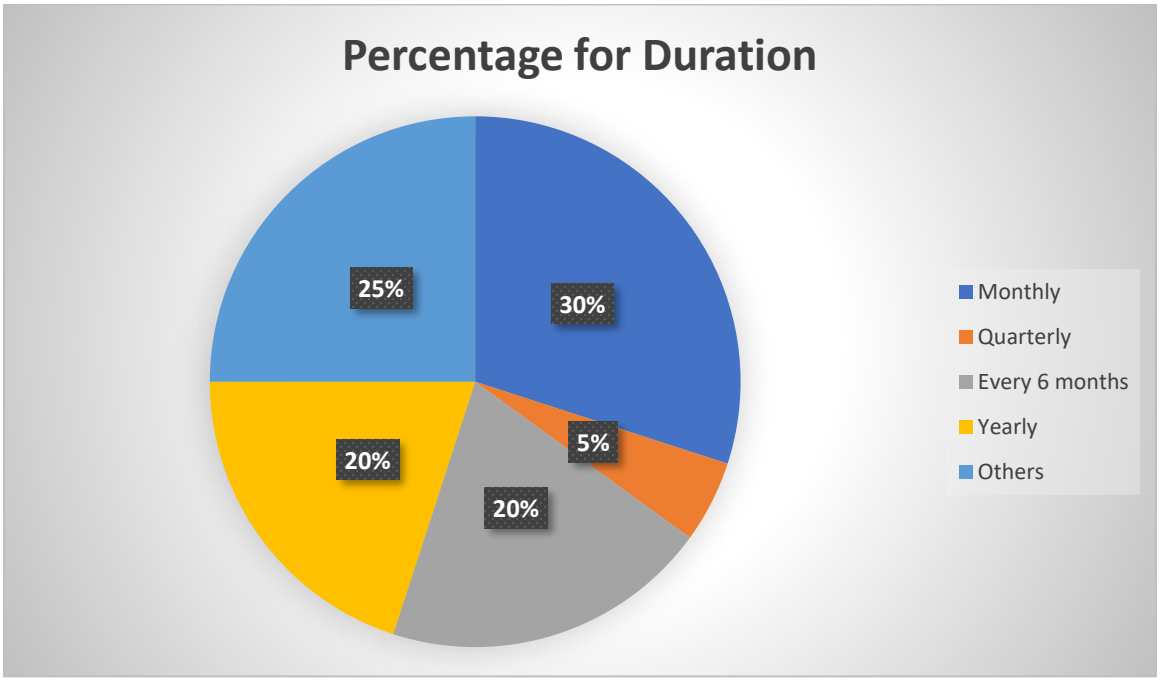

Figure 4:5 shows how often clean energy companies made impact surveys.

Source: Author's field survey, 2021.

Figure 4:5 above indicates that 30% of the respondents carried out impact surveys monthly, whereas 5% carried out impact surveys quarterly and 20% carried out impact surveys every six months. Moreover, 20% of the respondents carried out impact surveys yearly, while the other 25% carried out impact surveys on different durations from the above. Many of them carried out daily and weekly surveys after adding new sales to the old ones recorded in their system. Generally, all companies carried out impacts on different durations. However, to better track progress towards achieving SDG7, each sale of a product or service provided by a clean energy company to a client should be recorded electronically in a system based on the Multi-Tier Framework. In this way, impact reports would be produced anytime by the companies.

The study investigated the comprehensiveness of the surveys the clean energy companies carry out. The focus was on the questionnaires they use for surveys to know if they are worth and comprehensive enough to capture all information donors needed. The results indicated that 75%

of the clean energy companies had customized their surveys to suit the demands of their supporters. In comparison, 25% of the clean energy companies had not customized their survey questionnaires. Further investigation from the study revealed that 70% adjusted their survey questionnaires often to fit the demands of their donors, whereas 30% did not adjust their survey questionnaires.

4.4.3 Attributes of the MTF

Understanding the challenges related to using the multi-tier framework by clean energy companies, the study investigated the reality of collecting data about each attribute of the MTF. The results about characteristics are discussed below.

4.4.3.1 Affordability

Affordability refers to the ability of customers to pay for energy products and services without spending more than 5% of the household's annual expenditure (Koo et al., 2019). According to the IEA, 2021, affordability is a global concern to all governments and energy partners, and expenditures on energy are high, mainly on oils. Moreover, Uganda's high poverty levels compel clean energy companies to give out their products on an installment payment-based system. The practice was widespread in all solar companies that were surveyed. The study, therefore, investigated the ease of collecting data that clean companies can use to determine if one can afford the product and services, and the results are discussed below.

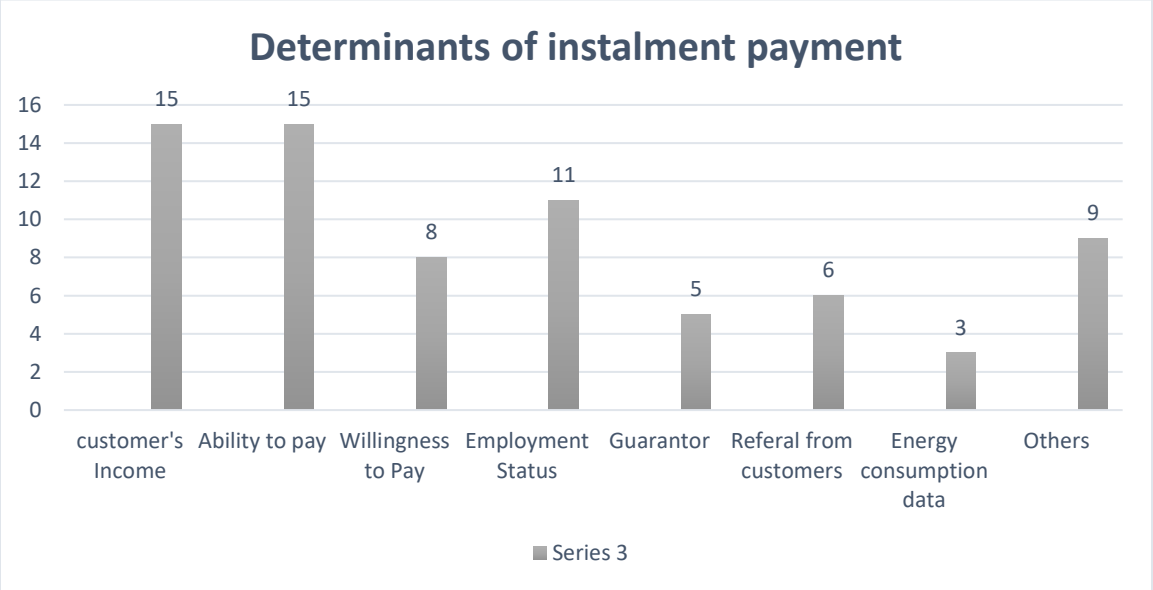

Figure 4:6 shows conditions that influence companies' decision to include a customer on an installment payment system.

Source: Authors field survey, 2021.

Most respondents (15) considered one's income status and ability to pay as crucial determinants for enrolling on the installment-based payment system as shown in **Figure 4:6**. A part of the above determinants, eight respondents, considered willingness to pay as a critical determinant before enrolling a customer in the installment-based plan. Eleven respondents felt a customer's employment status while five respondents based on guaranteeing from a respected person. In comparison, six respondents considered the referrals from serial customers. In contrast, three felt the customers' energy consumption data to determine if they could afford to pay for the new system or product they needed. Besides the above determinants, nine respondents considered other essentials, such as background information from local authorities about the financial integrity of the prospective client. Other determinants given were the assets one and the number of students in the case of education institutions. Some respondents said they were also required to know ones' financial burdens, such as loans and dependability ratio, while others considered recommendations from Savings and Credit Corporative Societies and local authorities.

The above determinants depend solely on the availability of data about customers' income levels, employment status, ability to pay, etc. The study investigated the ease of collecting such data by clean energy companies to report using the Multi-Tier Framework easily. In this way, the study found the challenge clean energy companies face in utilizing the MTF for measuring impact.

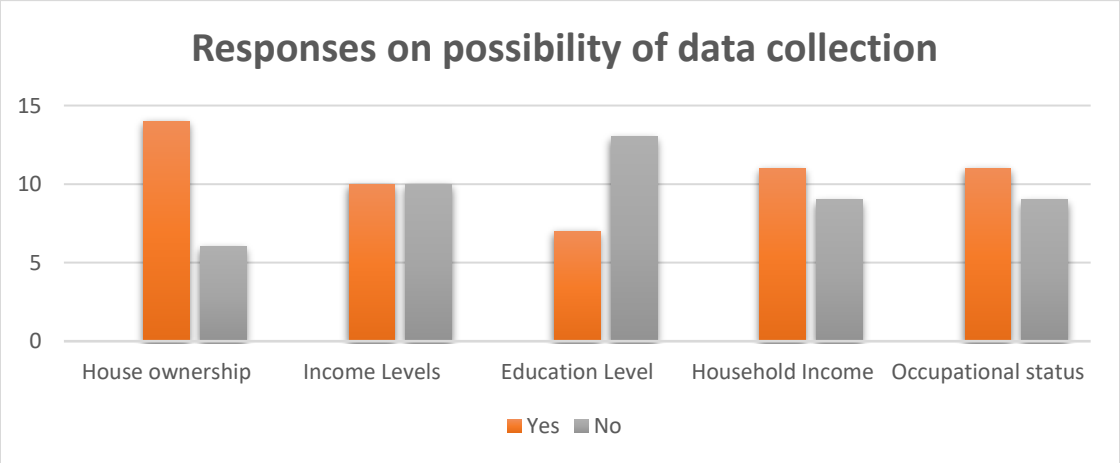

Figure 4:7 shows responses on the ease of collecting data that determines affordability.

Source: Author's field survey, 2021.

The results shown in Figure 4:7 above indicate that fourteen (14) respondents could get data about household ownership quickly. It was always got from the conversations company officials had with prospective customers. They could promptly know if they were renting or owning the houses they occupied. At the same time, six (6) respondents could not get data about homeownership. In comparison, ten (10) respondents were able to get information about the income levels of their prospective customers to help them determine affordability.

In contrast, the other ten (10) respondents could not capture such information. Most respondents were unable to capture information about the education level of their prospective clients citing irrelevancy of knowing such data or customers not willing to share. Some respondents were not interested in understanding customers' education level, saying it does not contribute much to someone's willingness to pay. Instead, the need for the product can drive anyone of any education level to deliver. Eleven respondents could collect such data from customers on household income and occupation status, unlike the nine (9) respondents who could not collect such information from their customers.

Moreover, respondents who could not get information on any particulars of affordability cited the following reasons.

- Customers are skeptical about sharing details about their incomes and other related information for security and personal reasons. One respondent is quoted as, *'customers do not like people who ask questions, I remember asking one man his source of income, and he left my stall. It is even worse if they see you recording on paper, they will not like it, and you will take along to convince them. Personally, pleading for such data is my hardest thing in the field'* (interviewed on 30th August 2021).

- Data collection causes a delay in the field. Respondents asserted that data collection causes a lot of details in the selling process. Respondent is quoted, *', where do you get that time to ask all these questions yet you are talking to many customers. We sell our products in public places and remember we do not have enough human resources to record all data,*

yet we target making as many sales as possible. Recording data causes delays, and we may lose customers in that process' (interviewed on 3rd September 2021).

- It is expensive to collect data. It requires papers or a digital tool which is costly for clean energy companies, most of which have not taken off. The respondent's argument confirmed the survey made by (Mudaliar et al., 2017), where respondents spent about 12% of their budget on impact reporting activities with data collection taking lions to share.

- Data collection and management require that a company employs staff that collects data, yet they do not have enough capital base apart from sales income and very few donations.

- Movement restrictions caused by the Covid-19 pandemic were cited as a critical challenge to collecting data from customers. A respondent was quoted s, *'it was hard to move due to the lockdown and partial lockdown imposed by the government. Even if someone got a permit to move, the transport was expensive, yet we could not meet many people since gatherings were not permitted. Sales went down as well as data collection'* (Interviewed on 3rd September 2021).

- Data is unreliable. Most customers exaggerate their income flows so that energy companies can give them products. The behavior causes bad debtors that are a threat to business growth. A respondent was quoted, *'do not risk and give a great product to someone before making underground checks. People lie a lot about their income levels when they target products. It is unfortunate, but we have now incorporated the idea of seeking approval from local leaders before giving out large solar Home systems to household'* (Interviewed on 2nd September 2021).

- Data collection requires that staff from clean energy companies move long distances, which is tiresome and expensive.

- Difficult to find household heads when collecting sensitive information such as level of education, income, and occupational status. A respondent from a clean energy company was quoted as *'it is hard to meet heads of families whom such questions can be asked. We always find housemaids and women when we go for cooking demonstrations. Those people*

may not provide such information (*interviewed* on 30th September 2021).

The study also investigated the solutions that clean energy companies can uphold to easily collect data that determine customer's affordability, one of the Multi-Tier Framework attributes. The results are displayed below.

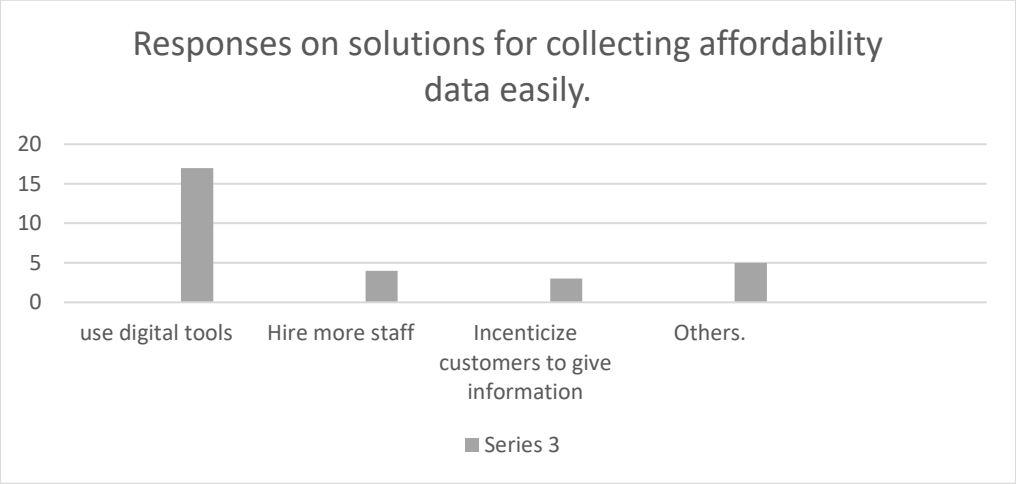

Figure 4:8 shows responses on solutions for collecting affordability data efficiently.

Source: Author's field survey, 2021.

From Figure 4:8 above, it is observed that seventeen (17) respondents agreed that using digital tools such as smartphones and computers with digital applications could reduce expenses of paperwork and other inconveniences. Whereas this cannot solve the issue of customers' skepticism about sharing information, respondents believed it could be cheaper. However, respondents suggested that the applications used in digital appliances have to be easy to use and flexible with offline and online use. Moreover, four (4) respondents believed hiring additional technical staff could increase the chances of collecting data on affordability. However, hiring more staff is expensive, and it can only be possible with additional funding. Finally, three (3) respondents confirmed that incentivizing customers to share data freely would be the ideal solution to gathering detailed data that would determine clients' affordability.

Five (5) respondents gave other suggestions, such as training sales teams on multi-tasking and good customer care to quickly gain customer loyalty and get all income-related data they need to access affordability, an attribute of the MTF.

4.4.3.2 Quality and Affordability

The use of the multi-tier Framework demands that data on the quality and availability of the products and services be available. Reporting with the MTF unearths all practices related to the availability of a product. Quality of the products or system is vital since it can lead to system intermittences or accidents if not handled properly. Moreover, availability captures hours of access to products and services. It captures how many hours people use a particular technology for electricity and clean cooking receive services. For example, one is considered Tier 5 if they receive reliable electricity for 23 hours and above. Evenings and daytime are also considered. It is vital that households get electricity in the evenings; hence those that receive electricity for 4 hours, of which one hour has to be in the evening hours, are considered to be in tier 1. The study investigated if the energy companies collected data on the number of hours their customers received electricity, and the results are discussed in the next paragraph.

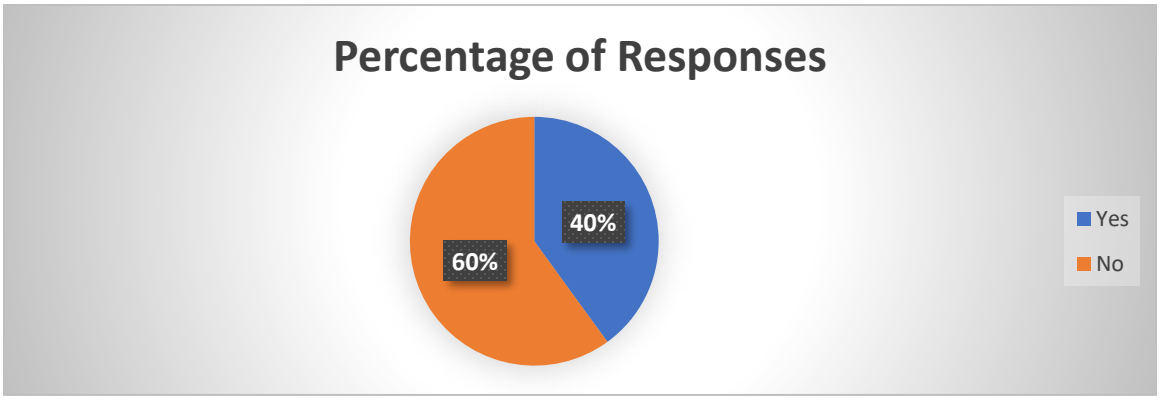

Figure 4:9 shows clean energy companies collecting data on the number of hours customers received electricity.

Source: Author's field survey, 2021.

From Figure 4:9 above, it is observed that 60% of the respondents were collecting data on the number of hours their customers have electricity while 40% were not collecting such data. The energy companies that collected this data said they asked their customers the details when they visited them or telephone calls. The study investigated the challenges customers faced during system interruptions. The results indicated that it often takes long to repair systems because of the long distance between technicians and customers. Customers could not charge phones and other types of equipment during blackouts, while some business people lost their perishable items when

there were system disruptions.

Furthermore, 55% of the energy companies followed up to know if the systems/products were stable and working well, whereas 45% did not follow up to assess whether products/services were working well. The follow-up was in by telephone calls and physical visits by company technicians. Other systems were monitored remotely using control systems while other companies pretested systems before being sold out. Other companies size plans appropriately according to customer needs to promote system stability.

The study investigated the challenges clean energy companies face in collecting data about the quality and availability of products and services offered. The responses are the same they gave for affordability in 4.4.1a above. To avoid repetition, they have not been written here.

4.4.3.3 Efficiency

Efficiency concerns the amount of fuel or electricity one uses to produce or offer a service. In cooking, efficiency involves the amount of fuel one uses to make food. It concerns using fuels sparingly while doing quality service. Heat losses have to be avoided as much as possible by using the right technology. In contrast, the lighting system has to be highly energy-saving to achieve maximum efficiency.

Moreover, improving energy efficiency has been named one of the critical strategies driving SDG7(IRENA & Bank, 2019). Reporting using the MTF requires that clean energy companies collect data about efficiency as a framework attribute. The study investigated the ability of clean energy companies to collect data about customers' systems' efficiency efficiently, and the results are shown below.

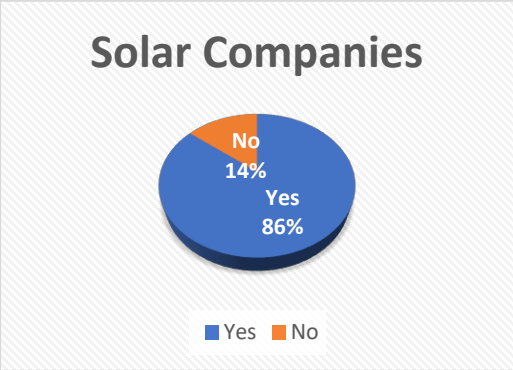

Figure 4:10 shows the ability of solar companies to collect data about the efficiency

Source: Author's field survey, 2021.

From Figure 4:10 above, it is observed that 84% of respondents were interested and capable of collecting data concerning the efficiency of their solar systems from their customers. In contrast, 16% were unable to collect data concerning the efficiency of their solar products and services. The study investigated the relevancy of efficiency data to solar companies in determining the type of product and services they offered. The results rated from 0 standing for not relevant at all to 5, which stands for very suitable, indicate the relevant information below.

Table 4:7 shows the relevance of efficiency data to solar companies.

Relevance score	**0**	**1**	**2**	**3**	**4**	**5**
Meaning	Not relevant	Fairly relevant	Somewhat relevant	Relevant	Very Relevant	Extremely relevant
Number of Responses from Solar Companies	0	0	0	1	6	5

Source: Authors field survey, 2021.

The results in Table 4:13 above indicate the relevance of the data about efficiency in determining the type of products and services offered by solar companies meaning that data on efficiency needs to be collected by solar companies.

Figure 4:11 shows clean cooking companies' ability to collect data about efficiency.

Source: Author's field survey, 2021

Figure 4:11 above indicates 75% of the clean cooking companies were interested and capable of collecting data on the efficiency of cooking stoves, briquettes, LPG. Whereas 25% were unable to collect data on the efficiency of stoves, briquettes, and LPG, citing the venture being costly and involving moving long distances. Other respondents argued that customers are skeptical about sharing some information. Most of them do not understand the technicality of systems and are therefore unable to access their systems' efficiency.

Moreover, the survey investigated the relevancy of detailed data on the efficiency of products and systems on determining the nature of products and services offered by clean cooking companies, and survey results were positive. It was discovered that data on the efficiency of stoves, LPG was relevant to the companies, as indicated below.

Relevance score	0	1	2	3	4	5
Meaning	Not relevant	Fairly relevant	Somewhat relevant	relevant	Very relevant	Extremely relevant
Responses from clean	0	0	0	1	3	5

cooking companies						

Table 4:8 shows the relevance of data on efficiency to clean cooking companies

Source: Authors field survey, 2021.

On examing how collecting data on the efficiency of products and systems can be simplified, the respondents suggested the following solutions.

- The use of digital tools such as mobile applications to reduce paperwork and store results electronically. It was identified as an appropriate solution for costly use of papers to record data

- Technical support in the form of a staff. The energy companies suggested that having staff trained on data collection and analysis would make collecting data on efficiency easy.

- Financial support was proposed to boost transportation and other expenses to collect data since it requires staff from energy companies to move long distances

4.4.3.4 Health and Safety.

It concerns the occurrence of accidents caused by the energy system (Kol et al., 2018). The multi-tier framework captures the number of accidents a system generates. Reporting using the MTF captures incidents that happen to users. Some incidents can be minor, while others can be serious and deadly. The use of the MTF by clean energy companies requires that they collect data from customers about any incidents that might have happened. Moreover, clean energy companies have to design solar systems and cooking fuels that are safe for human use. The connections in the case of electricity have to be safe for use and clean cooking fuels and technologies.

The study investigated how clean energy companies handled the safety issues of their customers and knew how they collected such data. The results are presented below.

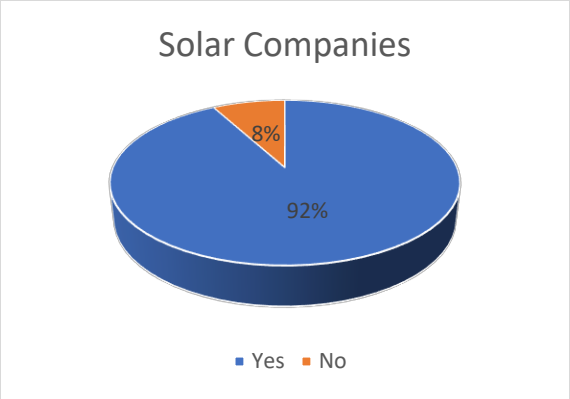

Figure 4:12 showing the percentage of solar companies that assessed whether lighting systems were safe for customers.

Source: Author's field survey, 2021.

From Figure 4:12 above, it is indicated that 92% of the solar companies assessed the safety of their customers with their solar systems while 8% did not assess whether the solar systems are safe to the users assuming that the initial training on usage

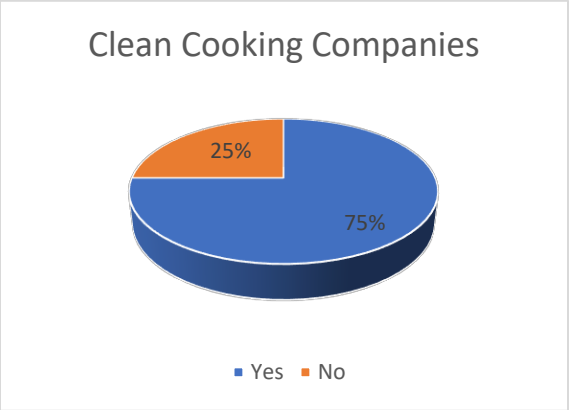

Figure 4:13 shows the percentage of clean energy companies that assessed whether their cooking fuels were safe for customers

Source: Author's field survey, 2021.

Figure 4:13 above shows that 75% of the clean cooking companies assessed whether their cooking fuels and technologies were safe. In comparison, 25% of the clean cooking companies, primarily those delt in cooking stoves and charcoal briquettes, did not assess whether their fuels and technologies are safe to customers.

Furthermore, the survey revealed that the clean energy companies that assessed the safety of their customers took pictures of the lighting systems and cooking places using smartphones. The study investigated the relevancy of safety data from customers to energy companies, and 100% of the energy companies consented that the information was crucial for planning and avoided legal suits related to accidents. More respondents argued that the information guides change and gives way for improvement, and ensures customers' safety.

However, respondents noted challenges in collecting data related to safety, and the challenges were the same as those mentioned in capturing data about other attributes.

4.5 Incentives for private energy companies to report Using the Multi-tier Framework

- Make easy-to-use digital applications. The study revealed that easy-to-use digital applications are the ideal incentive for private energy companies. The multi-tier framework is based on comprehensive data from the field that is captured from customers. Easy to use digital applications can be used to capture the data from the area. These digital tools must be developed with all components of the MTF.

- Moreover, the digital applications must be online and offline support to ease work. One respondent said, '*you see, digital tools can motivate us to capture the multi-dimensional data in the field. Our reports would be easy to make because the tool can be automated to produce a report anytime. But this issue of going with papers and fill them in from the field is time-consuming and can delay us and lose customers. Digital tools can be of excellent benefit to us as a company to track our growth as well as the impact in the communities we serve'* (*Interviewed* on 9th September 2021).

- Funding. The study revealed that most private energy companies did not have enough funds to support all the activities they needed. The respondents cited high taxes the government charged them and bad debtors arising from non-cash transactions. The effects of the Covid-19 pandemic worsened this as it affected customers' income flows, and they were unable to pay the stipulated installments. Moreover, 100% of the surveyed energy companies have not reached the take-off stage implying that they were still struggling financially and could not collect comprehensive data to report using the Multi-tier Framework. Funding was

identified as a critical boost to the activities of the private energy companies so that they can operate at the desired level and reach the last mile customers.

- Technical support. Most surveyed companies lacked specialized data analysts who would be pertinent in reporting based on the multi-tier framework. The idea of using the MTF was seen to call for technical experts that can collect comprehensive data, analyze it and produce sounding reports that would inform policymaking and guide company growth. However, most companies had electrical engineers, accountants, and administrators, and only three private energy companies had data officers. Moreover, the data officers handled just minor and not complex data. There is a need to have technical support in the form of Human resource training that can pave the way for comprehensive data collection and reporting based on the MTF. One respondent said, '*I think we can use that advanced framework if we were trained. It seems a very good one, but we do not have much knowledge on it and maybe the ability to have all the required data* (Interviewed on 16th September 2021).

- Sensitize customers to share information. At least 80% of the surveyed private energy companies showed the willingness to collect comprehensive data that captures the quality, safety, availability, and other attributes of the MTF. However, it was made clear that most customers were not willing to share data easily. For example, data related to income levels, education standards, ownership of assets was cited to be the hardest to get as most customers were skeptical at sharing such information. In contrast, others exaggerated the data or lied. Yet this data is ideal in determining one's ability to pay for a system or product. The respondents proposed a broad national sensitization of all people to share more data with field officers from energy companies. Impact reporting can be made comprehensively based on the multi-tier framework, which would inform policy formulation to curb the energy poverty challenge. In the same way, better interventions would be reached to move a specific group of clients from lower tiers of the MTF to higher tiers based on the impact reports.

4.6 The impacts of detailed data on the clean energy companies.

- Impact analysis becomes easy. Respondents emphasized that detailed data would make broad, comprehensive, and straightforward impact analyses. A company would know how best it has moved a particular group of people from one tier of energy access.

- Products are designed based on customer needs. Data collection through customer surveys helps energy companies to customize systems that fit customer needs, increasing customer satisfaction and full energy access. Surveys enhance feedback which is ideal in making customer-centered systems and products.

- Companies will supply good quality products. Feedback on quality will enhance quality and standards in products. The clean energy companies will work hard to reach the quality the customers need hence improving quality which is an attribute of the Multi-Tier Framework.

- Increase Customer safety. The surveys gather data about the safety of customers concerning the systems and cooking fuels. The prerequisite of ensuring that customers are safe by ensuring that electric systems are safely installed and cooking technologies are correctly installed.

- Track our customers efficiently. Detailed data provides comprehensive customer data, which makes customer tracking easy. Most solar energy companies offer solar systems on installment-based payment, requiring companies to have good customer data and important information such as the client's name, location, telephone numbers, and others.

- Gain confidence from funders. Comprehensive impact data increases the chances of winning funding opportunities. One respondent is quoted, *funders are interested in the impact we make with their funds. I think presenting a comprehensive report would increase chances of more funding'* (*Interviewed* on 26th August 2021).

The arguments from respondents conquers with (Mudaliar et al., 2017) who argues that impact measurement increases financial strengths and aids in risk measurement factors which investors are very interested in.

- Understand market dynamics well—the detailed energy data guides in marketing decisions. The company identifies the regions of significant influence and sales and other exceptional dynamics related to gender, age, and further planning details.

- Guide in setting sales targets. Detailed energy access data can be good guidance in setting future sales targets. Generated data produces a deep analysis that guides the company on the future targets and expectations—moreover, all other decisions are based on the same data.

- Enhance partnerships with research organizations. Detailed energy access data can lead to collaborations with research organizations. The energy company will provide data for studies that are a ground for policy-making and guide investment decisions.

CHAPTER FIVE

5 CONCLUSIONS, RECOMMENDATIONS, AND SUMMARY

5.1 Introduction

This final chapter presents the conclusion, recommendations based on the presentations, facts, and results from the previous chapters. The chapter analyzes the results to see if they meet the study's objectives and offers a conclusion and recommendations based on the results.

5.2 Conclusion.

Energy access is increasing in Uganda, although slowly compared to the targets set out in SDG7 by 2030. The study included analyzing the existing frameworks for measuring energy access. As argued by (ESMAP, 2017), the binary lens offers limited knowledge of the challenge of energy poverty. However, the Multi-Tier Framework proves more comprehensive and a better tool for reporting and tracking energy access progress. The MTF based impact reports would guide energy planning, investment, and policymaking towards increasing energy access in Uganda. The researcher identified the challenges and ways forward for using the Multi-tier Framework initiated by the Energy Sector Management Assistance Program to measure and track progress towards increasing energy access in Uganda.

The researcher concentrated on the private, clean energy companies in Uganda. He used the purposive sampling technique to identify critical clean energy companies in Uganda's energy business and selected twelve solar companies and eight clean cooking companies. Based on the findings from the study, one can recognize the need to have detailed energy data from all citizens to understand the energy poverty challenge adequately. Moreover, the energy data from government agencies in the generation, transmission, and distribution of electricity and clean cooking technologies is insufficient. It must be supplemented by energy data from private, clean energy companies. The problem of energy access is complex yet needs an urgent address. It, therefore, calls for both government and private players to join hands in addressing it. The application of the multi-tier framework gathers almost all customer energy data based on the seven attributes of the multi-tier framework with corresponding tiers, which offers the undoubted energy access status of citizens in a particular location. However, the results indicate a severe challenge in collecting data from customers mainly characterized by individuals who are unwilling to share

information yet measuring energy access is based on detailed information from citizens. There is an imminent need to raise awareness in the population to share all details of their economic, social, and energy statuses to these committed energy companies so that planning can be made easy to achieve energy access for all. However, data collection by private, clean energy companies is an expensive venture requiring funding or subsidization from the government and other partners. The results show that detailed customer-centric data offers clean energy companies an advantage to easily measure their impact, plan, set company targets, and identify locations where they have more customers. Therefore, clean energy companies must be empowered to collect customer-centric data easily to enjoy the above benefits and avail data to the government to track the national energy access level easily.

5.3 Recommendations.

Following the survey results, the following recommendations are proposed as a way forward to proper policy-making and application of the Multi-Tier Framework for reporting and tracking energy access.

Policymaking should start with proper problem identification and measurement, which must be data-based. Comprehensive data leads to better problem identification and helps develop an ideal solution to the problem. Moreover, the implementation/solution is guided by problem-focused data, leading to better results, as illustrated in the figure below.

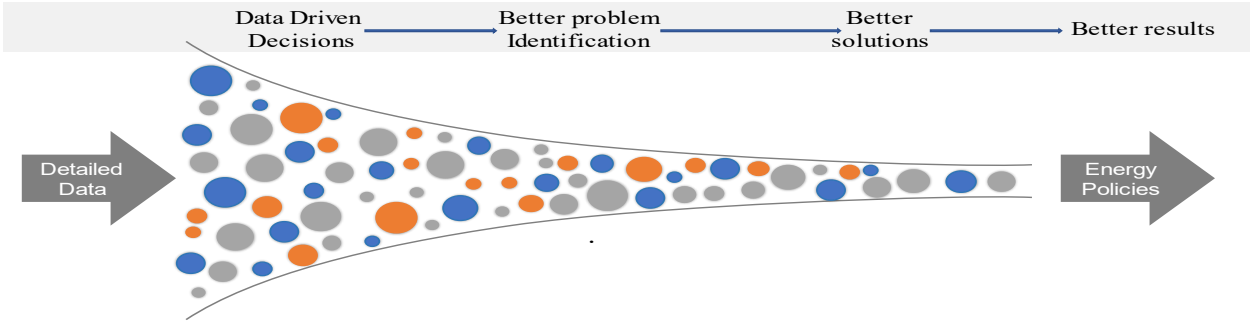

Figure 4:14 shows an illustration of the data-based policy making model.

Source: Author's creation, 2021.

Government should popularize the use of the Multi-tier Framework as the new and more comprehensive framework for measuring energy access. The survey revealed that most clean energy companies did not know anything about the Multi-Tier Framework. Yet, it is an ideal framework that has been piloted in Rwanda, Ethiopia, and other energy-poor countries. The benefits of reporting impact based on the Multi-Tier Framework have been evident in the pilot countries. Uganda will benefit if both energy providers in Uganda use the framework. The government should utilize the framework to gather comprehensive data about our citizens and plan accordingly quickly.

Enact strict regulation on supply of energy products and technologies to only registered and certified clean energy companies. The rules would reduce the sale and distribution of sub-standard solar products on the market in Uganda. Based on the Multi-Tier Framework attributes, consumers must have good quality products to achieve a specific tier. Banning the sale of such poor-quality products would empower legal private, clean energy companies to enjoy a free market while supplying products of standard and quality. We would achieve access to affordable, good quality, and sustainable energy for all.

Government should support private, clean energy companies to collect data so that they can be better informed of the gaps and challenges within the energy sector. According to the results of the study, support should be in form of funding, specialized trainings and experts so that private energy companies can dedicate to data collection and reporting to government for better planning. To achieve this, the government should enroll a national awareness program about the need for citizens to share all data required by field and sales officers from clean energy companies. The collected data would go to the central processing hub hence generating appropriate figures and statistics of energy access levels from each area, the technologies in use, and capacity from time to time. The detailed information would guide policymakers and implementers in closing the identified energy poverty gap.

5.4 Summary.

The study identified the challenges and ease of using the Multi-tier Framework for reporting/measuring energy access. It focused on the possibility of the private, clean energy companies using MTF for reporting as energy players. The study was subdivided into five chapters, and the first chapter was the general introduction of the research and a quick overview of the challenge.

The second chapter detailed the existing literature about the Multi-Tier Framework as a proposed framework for reporting energy access. It also presented a detailed account of other frameworks that different organizations and scholars proposed.

The third chapter presented the researcher's methodology to find the solution to the investigated problem. The chapter also gave an account of Uganda's energy situation and the actors in the energy sector.

The fourth chapter presented the results of the study. Highlighted survey results carried out among 20 private, clean energy companies in Uganda. The responses on the challenges clean energy companies faced in collecting detailed customer-centric data highlighted the benefits of data. Moreover, the same chapter provided an interpretation of the results backed by literature and the researcher's analysis.

The last chapter presented the conclusion and recommendations concerning the previous chapter's results.

5.4 Possibilities for further research

- Studies on an integrated framework that combines multi-Tier framework and other frameworks
- The economic applicability of the Multi-Tier Framework for better and cheaper tracking of energy access.

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7 Appendices.

Appendix A. Data from survey

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	SubmissionDate		meta_end	meta_dev	meta_use	generatec	company_	company_	company_	company_	company_	company_	company_	company_	company_	energy_q	energy_q	energy_q	energy_q	energy_q	energ
2	2021-09-3	2021-09-3	2021-09-3	odk-centr	username	not found	solar	Engie Ene	12	Kampala c	Solar	60	380	65	41	household consump		performance benchr		paper_quesrion	
3	2021-09-3	2021-09-3	2021-09-3	odk-centr	username	not found	cooking	Total Ener	66	Kampala	LPG	70	500	46	41	satisfaction details		performance registr		receipt	
4	2021-09-3	2021-09-3	2021-09-3	odk-centr	username	not found	cooking	Wana Ene	13	Entebbe	LPG	4	14	57	40	household satisfacti		performance benchr		own_app	receip
5	2021-09-2	2021-09-2	2021-09-2	odk-centr	username	not found	solar	BrightLife	6	uganda	Solar	9	101	90	40	household demand		registration		own_app	receip
6	2021-09-2	2021-09-2	2021-09-2	odk-centr	username	not found	solar	Irrisol Eng	4	Kasese	Solar	2	13	12	5	household consump		performance benchr		receipt ot	Ask cu
7	2021-09-1	2021-09-1	2021-09-1	odk-centr	username	not found	solar	All in trad	11	Kampala	Water	1	27	40	10	household	Feedback	benchmarking regist		paper_qu	Verba
8	2021-09-0	2021-09-0	2021-09-0	odk-centr	username	not found	solar	Equatorial	3	Kampala,	Solar mini	0	35	90	30	household consump		other	Determin	own_app	
9	2021-09-0	2021-09-0	2021-09-0	odk-centr	username	not found	solar	Ruhiira wa	10	Isingiro	Solar	2	15	60	13	consumption deman		registratic	Foresee d	receipt ot	Ledge
10	2021-09-0	2021-09-0	2021-09-0	odk-centr	username	not found	solar	SolarNow	10	Kampala-I	Solar proc	5	500	60	40	consumption deman		performance benchr		paper_quesrion	
11	2021-09-0	2021-09-0	2021-09-0	odk-centr	username	not found	cooking	Weye clea	4	Mukono	Charcoal	2	14	100	25	consumpt	Abillity to	performar	Planning,	paper_qu	Talk t
12	2021-08-3	2021-08-3	2021-08-3	odk-centr	username	not found	solar	SolarNow	6	Kampala	All solar p	5	500	60	40	consumption willing		registration		paper_quesrion	
13	2021-08-2	2021-08-2	2021-08-2	odk-centr	username	not found	cooking	Ndenje Ur	6	Ndenje	Briquettes	1	6	100	20	satisfaction details		benchmarking regist		receipt	
14	2021-08-2	2021-08-2	2021-08-2	odk-centr	username	not found	solar	Bright life	3	Kampala	Solar pane	14	61	88	30	details ot	Location,	registratic	Keep trac	own_app	
15	2021-08-1	2021-08-1	2021-08-1	odk-centr	username	not found	cooking	Eco stove	9	Mengo	Stoves	2	49	72	61	household consump		satisfactic	Marketing	receipt ot	Order
16	2021-08-1	2021-08-1	2021-08-1	odk-centr	username	not found	cooking	Josa Gree	6	Nansana k	Briquette	2	26	69	38	other	Location,	performar	Follow up	own_app	Custo
17	2021-08-1	2021-08-1	2021-08-1	odk-centr	username	not found	cooking	BM energ	8	Jomayi Na	Metal fabi	3	107	85	20	consumption satisfa		other	House hol	paper_quesrion	
18	2021-08-1	2021-08-1	2021-08-1	odk-centr	username	not found	solar	Village En	13	Kiwatule	Solar	3	22	29	41	household	Ability to	performar	To learn a	own_app	Data c
19	2021-08-1	2021-08-1	2021-08-1	odk-centr	username	not found	solar	Anuel ene	6	Kyanja	Paygo,no	1	12	78	56	household	Customer	performar	To determ	own_app	receip
20	2021-08-1	2021-08-1	2021-08-1	odk-centr	username	not found	cooking	Green Bio	9	Mukono	Briquette	2	35	80	40	household	Expenditu	benchmar	Beat com	paper_quesrion	
21	2021-08-0	2021-08-0	2021-08-0	odk-centr	username	not found	solar	Powertrus	11	Ntimba	Solar	2	15	90	20	household	How systems are perfoming, expetetions,				

	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	A
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	esrionnair	fisrt purchase		planning willingness		household consump		skeptical	time_cons	yes	yes	subsidy		yes	external i	management investi		monthly		yes	yes
		purchase		targets impact		satisfaction details		other	We get cu	yes	yes	subsidy ot	Favourabl	yes	internal	management investi		yearly		no	no
	receipt	fisrt purchase		planning willingness		consumption satisfa		skeptical	distances t	yes	yes	funding subsidy		yes	external i	management investi		6_months		yes	yes
	receipt	fisrt purchase	install	planning willingness		household satisfacti		distances	time_cons	yes	yes	funding subsidy		yes	internal	management investi		monthly		no	yes
	Ask custo	fisrt always		planning willingness		consumption satisfa		skeptical	distances t	yes	yes	funding subsidy		yes	external i	management applic		other	Everytime	yes	no
	Verbal	always ot	Prior to sy	planning targets imp		consumption		skeptical	expensive	yes	yes	funding subsidy		yes	internal	application		other	Daily and	yes	no
		other	During the	willingness ability in		consumption deman		skeptical	expensive	yes	yes	funding subsidy ana		yes	external i	management investi		6_months		yes	yes
	Ledger ca	always		planning willingness		household		expensive	distances	yes	yes	funding		yes	none			yearly		no	no
	esrionnair	fisrt purchase	maint	planning willingness		consumption deman		skeptical	restriction	yes	yes	analysis		yes	external i	management investi		monthly		yes	yes
	Talk to cu	fisrt other	When we	planning targets abil		consumption willing		skeptical		yes	yes	funding su	Grants, dc	yes	external i	management investi		6_months		yes	yes
	esrionnair	fisrt purchase		planning impact		consumption willing		skeptical	distances r	yes	yes	analysis		yes	spi extern	management investi		monthly		no	yes
		purchase		targets impact feedb		consumption satisfa		distances	staff restri	yes	yes	funding subsidy		yes	internal	management donor		yearly		no	no
		fisrt other	At the tim	willingnes	Assess the	willingnes	Affordabil	skeptical	Customer	yes	yes	funding su	Share with	yes	external i	managem	REA	other	Everyday,	yes	yes
	Order for	fisrt purchase	install	targets ability feedb		details		skeptical	Language	yes	yes	funding subsidy		yes	external i	management donor		monthly		yes	yes
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	esrionnair	purchase	Once in a	planning \	How effici	satisfactic	Sales mad	skeptical	Always ha	yes	not_sure	funding su	Especially	yes	external i	management investi		yearly		yes	no
	Data colle	other	Monthly	planning a	Improve s	consumption		skeptical	Areas are	yes	yes	funding		yes	external i	management investi		monthly		yes	yes
	receipt	fisrt purch	For PagGo	planning \	Investor r	satisfaction		skeptical	Sensitivity	yes	yes	funding su	Gadgets, t	yes	external i	management investi		other	Collected	yes	yes
	esrionnair	fisrt purchase	install	willingness targets i		consumption details		expensive	Some data	yes	yes	analysis		yes	external i	management donor		other	Everytime	yes	yes
	,									yes	yes	analysis o	Dependin	yes	gogla	management investi		6_months		yes	yes

reporting-	reporting-	reporting-	mtf-know	mtf-know	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford
yes	impact		no	Not sure	income	ability	willin	yes			no	skeptical		no	skeptical		no	skeptical		yes
no			no	I dont kno	other	We donot		no	other	We are nc	no	other	Not intere	no	other	Not releva	no	other	Not releva	no
yes	financial		yes	used to m	income	willingness		yes			no	skeptical		no	skeptical		no	skeptical		no
yes	household	impact	no		income	ability	willin	yes			yes			no	other	not impor	yes			yes
no			no	World bar	income	ak	Backgrour	yes			no	skeptical		no	skeptical		no	skeptical		no
no			no	Not realy	income	ability	willin	yes			yes			no	skeptical		no	skeptical		no
yes	household	impact	no		ability	willingness		yes			yes			yes			yes			yes
no			no	Not realy	income	ability	willin	yes			no	skeptical		yes			yes			yes
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yes	household		yes	Too gener	income	willingness		no	other	Donot nee	yes			no	other	Not releva	yes			no
yes	financial	impact	no		income	guarantor		yes			yes			no	unreliable		yes			no
no			yes	Tool for M	income	ak	Number o	no	other	We donot	no	expensive		no	expensive		no	skeptical	expensive	no
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mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-afford	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-qualit	mtf-q
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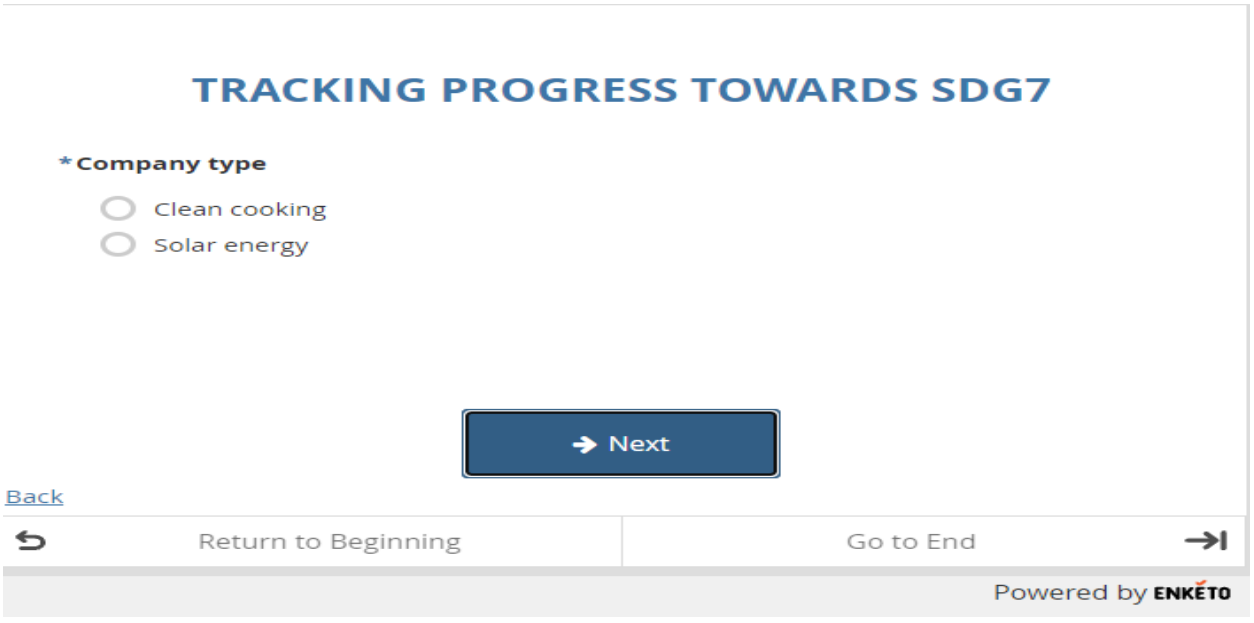
6.2 Appendix B Survey Questionnaire for Clean Energy Companies



TRACKING PROGRESS TOWARDS SDG7

Company details

* A1- Company name

* A2- Years of existence

* A3- Location of the company

* A4- Products you deal in

s

* A5- Number of branches that the company has

---

* A6- Number of employees

* A7- Percentage of youth employees (less than 30 years old)

Between 0 and 100

* A7- Percentage of women employees

Between 0 and 100

Next

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TRACKING PROGRESS TOWARDS SDG7

Energy Data Questions

*** B1 - What type of data do you collect from customers?**

Click all that apply

- [ ] Household data
- [ ] Energy consumption data
- [ ] Customer satisfaction
- [ ] Future Energy demand
- [ ] Willingness to pay
- [ ] Customer details(Personal/Gender data)
- [ ] Others
- [ ] We do not collect customers data

» Data Collection

*** B2- If you collect any household data, why do you do it ?**

Click all that apply

- [ ] Assess periodical performance
- [ ] Benchmarking purposes
- [ ] Customer Registration
- [ ] Accountability
- [ ] Customer Satisfaction survey

- [ ] Impact Reporting
- [ ] Legaal Purchase Contract
- [ ] Financial Viability Survey
- [ ] Guarantee Contract
- [ ] Other reason

*** B3- How do you collect data?**

Click all that apply

- [ ] Digital: Own App
- [ ] Questionaire
- [ ] Receipt
- [ ] Accountability/Sales App
- [ ] Collect App
- [ ] Other
- [ ] No, we do not collect this type of data

*** B4- When do you collect data?**

Click all that apply

- [ ] At the first visit
- [ ] During the purchase of the product
- [ ] When installing the product
- [ ] Maintenance visit
- [ ] Any time
- [ ] Others

*** B5- How useful is this data to your company?**

Click all that apply

- [ ] Data guides planning
- [ ] Data help to determine the customers willingness to pay
- [ ] Data helps to set sales targets
- [ ] Used to determine the customer's ability to pay
- [ ] helps in measuring the project impact
- [ ] Gathers customer feedback
- [ ] Discover areas of improvement
- [ ] Understand customer preferences
- [ ] Data guide changes
- [ ] Other
- [ ] No, it is not relevant to my work

*** B6- What type of client information is most relevant to transforming your business and the quality of products?**

Click all that apply

- [ ] Household data
- [ ] Energy consumption data
- [ ] Customer satisfaction
- [ ] Future Energy demand
- [ ] Willingness to pay
- [ ] Customer details(Personal/Gender data)
- [ ] Others

- [ ] We do not collect customers data

*** B7- What challenges do you experience while collecting data?**

Click all that apply

- [ ] Some customers are skeptical about sharing information
- [ ] Expensive to collect data
- [ ] Movement of long distances in different regions
- [ ] Time consuming
- [ ] Data collection requires many staff
- [ ] Restrictions in movement due to COVID-19
- [ ] Data from surveys unreliable over time
- [ ] Customers do not know the specific information and/or are not aware of product specifications and performance
- [ ] Others : Specify

Next

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Return to Beginning | Go to End

TRACKING PROGRESS TOWARDS SDG7

Impact Reporting

***C1-In your view, would you say it is important for clean energy companies to assess the impact in their communities?**

- ○ Yes
- ○ No

***C2- Do you think it is relevant for companies to report and share about the impact their products and services have had in the community/country to a third party (e.g., government, researchers)?**

- ○ Yes
- ○ No
- ○ Not sure

***C3- Under what conditions would you consider this arrangement?**

Click all that apply

- ☐ Funding
- ☐ Subsidy
- ☐ Share analysed data
- ☐ Others Specify

* **C4- Do you think it is relevant for companies to report about the impact their products and services have had in the community/country?**

- ○ Yes
- ○ No

* **C4- Do you use any of the following standard frameworks to report your impact?**

Click all that apply

- ☐ GOGLA
- ☐ ESMAP-Multi Tier Framework
- ☐ Poverty Probability Index
- ☐ Social Performance Index
- ☐ IRIS+ (GIIN)
- ☐ SMART (client Protection)
- ☐ External KPIs from a funding partner
- ☐ Internal KPIs
- ☐ No we don't report the impact assessment

* **C5- To whom are the results of the impact assessment reported to?**

Click all that apply

- ☐ Company Management
- ☐ Investor
- ☐ Donor
- ☐ Government
- ☐ Application for Financing

☐ Others Specify

*** C6- How often do you carry out the Impact surveys or any other data collection method you use?**

Click all that apply

- ○ Monthly
- ○ Quarterly
- ○ Every 6 months
- ○ Yearly
- ○ Others: specifiy

*** C7- Have you customized the questions in your data collection tool/survey to suit the demands of your funders or supporters?**

- ○ Yes
- ○ No

*** C8- Have you always had to adjust the way you collect data depending on the type of donor or investor you work with?**

- ○ Yes
- ○ No

→ Next

TRACKING PROGRESS TOWARDS SDG7

MTF Reporting Framework

D- Do you know about the Multi-Tier Framework of the World Bank for measuring/tracking energy access?

- ○ Yes
- ○ No

→ Next

MTF Reporting Framework

D- If yes, what do you know about it? Please specify

→ Next

» Affordability

D1-What influences your decision on determining whether a customer can be included in the installment-based payment system?

Click all that apply

- [ ] Customer's income level
- [ ] Ability to pay
- [ ] Willingness to pay
- [ ] Employment status
- [ ] Guarantor
- [ ] Referral from other customers
- [ ] Energy consumption data
- [ ] Other

D2a-Are you able to collect data about the household status (Rented or Owned)?

- ○ Yes
- ○ No

D2b-Are you able to collect data about income status of the customer?

- ○ Yes
- ○ No

D2c-Are you able to collect the highest level of education data?

- ○ Yes
- ○ No

* **D2d-Are you able to collect data about the household income status?**

- ○ Yes
- ○ No

* **D2e-Do you collect data about the occupation data?**

- ○ Yes
- ○ No

* **D3- Do you think it is relevant to know this type of information about your customer aside from the location?**

- ○ Yes
- ○ No

* **D4- What challenges do you face in collecting customer data?**

Click all that apply

- ☐ Some customers are skeptical about sharing information
- ☐ Expensive to collect data
- ☐ Movement of long distances in different regions
- ☐ Time consuming
- ☐ Data collection requires many staff
- ☐ Restrictions in movement due to COVID-19
- ☐ Data from surveys unreliable over time
- ☐ Customers do not know the specific information and/or are not aware of product specifications and performance
- ☐ Others : Specify

D5 - How do you think the above information can be collected efficiently from th customers?

Click all that apply

- ☐ Use digital tools (on smartphone, tablets, or laptop)
- ☐ Hire additonal technical support
- ☐ Incentivize customers to provide information
- ☐ Other

→ Next

» Quality and Availability

D6 - Do you collect data on the number of hours your customers have electricity per day or evening?

Click all that apply

- ○ Yes
- ○ No

D7 - What challenges do you face in collecting this type of data?

- ☐ Some customers are skeptical about sharing information
- ☐ Expensive to collect data
- ☐ Movement of long distances in different regions
- ☐ Time consuming
- ☐ Data collection requires many staff
- ☐ Restrictions in movement due to COVID-19
- ☐ Data from surveys unreliable over time
- ☐ Customers do not know the specific information and/or are not aware of product specifications and performance
- ☐ Others : Specify

D8 - What challenges do customers face during interruptions in the service?

Click all that apply

D8b - If a customer has electricity, do you further determine whether the power is stable or not?

Click all that apply

- ○ Yes
- ○ No

D9 - How do you make sure customers have the right voltage all the time?

* **D10 - Is there any form of assistance that can be given to enable you to collect this type of data?**

- ☐ Digital tools
- ☐ Smart mobile phones/laptops
- ☐ Technical support in form of human resources
- ☐ IT support
- ☐ Incentive
- ☐ Others (to specify)

→ Next

MTF Reporting Framework

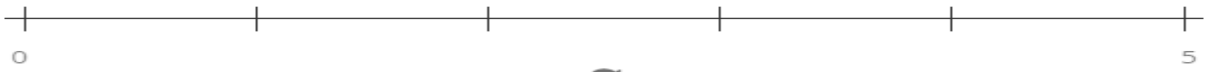
» Efficiency

* **D11- Do you collect data on the type of bulb/technology that is previously used by your customer?**

- ○ Yes
- ○ No

* **D13-How relevant is this information in determining the type of product or service you render?**

Please rank from 0: no relevant at all, to 5: extremely relevant



* **D14 - How do you think the process can be simplified to enable you to collect this type of data?**

- ☐ Digital tools
- ☐ Smart mobile phones/laptops
- ☐ Technical support in form of human resources
- ☐ IT support
- ☐ Incentive
- ☐ Others (to specify)

→ Next

» Safety

D15 - Do you assess whether the existing lighting or power system for the customer is safe?

- ○ Yes
- ○ No

D16- How do you collect images of the lighting or power system?

Click all that apply

- ☐ We use the app
- ☐ Store image in the phone
- ☐ No we don't collect this type of data
- ☐ Others (to specify)

D17- Have you assessed whether the type of system that your customers have has safely been constructed and protection measures such as grounding taken?

- ○ Yes
- ○ No

D18-Do you think this kind of data is relevant to the work that you do and the company in general?

- ○ Yes
- ○ No

D20- What challenges have you faced in collecting this type of data?

- ☐ Some customers are skeptical about sharing information
- ☐ Expensive to collect data
- ☐ Movement of long distances in different regions
- ☐ Time consuming
- ☐ Data collection requires many staff
- ☐ Restrictions in movement due to COVID-19
- ☐ Data from surveys unreliable over time
- ☐ Customers do not know the specific information and/or are not aware of product specifications and performance
- ☐ Others : Specify

→ Next

Usge of HEDERA App

E1- What has been your experience using HEDERA ODK collect App?

- ○ Bad
- ◉ Somewhat good
- ○ Good
- ○ Very good
- ○ Excellent
- ○ I did not use the app

E2- What challenges have you faced in using the app right from inception till the point you started using it?

Click all that apply

- ☑ Too many questions
- ☐ Disruptions during use
- ☐ Offline features functionality
- ☐ Update of the app
- ☐ A lot of commitment needed
- ☐ Other

E3- Does the app help you to be more productive?

Please indicate a number between 0 (=iit did not help at all) and 5 (=it helped a lot to be more productive)

E4- Suggest any further improvement on how the Hedera ODK collect App can ease your work?

→ Next

Incentives

F1- In light of all the challenges that have been discussed what do you think will make it easier for you to collect this kind of data?

Click all that apply

- [ ] Make easy to use Apps
- [ ] Raise awareness among customers to share information freely
- [ ] Get funding for survey implementation
- [ ] Technical support in form of personnel for data collection
- [ ] Other

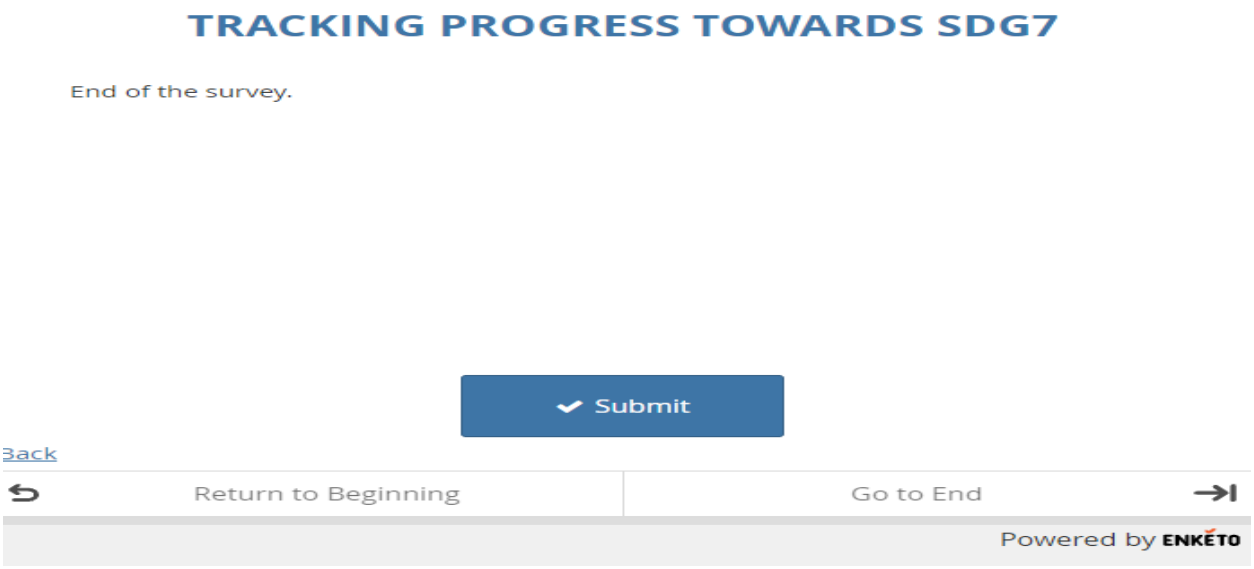
F2- How do you think the performance of your company will change when you collect this type of information?

Click all that apply

- [ ] Impact analysis will be easy
- [ ] Products will be customer-based
- [ ] Timely feedback from customers
- [ ] Good quality products
- [ ] Relationship with customers will increase
- [ ] Other

F3- How do you usually take strategic decisions at your company?

Next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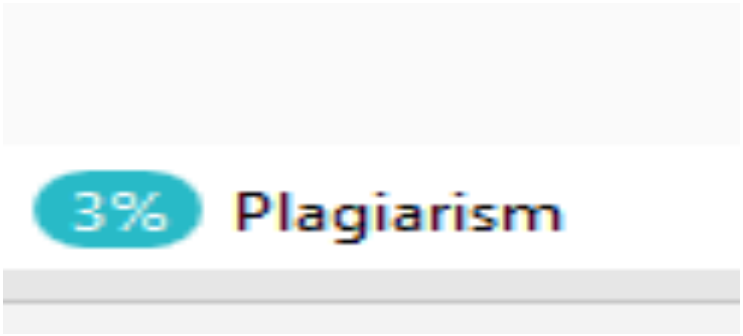
Appendix C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