AN EVALUATION OF HUMAN DEVELOPMENT THROUGH RENEWABLE ENERGY PROVISION IN AN OFFGRID TSUMKWE SETTLEMENT AREA OF OTJOZONDJUPA REGION IN NAMIBIA

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ABSTRACT

Provision of electricity in rural areas enhances the achievement of economic and social development objectives. A photovoltaic mini-grid in the Tsumkwe Settlement Area of Namibia was established to enhance human and community development in the sparsely populated rural areas of Namibia to alleviate poverty. The impact that the mini-grid has had on the target beneficiaries has not been fully quantified and qualified. This study evaluated, and documents such impacts, thus facilitating the motivation for replication on a wider scale. Quantitative data on the community's perception of energy access and energy poverty was collected through questionnaires administered to 47 household heads in Tsumkwe Settlement Area. In-depth social perceptions on the use of electricity from the mini-grid photovoltaic plant were evaluated through interviews with thirteen key informants, focus group discussions and direct observations. It was established that there is a significant relationship between provision of adequate modern energy services and enhancement of human development opportunities. The provision of electricity has contributed to the improvement in the quality of life of Tsumkwe community members as evidenced by good health, increased small businesses, and decreased crime rates. Replication of such systems countrywide is strongly recommended in order to increase the number of available working hours after sunset, and access to information, thus addressing some of the social and economic needs of the rural population in Namibia.

Key words: human development, photovoltaic plant, modern energy services, renewable energy.

LIST OF CONFERENCE PRESENTATIONS

Chiguvare, T.M., Matsa, M.M, & Kimaro, M.E. (2018). Enhancement of human development initiatives through renewable energy provision in Tsumkwe, Namibia. International Geographical Union - Namibia conference 17-18 May 2018-Windhoek Namibia.

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LIST OF ABBREVIATIONS AND ACCRONYMS

ADB	Asia Development Bank
ATM	Automated Teller Machine
CENORED	Central North Regional Electricity Distributor
DRC	Democratic Republic of Congo
DRFN	Desert Research Foundation of Namibia
ESMAP	Energy Sector Management Assistance Program
GEF	Global Environmental Facility
GRN	Government of the Republic of Namibia
HPP	Harambee Prosperity Plan
IEA	International Energy Agency
IED	International Energy Development
kV	kilo Volt
kWh	Kilo watt hour
kWp	kilowatt peak
LDC	Less Developed Countries
LPG	Liquefied Petroleum Gas
MET	Ministry of Environment and Tourism
MGECW	Ministry of Gender Equality and Child Welfare
MTF	Multi-Tier Framework
MWAF	Ministry of Water, Agriculture and Forestry

NAMREP Namibia Renewable Energy Programme

NDP National Development Plan

NSA Namibia Statistics Agency

OGEMP Off-grid Energisation Master Plan

OTRC Otjozondjupa Regional Council

PV Photovoltaic

PwC Price Waterhouse Coopers

REDMP Rural Electricity Distribution Master Plan

REN21 Renewable Energy Policy Network for the 21st Century

RERA Regional Electricity Regulators Association of Southern Africa

RE Renewable Energy

RETs Renewable Energy Technologies

SDGs Sustainable Development Goals

TB Tuberculosis

UNDP United Nations Development Program

WEO World Energy Organisation

WHO World Health Organisation

WPEP White Paper on Energy Policy

Definition of key terms

Human development: A process of enlarging people's freedom and opportunities and improving their well-being. Human development is about the real freedom ordinary people have to decide who to be, what to do and how to live.

Photovoltaic mini-grid: A power station that generates electrical power by using photovoltaic cells; usually such as a power plant feeds electricity straight to the consumers.

Modern energy services: The inclusion of access to electricity for the provision of clean water, sanitation and healthcare and for the provision of reliable and efficient lighting, heating, food, clean cooking facilities (e.g., fuels and stoves that do not cause air pollution), transport, and telecommunication service.

Renewable energy: Energy produced from sources that do not deplete or can be replenished within a human's life time. The most common examples include wind, solar, geothermal, and hydropower.

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DEDICATION

I dedicate this dissertation to my husband Zivayi, and children Dananai, Tadiwa Nashe and Tomupeishe for their overwhelming support.

DECLARATION

I, Theodora Mutauro Chiguvare, hereby declare that "An Evaluation of Human Development through Renewable Energy Provision in an Off-grid Tsumkwe Settlement Area of Otjozondjupa Region in Namibia", is a true reflection of my work, and that all the sources used have been acknowledged in the text and the bibliography. The version of this work is an original work, and has not previously been submitted or in part for the degree at any other university.

Signature_____ Date: _____

1. CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

Electrification helps to achieve economic and social development objectives, be it in the rural or in urban areas. It provides lighting, refrigeration and appliance power that would be difficult to replace with other forms of energy. It is estimated that 1.4 billion people – 20% of the global population – lack access to electricity, and that a further 1 billion lack reliable access. Some 2.7 billion people, constituting 40% of the global population, rely on traditional use of biomass for cooking (IEA, 2015; Morrisey 2017). Although these statistics are well known to many already engaged in the energy aspect of the development agenda, they serve as a relevant reminder of the scale of the challenge. Lack of access to modern energy services is most prominent in emerging economies and developing countries, although issues of energy access and energy poverty are evident throughout the world. IEA (2015) and World Bank (2015) add that despite efforts to provide electricity over the last few decades in several Sub-Saharan African countries, most of the population remains unconnected. Pachauri and Rao, (2017, p 6), assert that 'geographic expanse and population density play a part'. The United States of America embarked on electrification from the early 1970s to late 1990s, and it took them 25 years to increase access from 20 %-80 % (Pachauri and Rao, 2017). The same was for China with a similar geographical area but larger population size, where it took 19 years to cover the same percentage. The population density of Namibia is less than 3 persons per square kilometre, making it

unfeasible to economically connect everyone (Namibia Statistics Agency, 2011; Ministry of Mines and Energy (REDMP), 2005, and Ministry of Mines and Energy (OGEMP), 2007). This could explain the slow rate of rural electrification and why development of activities related to modern energy services and technologies lag behind.

It is estimated that globally 70% of the rural population lack modern energy access as opposed to 30% of urban populations (World Energy Outlook, 2016; PwC global power utility, 2016). Two thirds of the global population lacking electricity access are located in Sub-Saharan Africa and South Asia. The region with the lowest electrification level is Sub-Saharan Africa, where only 11% of the rural population has access to electricity (Pachauri, 2017; and Brew-Hammond, 2014). The majority of the world's energy poor are living in Asia and the Pacific. More than 700 million people in the region do not have access to electricity and almost two billion people burn wood, dung, and crop waste to cook and heat their homes (Asian Development Bank, 2017).

The World Energy Outlook Report, (2016) states that China, with a total population of 1.39 billion people as of 2014, achieved universal electrification by 2015. India with a population of 1.27 billion people in 2014, still had 244 million people without access, and it is expected that this will have reduced to 56 million people by 2030. In North Africa more than 99% of the total population has access to electricity (Africa Energy Outlook, 2014).

Sub-Saharan Africa has more people living without access to electricity than any other world region. 633 million people did not have access to electricity in Sub-Saharan Africa as of 2014, but the number is expected reduce to 619 million people by 2030 – a reduction by only 14 million. About 145 million people gained access to electricity since the year

2000, where the leading countries were Nigeria, Ethiopia, South Africa, Ghana, Cameroon and Mozambique (IEA, World Energy Outlook, 2016). This resulted in a 9% improvement in energy access in Sub-Saharan Africa from year 2000 at 23% to 32% in 2012. In the other 37 Sub-Saharan countries the number of people living without electricity, however, actually increased by almost 100 million people during the same period (IEA, 2015; World Energy Outlook, 2016).

Namibia has made progress in her effort to increase the percentage of the population with access to modern energy services: In 1998 the Government of Namibia formulated the White Paper on Energy Policy (WPEP, 1998) through the Energy Policy Committee of the Ministry of Mines and Energy. The WPEP 1998 has six specific national energy objectives namely: effective governance, security of supply, social upliftment, investment growth, economic competiveness, and efficiency and sustainability. The WPEP recognises that the Namibian economy is energy intensive due to mining, and due to its inefficient use in households. The Policy Paper also wants to promote the use of energy efficient appliances and renewable energy technologies. However, WPEP has not been passed in parliament, so stakeholders in the energy industry do what befits them to maximise profit and may forget the welfare of the larger population in the rural areas, which makes up 57% of the Namibian population (Namibia Statistics Agency, 2011).

The Off Grid Energisation Master Plan (OGEMP, 2007) aimed to provide access to appropriate energy technologies to everyone living or working in the off grid areas. The OGEMP was initiated by the United Nations Development Programme and the Global Environment Facility (UNDP/GEF) and Ministry of Mines and Energy. Prior to this was

the Rural Electrification Development Master Plan (REDMP, 2005, p. 11), which defined access to energy as 'when one is located 500 m from Low Voltage transformer and whether you are connected or not to electricity supply is considered as access to electricity'. So far two off-grid photovoltaic (PV) mini-grids have been commissioned in Namibia: one each in Tsumkwe and Gam districts of the Otjozondjupa Region. Several containerized PV power plants have also been commissioned to power rural government institutions throughout the country.

Various studies were done in Asia, Europe and Africa and Africa South of the Sahara. In Asia studies were done in India by Ravindranath, (2004) and Hiremath 2009 indicate that India has a number of relatively successful off-grid energy studies. Case study of Salepada Power Plant in Kerala about 40 000 households benefitted from electricity generated from solar PV mini-grid 35 000 from SHS. Africa, South of the Sahara has had studies assessing energy provision programs but most of the focused on Solar Home Systems (SHS). Wamukonya and Davis, 2001 on Namibia, focused on socio-economic impacts of rural electrification using SHS, Gustavsson, 2007 also has an analysis of SHS use in Zambia. These studies targeted the individual households and institutions like schools, hospitals and public facilities.

This study will assess energy provision in rural area of Namibia that is Tsumkwe Settlement Area which gets its power from a hybrid power plant and affording everyone the opportunity to use power for household and economic use.

Despite these solar electrification efforts many rural areas in need of modern energy remain untouched, and traditional fuels continue to be the norm for both lighting and cooking (Tsumkwe Energy, 2012 and DRFN, 2008). It is against this background that this thesis

evaluates how Renewable Energy Technologies (RETs) can alleviate energy poverty and enhance human development at household level in Tsumkwe Settlement Area.

1.2 PROBLEM STATEMENT

The provision of social services worldwide is not in line with the increase in global population, and this has led to various forms of poverty. Energy poverty is one of the dimensions which has slowed down, and in cases, impeded human and economic development. Energy poverty entails absence of choice to affordable, reliable, and safe energy services (Cecelski, 2000). Conventional energy sources like coal, petroleum, uranium (for nuclear power), and natural gas and hydropower, have failed to satisfy productive economic needs because of unsustainability. Except for hydro-power, most of these sources of energy are non-renewable. Alternative energy sources such as solar, wind, and wave and tidal energy, have been developed, but perceptions must still be changed for increased acceptance (Botelho, et al., 2016).

People in rural areas may not be able to engage fully in various social and economic activities because of energy poverty, which the International Energy Agency (IEA) defines as lack of access to modern energy services like electricity and clean cooking facilities (IEA, 2015).,

In 2007 the Government of Namibia initiated the Off Grid Electrification Master Plan (OGEMP) whose main objective was to provide access to appropriate energy technologies to everyone living or working in off-grid, pre-grid and grey areas.

Although the Tsumkwe mini-grid was established to alleviate energy poverty and enhance human and development in the sparsely populated rural areas of Namibia, the real impact that such a mini-grid has had on the target beneficiaries has not been quantified and qualified, thus making it difficult to motivate for replication on a wide scale.

Renewable energy provision projects have been implemented for rural households but the benefits to human development have not been sufficiently assessed to adequately inform future interventions or policy making. Thus the impact of rural electrification on human development remains veiled in obscurity. It is in view of this gap in knowledge that this study evaluates the contribution of a renewable energy provision project in Tsumkwe Settlement Area to human development.

1.3 AIMS AND OBJECTIVES OF THE STUDY

1.3.1 Aim

The aim of the study is to evaluate the impact of renewable energy provision on human development in Tsumkwe Settlement area, for possible replication in similar settlements throughout the country.

1.3.2 Specific objectives

Specific objectives include:

- To evaluate the extent to which electricity provided to Tsumkwe Settlement Area, through a photovoltaic off-grid mini-grid, satisfies the definition of energy access;

- To determine the impact of solar energy usage on household and community energy poverty; and
- To assess the benefits of solar energy to the community of Tsumkwe Settlement Area in terms of human, economic and social development.

1.3.3 Hypotheses

H_0: There is no significant relationship between the provision of adequate modern energy services, and the enhancement of human development.

H_1: There is a significant relationship between provision of adequate modern energy services, and enhancement of human development.

1.4 SIGNIFICANCE OF THE STUDY

The field of the study is Applied Geography, and the study is expected to contribute in confirming that provision of affordable and sustainable energy services can help to holistically solve the problem of inadequacy of human development. Electricity can be a driver of human development, but there is limited research linking increased supply of renewable energy based technologies to energy poverty alleviation in rural areas. Such linkages are important for technical experts so that program design and implementation can be in line with community needs. The study will contribute to the body of knowledge by providing the definition of energy access and energy poverty in the context of rural Namibia. Findings are needed that enhance and introduce knowledge and education programs, along with development of syllabi for energy studies particularly in Namibia.

Findings from this study can also be used by development practitioners to come up with sustainable livelihoods programs aimed at transforming the quality of lifestyles of the people living in rural areas through the provision of off-grid photovoltaic energy. Policy makers will use quantitative and qualitative data as evidence to support recommendations on sound possible actions for solving fundamental issues relating to sustainable frameworks on energy and renewable energy policies and sustainable environmental policies relevant to Namibia. The communities and not only of Tsumkwe Settlement Area but other communities where such a project will be replicated, where quality of life is enhance through the provision of RE and provide people with appropriate technology which can help to expand their opportunities. The academia will appreciate the appropriate meaning of energy access and energy poverty in the context of Namibia. This will be a tool in building knowledge.

1.5 LIMITATION OF THE STUDY

Language was a limitation, therefore trained research assistants proficient in the local language assisted in data collection.

1.6 DELIMITATION OF THE STUDY

The research focused on the evaluation of the impact of the utilisation of electricity in the rural area of Tsumkwe in Otjozondjupa Region. This study sought to establish if energy poverty has been alleviated, and whether renewable energy technologies (PV) have helped in the provision of productive energy to the community of Tsumkwe, and towards

improvement of their quality of life. The study did not include households which were not directly served by the Tsumkwe power plant.

1.7 DESCRIPTION OF STUDY AREA: TSUMKWE SETTLEMENT AREA

1.7.1 Physical Description of the Study Area

Tsumkwe Settlement Area is located in the Otjozondjupa Region, north-eastern Namibia, about 300 km east of Grootfontein and 735 km from Windhoek (Figure 1.1). The geographical coordinates are 19˚36′ 0˚ South, 20˚ 30′ 0˚ East. Tsumkwe's altitude is 1000 -1200 metres above sea level, and is situated about 300km east of Grootfontein, and 735km from Windhoek. It had a population of 3 800 individuals when the mini-grid was considered (Tsumkwe Energy, 2008). In total there were about 250 households and homesteads within the settlement. The majority of the population are San. Additionally, the vast majority of surrounding villages are San of the Ju/'hoansi tribe, relying on Tsumkwe Settlement for social services such as education, medical care and law enforcement. The San are widely considered to be the most marginalized and vulnerable tribal group in Namibia. Tsumkwe is also home to members of various other Namibian ethnic groups such as the Ovambo, Ovaherero Damara/Nama Kavango, and Zambezi tribes (Ashton, Bisacky, Boyd, and Lopez, 2012).

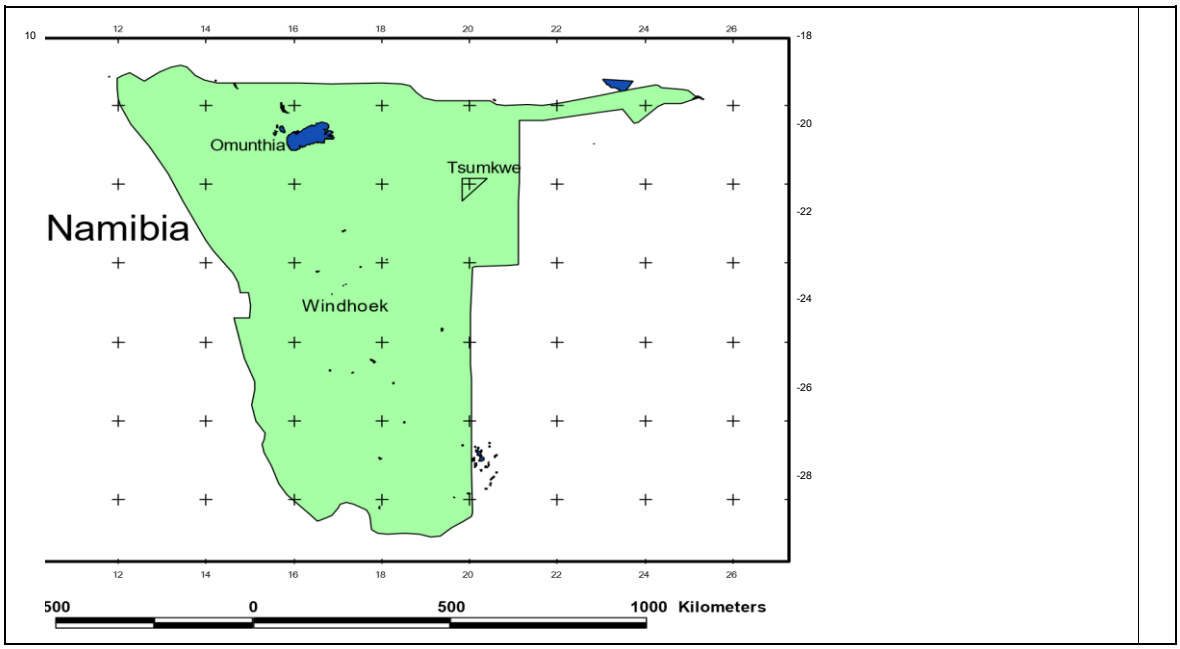


Figure 1.1 Map of Namibia showing the location of the Study Area - Tsumkwe.

The area is characterised by physical features which have in one way or the other resulted in the lagging behind in infrastructural development in the specific area and the welfare of the people and its surroundings. Its geology is part of the Kalahari group and mostly consists of the Namib sands. The Tsumkwe Settlement Area is located on a cusp between dominant dystric regosols infertile soil with low base saturation and petric calcisols which remain hard even when wet. This leads to low scale agricultural production, and the government assists 80% of Tsumkwe Settlement Area residents through the San Feeding Program. In addition to this, the infertile soils have resulted in stunted tree growth and dense bush savanna. The bush is not ideal for firewood, making it difficult to source wood fuel Consulting Services Africa, Baseline Study, 2005Government of the Republic of

Namibia (GRN), Tsumkwe Constituency, 2011).

The average annual temperature for the region is 20 - 22˚C, with maximum temperatures ranging between 32 and 34˚C. The warmest month of the year is November with an average temperature of 25.3˚C and July has the lowest average temperature of 14.8˚C (Mendelson, 2002).

Humidity is low, and low rainfall with the area normally experiencing 40-45 days of rain annually. Despite this, the incoming solar radiation of this area still remains high, with more than 300 cloudless skies (Solar Atlas for Namibia, 2002). Average annual rainfall is approximately 450 mm. Rainfall in the area is restricted to the summer and early autumn months, December to April. The driest month is June with 0 mm of rainfall. Most precipitation falls in January with an average of 132 mm (Consulting Services Africa Baseline Study, 2005). The soils in this area do not support commercial agriculture, so this is done on subsistence basis. According to Barker, (2012), this has led the majority of the San people to rely on external assistance for subsistence.

1.7.2 Socio-Economic Description of the Study Area

Tsumkwe Settlement Area was established in 1972 as a military post prior to Namibia's Independence in the area formerly known as Bushmanland. The South African military introduced basic infrastructure in Tsumkwe of which the most notable is a medium voltage mini-grid supplied with electricity from diesel generators and provided energy to the government institutions.

The Namibian government has established schools, a clinic, police station and other essential services in Tsumkwe Settlement Area. Tsumkwe Settlement Area also serves as a supply outpost, providing basic goods and services to the surrounding 37 villages within the conservancy and the constituency at large including areas like the Mangetti Duin area. (Hays, Thiem and Jones, 2014), and to travelers passing through on their way to or from Grootfontein.

The Otjozondjupa Regional Council (OTRC) assumed political control of Tsumkwe after the establishment of the Regional Government of Namibia in 2003 and continued to use the mini-grid as Tsumkwe Settlement Area's primary source of electricity. The OTRC maintained, managed, and operated the electricity production system. However, due to the high cost of diesel fuel, electricity supply was limited to 12 – 14 hours per day, and in addition most residents of Tsumkwe Settlement Area could not afford the cost reflective tariff of N$ 6.00 per kWh for electricity. The OTRC heavily subsidized the tariff, only charging residents N$ 0.52 per kWh and institutions to pay N$ 2.50 per kWh. This made the electricity affordable to many of the poverty stricken Tsumkwe residents, however the subsidized tariff resulted in an annual deficit of N$ 1.2 million to the OTRC (Tsumkwe Energy, 2012).

1.7.3 Electrical Infrastructure

In 2006, the Tsumkwe Settlement was identified as the site for a proposed solar-diesel hybrid energy plant, at the time the largest of its kind in southern Africa. The closest electricity grid access point is 300 kilometers away, and the settlement was not scheduled for grid electrification within 20 years (Off grid Energisation Master Plan, 2007). In order

to minimize the dependency on diesel for electricity generation and ensure uninterrupted and stable power supply, the Tsumkwe Energy Project established a 202 kWp solar PV array with 766 kWh battery storage capacity (Tsumkwe Energy, 2012. Furthermore the project repaired, up-graded and expanded the current 11 kV mini-grid and initiated mechanisms for access to alternative thermal fuels (such as LPG) and energy efficient appliances Desert Research Foundation ACP-EU Energy Facility, (2006). The Tsumkwe Energy project took place in the Otjozondjupa Region of Namibia from 2008-2012.

Tsumkwe is Namibia's largest off-grid settlement and home to the indigenous minority of Namibia's San community. The objective was to facilitate the supply of electricity through a solar-diesel hybrid energy source. Prior to the project, the electricity supply network was weak and caused frequent power interruptions and damage to electrical appliances, which interrupted water supply and other essential services to the settlement (Eisenbach, Hanlon, and Ingalls, 2009).

In 2012, Tsumkwe Settlement Area had about 700 permanent residents and functioned as a service provider to the greater 3,000 member San community from surrounding areas. Namibia's largest solar PV-diesel hybrid system with generators, PV system, inverters and batteries, was inaugurated in Tsumkwe Settlement Area in January 2012. The system would provide the community with access to 24 hour electricity, which would also improve the water supply situation. Over 36 new streetlights were installed and the electricity supply network was expanded with an additional 60 households connected to the mini-grid. More than 700 energy efficient lights were distributed since 2010 to selected residents. Also, a prototype solar charging kiosk was installed for charging electrical lanterns and mobile

phones for those residents that were not connected to the central mini-grid (Ashton, Bisacky, Boyd and Lopez, 2012; Baker, Brown, Morlath and Wang, 2011).

The direct beneficiaries were over 100 households, 20 different institutions and several small businesses. Tsumkwe Energy not only implemented technical improvements, but also investigated what additional economic opportunities that could be pursued under improved energy supply conditions. This was a vital strategy to ensure that Tsumkwe Settlement Area can reach a level of economic prosperity that will support the financial sustainability of the hybrid system (Desert Research Foundation ACP-EU Energy Facility, 2006). For this reason a sustained social behavior change component was implemented.

There are several small businesses including a tourist lodge, two small general dealers, several beer outlets, and a craft centre. In the town there is also a school, police station, Namibian Broadcasting Corporation (NBC) station, a NamPost Branch and a Community Development Centre, administrative offices for the Government of Namibia and NonGovernmental Organisations (NGOs) (Desert Research Foundation ACP-EU Energy Facility, 2006).

In 2007, the government initiated craft making to alleviate poverty in, and in surrounding areas of Tsumkwe Settlement Area, and the Ju/'hoansi are extensively involved in craft making. This has contributed immensely to the income they earn for a living (Ashton et al, 2012). Besides craft making they were given draught animals to give them the opportunity

to learn about agriculture to substitute food initially obtained through hunting and gathering.

Some of the largest employers in Tsumkwe are the government organisations, which include Ministry of Transport and Works, Ministry of Water, Agriculture and Forestry, Ministry of Environment and Tourism and the Ministry of Gender Equality and Child Welfare. The government institutions have employed a number of the previously disadvantaged San through the Affirmative Action drive. However other ethnic groups are also employed in the public sector.

1.8 THESIS OUTLINE

Chapter one introduces study. It has given a brief background, objectives of the study and justification. It also provided the description of the study area, and the circumstances around the establishment of the hybrid photovoltaic – diesel electricity mini-grid. Chapter two presents energy use in the Namibian context and reviews literature on solar energy use and how it enhances human development. Chapter three of the thesis presents the methodology and research tools used in the study. Subsequently, Chapter four presents the results, and analysis of the findings, which are discussed in Chapter five. Chapter six presents the conclusions drawn and recommendations for further action.

2. CHAPTER TWO: LITERATURE REVIEW

Chapter one has presented a brief introduction to the energy situation worldwide and in Namibia. Chapter two will present the theoretical approach that will be used and how energy access through renewable energy technologies will address energy poverty and enhance livelihood styles and human development.

2.1 THEORETICAL FRAMEWORK: CAPABILITY APPROACH

The Capabilities Approach (Sen, 1992; Nussbaum, 1993) is an evaluative approach, useful in the evaluation of set standards for energy access and energy poverty, as well as attributes of human development. The Capabilities Approach proposes the use of two linked concepts: functionings and capabilities, which relate to individuals. Functionings are defined as beings and doings (Sen, 1992). These include being in good health, and activities such as doing work. Capabilities are the actual or real opportunities to realise given functionings, whether one chooses to at any particular time or not (Sen 1993). Promoting capabilities maximises opportunities, but leaves the individual free to decide what kind of life they value. Development programmes should thus be aiming to increase the capabilities of individuals, and should be evaluated in these terms (Day, Walker, 2016). The main aim of development initiatives is to expand capabilities and their choices in life. Human development is indicated by availability of freedom of choice and opportunities, and it facilitates the production and distribution of commodities, the expansion, and utilisation of human capabilities (UNDP Human Development Report,
2018).

"The approach is essentially a 'people-centred' approach, which puts human agency (rather than organizations such as markets or governments) at the centre of the stage. The crucial role of social opportunities is to expand the realm of human agency and freedom, both as an end in itself and as a means of further expansion of freedom. The word 'social' in the expression 'social opportunity' is a useful reminder not to view individuals and their opportunities in isolated terms. The options that a person has, depend greatly on relations with others and on what the state and other institutions do. We shall be particularly concerned with those opportunities that are strongly influenced by social circumstances and public policy" (Drèze & Sen, 2002). Day et al, (2016) maintains that the framework provides a much more comprehensive understanding of the ways in which energy services are connected to socio economic development, well-being, and the quality of life. According to Anand, Hunter and Smith (2005), the 'Capability' Approach thus focuses more on people and less on goods. In the approach resources do not have an intrinsic value; instead their value derives from the opportunity that they give to people.

The capability approach is a broad normative framework for the evaluation of individual well-being and social arrangements, the design of policies and proposals about social change in society. The capability approach is used in a wide range of fields, most prominently in development thinking, welfare economics, social policy and political philosophy. It can be used to evaluate a wide variety of aspects of people's well-being, such as individual well-being, inequality and poverty. It can also be used as an alternative evaluative tool for social cost-benefit analysis, or to design and evaluate policies, ranging from welfare state design in affluent societies, to development policies by governments and non-governmental organisations (NGOs) in developing countries (Robeyns, 2003).

In this particular study the Capabilities Approach is going to be used to help evaluate the community wellbeing of the community of Tsumkwe Settlement and ascertain if there has been any social change within the Tsumkwe Settlement. By reflecting what people are able to be and do which are their capabilities different stakeholders can use them in the development policies which can make visible difference in future projects relating to RE provision.

2.2 THE CAPABILITY APPROACH AND ENERGY POVERTY

The Capability Approach is often used in relation to defining poverty. The Capabilities Approach as mentioned by Sen (1993) is on opportunities, i.e., capabilities that a person is given and freedom to realize them, if one wishes to do so. Poverty is defined as the deprivation of capabilities. Since the focus is on capabilities this approach provides a multidimensional view on poverty, (Day, Walker & Simcock, 2016). Day et al 2016 developed a model in which they conceptualize energy poverty within the Capability Approach, they divided the achieving of well- being into different levels and examining the relationship between each of the levels. The basic capabilities if realized are the ultimate stage of the approach. It starts with resources (for example different types of fuels), this is followed by energy supply (e.g. electricity and other forms of energy that can be consumed by the household), energy services (lighting and heating/cooking, etc., secondary capabilities (preparing food, reading, accessing the internet etc.) and the basic capabilities as mentioned (Day et al., 2016).

2.3 ENERGY ACCESS

2.3.1 Defining Energy access

Energy is inherently linked to economic and social development. Scaling up access to reliable and affordable modern energy services has proved an essential driver for sustainable economic growth in both industrialized countries and emerging economies (Morrisey, 2017). Brew-Hammond (2010) adds that is undeniable that access to modern energy services can significantly contribute to efforts to eradicate poverty; increase food security; provide access to clean water; improve public health; enhance education, and income generation.

Energy is fundamental to modern life, but 1.3 billion people around the world live without access to modern electricity (Morrisey, 2017). The current definition of modern energy access—100 kilowatt-hours per person per year—is insufficient and presents an ambition gap with profound implications for human welfare and national economic growth.

The Advisory Group on Energy and Climate Change—an intergovernmental body composed of representatives from businesses, the United Nations, and research institutes—divided energy access into incremental categories. The first category is basic human needs met with both electricity consumption of 50–100 kilowatt-hours (kWh) per person per year and 50 – 100 kilograms (kg) of oil equivalent or modern fuel per person per year (or the ownership of an improved cookstove). Second are productive uses such as access to mechanical energy for agriculture or irrigation, commercial energy, or liquid transport

fuels. Consumption here rises to 500–1,000 kWh per year plus 150 kg of oil equivalent. Third is modern needs which include the use of domestic appliances, cooling and space heating, hot and cold water, and private transportation which in aggregate result in the consumption of about 2,000 kWh per year and 250–450 kg of oil equivalent
(Sovacool, 2013).

Efforts to address energy poverty have focused on providing energy access. As with energy poverty, until recently there has been little agreement on how to define energy access beyond a general sentiment that it includes increasing households' access to sufficient quantities of energy while ensuring that they can avoid unnecessary risk or undue drudgery (Bhattacharyya, 2012). The vagueness of the term has not, however, diminished efforts to promote energy access. Given the myriad potential benefits mentioned above, it has been a mainstay of government policy in many countries.

Electricity has come to play a central role in the definition of energy access owing to its particular ability to provide an enormous array of energy services. As a consequence, efforts to promote energy access have often been reduced to a narrow focus on providing access to electricity. One result has been a binary view of energy access in which people are either "connected" or "not connected" (Practical Action, 2014). This narrow, binary approach belies the complexity of how people actually consume energy. To understand why, it may be necessary consider if a household that is connected to a source of electricity so unreliable that it has access to energy services for only four hours a day, can be said to have access. One may also imagine a household that has access to electricity but is unable

to afford to pay for a poor indicator of whether they have access to the energy they need to avoid the deprivations, risks, and injustices associated with energy poverty.

Table 2.1**:** Multi-tier matrix of energy access

Attributes of energy supply		**Tier 0**	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 4**	**Tier 5**
Capacity	Household electricity	No electricity	Very low power	Low power	Medium power	High power	
	Household cooking	Inadequate capacity of the primary cooking solutions				Adequate capacity of the primary cooking solutions	
Duration and availability	Household electricity	< 4 hours	4-8 hours		8-16 hours	16-22 hours	>22 hours
	Household cooking	Inadequate availability of primary cooking solution				Adequate availability of primary cooking solution	
Reliability	Household electricity	Unreliable energy supply				Reliable energy supply	
Quality	Household electricity/ cooking	Poor quality energy supply			Good quality of energy supply		
Affordability	Household electricity	Unaffordable energy supply			Affordable energy supply		
	Household cooking	Unaffordable energy supply			Affordable energy supply		
Legality	Household electricity	Illegal energy supply			Legal energy supply		
Convenience	Household cooking	Time and effort spent sourcing energy cause inconveniences			Time and effort spent sourcing energy do not cause inconveniences		
Health and safety	Household electricity	Unhealthy and unsafe energy system				Health and safe energy system	
	Household cooking	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**

Source: World Bank (ESMAP), 2016

There has been a recent push to develop more comprehensive measures of energy access that capture the multidimensional and multi-tiered nature of the term, to address the afore mentioned. Measures of energy access now include tiered considerations of the energy's (1) capacity, (2) duration and availability, (3) reliability, (4) quality, (5) affordability, (6) legality, (7) convenience, and (8) health and safety (Table 2.1). For each category, the energy source is broken down into energy for household electricity and energy for household cooking (World Bank Group, 2012).

Despite this more comprehensive approach, imperatives to see people rise above the most basic level of access, and to create energy access goals against which progress can be measured, have driven a push back towards a binary definition, whereby some tier within the energy access matrix is considered the basic threshold for "energy access."

2.3.2 Energy access - a rural problem in developing countries

According to IEA, (2011) and Morrisey, (2017), 1.3 billion people in the world did not have access to electricity while 2.7 billion people do not have access to clean cooking energies. Further, energy access is predominantly a rural problem. 1.1 out of 1.3 billion, (or 85%) people lacking electricity access, worldwide, are found in rural areas. Huge challenges to developmental projects in rural areas may still be present due to almost 40% of the global population still lacking access to clean cooking energies. More than 2.2

billion out of 2.7 billion (or 81%) lacking clean cooking energy access reside in rural areas (IEA, 2011).

This problem, is acute in low income countries in general and in Sub-Saharan Africa in particular. UNDP-WHO (2009) indicated that 87% and 89% of rural population of LDC and SS-Africa lack access to electricity respectively. Similarly, 97% and 95% of rural population of Less Developed Countries (LDC) and Sub Saharan-Africa lack access to clean cooking energies in 2008 (UNDP-WHO, 2009; Bhatacharyya, 2012). Similarly, more than 2.2 billion (out of 2.7 billion or 81%) lacking clean cooking energy access reside in rural areas (IEA, 2011). The access problem has a distinct regional dimension – Sub-Saharan Africa and Developing Asia are two distinct regions where the problem is acute. 630 million people in Sub-Saharan Africa lack access to electricity while 675 million in Developing Asia face the same problem (IEA, 2011).

Similarly, 653 million people in Sub-Saharan African and 1.9 billion in Developing Asia do not have access to clean cooking energies. Near 100% electrification in China has significantly improved the electricity access figure in Developing Asia but the cooking energy challenge persists. The regional averages also mask the severity of the problem faced by many countries. For example, 97% of population of Burundi, Liberia and Chad, 95% of Rwanda, Central African Republic and Sierra Leone lacked electricity access in 2008 (UNDP-WHO, 2009). 83% of Kenya's population and 93% of Ethiopia's population do not have access to cooking energy (IEA, 2011).

2.3.3 Energy access in Namibia

Namibia is characterized by sharp disparities in terms of energy access between urban and rural areas. Although access to modern energy services is not a key issue, imports of oil products and above electricity may put under pressure poor urban people with limited access to energy services due to the financial constraint (Von Oertzen, 2016). Lack of access to modern energy services (rural electrification only 25 %) remains a key issue for rural areas. This constraint is compounded by the financial barrier.

Namibia still relies heavily on traditional biomass for cooking and space heating. Despite being the driest country in Southern Africa, Namibia nonetheless produces considerable woody biomass on its total land area (Von Oertzen, 2016). According to the 2009 IEA energy balance, biofuels and waste account for 13 % of the total final consumption.

However for the household sector, biofuels, particularly in rural areas, are the main source for cooking and space heating. With respect to cooking and space heating, there is still a great disparity between urban and rural areas. In the latter, traditional biomass remains the main fuel for cooking and space heating. 90% of rural households use firewood for cooking, 34 % LPG, nine % paraffin, and eight % electricity. However the share of LPG might be over-estimated in quantitative terms as 40 % of households use multiple fuels with biomass as a dominant fuel. Approximately 80% of firewood users in rural areas gather it themselves. In 63% of rural households women and children are responsible for the collection of firewood. Approximately 12, 000 tons of charcoal is produced annually in

Namibia, much of which is exported. The use of charcoal and charcoal briquettes is almost totally limited to urban areas (Von Oertzen, 2016).

Namibia is still characterized by a great disparity between urban and rural areas. The electrification rate for urban households is estimated at 70%, whereas for rural households, it has reached 25 % in 2011 (National Statistics Agency, 2011).

2.4 EFFORTS TOWARDS RURAL ELECTRIFICATION IN NAMIBIA

Efforts have been done and are still being made to make sure that rural areas of Namibia have access to electricity which is sustainable, affordable and reliable. Since 1998 the Ministry of Mines and energy have come up with programmes and policies to address energy access in rural areas. In 1998 the Ministry of Mines and Energy drafted the White Paper on the Energy Policy of Namibia. Its main seven goals were effective governance, security supply, social upliftment, investment and growth, economic competitiveness and efficiency and sustainability.

In order to achieve sustainability the government will promote the use of renewable energy through the establishment of an adequate institutional and planning framework, the development of human resources and public awareness and suitable financing systems. It also seeks to meet development challenges through improved access to renewable energy sources, particularly in rural electrification, rural water supply and solar housing and water heating.

The Ministry had the Rural Electrification Distribution Master Plan (2005) and was reviewed in 2010. This aimed to systematically electrify rural localities which included government buildings, schools and homesteads. This was to be achieved through improved access to renewable energy sources.

The *Off-Grid Energisation Master Plan for Namibia (OGEMP)* (2007), was one of several projects that were initiated by the UNDP/GEF/MME Barrier Removal to Namibian Renewable Energy Programme (NAMREP). The underlying objective of the OGEMP was to provide access to appropriate energy technologies to everyone living or working in off-grid, pre-grid and "grey" areas.

The following are definitions of off-grid, pre-grid, and grey areas as used in the OGEMP:

- **Off-grid areas** are those areas that, according to the REDMP, will not have access to electricity within 20 years.

- **Pre-grid areas**, as defined in the REDMP, are those areas that would not have access to electricity within 5 years. However, the OGEMP only focused on providing access to Pre-grid areas that would not have access to electricity within 10 years in the updated REDMP GIS database.

- **Grey areas** are locations where it is not clear in the 2005 REDMP how or if access to electricity will be provided. Examples of grey areas include 1) informal settlements, where the majority of the inhabitants either do not have access to

electricity or clearly cannot afford it, and 2) farm worker settlements on commercial farms – although the farm owner may have access to electricity, the farm worker families most often do not.

The OGEMP was to focus on providing informal settlements with access to energy. The government of Namibia is also signatory to various international and regional conventions which advocates for use of sustainable energy carriers and sources. These include the Sustainable Development Goals which supports Agenda 2030 which strives to address the causes of poverty and unite everyone to come together and make a positive change for both people and planet. Besides the 2030 Agenda, African countries, implemented the African Union Agenda 2063 which support Agenda 2030. Most African countries have taken steps to translate Agenda 2063 and 2030 into tangible outcomes for their people. Namibia has the National Development Plans (NDP) from NDP1 now it is at National
Development Plan 5 whose general strives to make Namibia an industrialised country by 2030, and the Harambee Prosperity Plan (HPP), (2016), which aims to attain effective governance, economic advancement, social progression, international relations and cooperation and infrastructure development which includes energy infrastructure among others. All these ambitions are fulfilled if the country has access to reliable, affordable and sustainable energy and a framework which addresses energy issues.

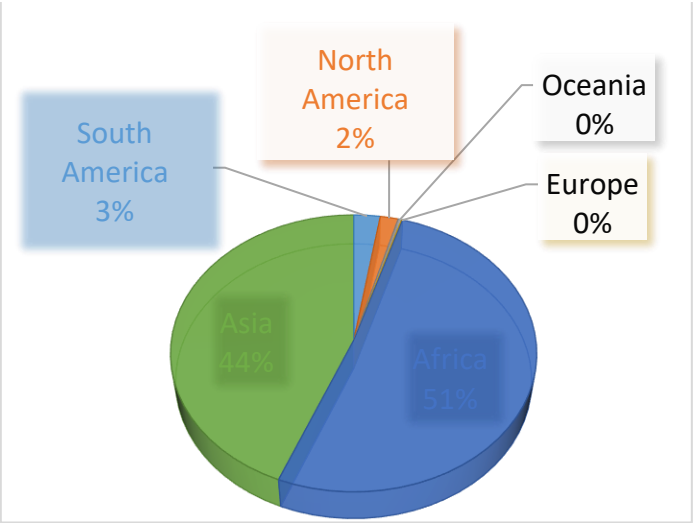
In 2017, the country of Namibia through the Ministry of Mines and Energy had the Energy Policy and Renewable Energy Policy passed in Parliament. This has shown how serious the country is in energy provision and towards fulfilling SDGs such and SDG 7 which aims to ensure access to affordable, reliable, sustainable and modern energy for all, which will

also translate to other sustainable development goals like SDG1 on poverty; SDG3 on good health and well-being; SDG4 on quality education; SDG5 on gender equality; and SDG13 on climate action.

2.4.1 Poverty

Poverty is the most fundamental reality of developing countries. Poverty refers to an individual's (or family's) lack of access—associated primarily with inadequate income—to basic human needs such as food, shelter, fuel, clothing, safe water, sanitation, health care, and education. Poverty is manifested as the inability to achieve a minimum standard of what is needed for material well-being. Human poverty also entails the denial of opportunities and choices most vital to human development—including a long, healthy, creative life, a decent standard of living, dignity, self-esteem, the respect of others, and the things that people value in life (Human Development Report, 2018).

The global incidence of extreme poverty has gone down from almost 100% in the 19th century, to 10.7% in 2013. While this is a great achievement, there is absolutely no reason to be complacent: a poverty rate of 10.7% means a total poverty headcount of 746 million people (World Bank, 2016). Africa is the continent with the largest number of people living in extreme poverty. The breakdown by continent is as shown in Figure 2.1.



WORLD POPULATION LIVING IN POVERTY

383 Million in Africa

327 Million in Asia

19 Million in South America

13 Million in North America

2.5 Million in Oceania

0.7 Million in Europe

Figure 2.1: World population living in poverty. Source: Author, using data from Morrissey, (2017).

In Asia, India is the country with the largest number of people living in extreme poverty (218 million people), in Africa it is Nigeria, followed by Congo (DRC) with 86, and 55 million people, respectively.

In 1990, Asia was the world region with the largest number of poor people (505 million in South Asia, plus 966 million in East Asia and the Pacific). However, with rapid economic growth in Asia over the past two decades, poverty in Asia fell more rapidly than in Africa. Thus poverty has remained a global issue, despite changes in development paradigms in the first half of the 20th century, the promise to bring well-being remained unfulfilled (Roser and Ortiz-Ospina, 2017).

2.4.2 Energy Poverty

The term "energy poverty" has no formally agreed definition. Usually, the term focuses on household energy use, such as energy for cooking, lighting, and heating. More recently, however, the notion of energy poverty has been expanded to include both the energy needed for small-scale commercial activity (such as energy needed to run appliances in a small business) and energy for services (such as street lights and health clinics) (Practical Action, 2014). Work on energy poverty usually excludes discussion of the energy provided by nutrition and the energy needed for transportation.

Energy poverty tends to be understood in two main ways. The first is the idea of energy poverty as the energy consumption habits of populations who are deemed poor by other measures, such as income (Khandker et al., 2010). The second idea is that energy poverty is itself a form of deprivation, so that energy poor populations are those that lack access to the energy required to meet their basic needs (Bhattacharyya, 2012; Khandker et al., 2010; Practical Action, 2014). In the latter case, the notion of energy poverty is also thought to account for the fact that many populations must expose themselves to undue risks (such as risks from pollution) or hardships (such as having to walk long distances and expend significant amounts of time collecting fuelwood) in order to meet their basic energy needs.

Energy services are a crucial input to the primary development challenge of providing adequate food, shelter, clothing, water, sanitation, medical care, schooling, and access to information. Thus energy is one dimension or determinant of poverty and development, but it is vital. Energy supports the provision of basic needs such as cooked food, a comfortable

living temperature, lighting, the use of appliances, piped water or sewerage, essential health care (refrigerated vaccines, emergency and intensive care), educational aids, communication (radio, television, electronic mail, the World Wide Web), and transport. Energy also fuels productive activities, including agriculture, commerce, manufacture, industry, and mining. Conversely, lack of access to energy contributes to poverty and deprivation and can contribute to economic decline.

The energy dimension of poverty - energy poverty - may be defined as the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe, and environmentally benign energy services to support economic and human development.

Energy poverty is defined by Modi et al., (2005, p.9) as the "inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset". Modi et al., definition clearly indicates people's willingness to cook their meals with modern cooking services but due to lack of it they cannot do so. It also refers to "absence of access to convenient, reliable, efficient and modern energy technologies to satisfy the basic needs that can support human and economic development" (Parajuli, 2011, p 6). They are without access to modern energy services defined as -household access to electricity and clean cooking facilities i.e. clean cooking fuels and stoves, advanced biomass cookstoves, and biogas systems (WEO, 2010) However, it was particularly silent on the issue of affordability and reliability and how sustainable the energy should. Energy sustainability here refers to energy produced and used in ways that support human development over the long term, in all its social, economic and environmental dimensions (Ottinger, and Zalcman, 2000). These concerns were addressed by Reddy (2000, p. 44), who defined Energy poverty as 'the absence of sufficient

choice that allows access to adequate energy services, affordable, reliable, effective and sustainable in environmental terms to support the economic and human development' (Reddy, 2000). With regards to above definitions a household is referred to as energy poor where supply of reliable and convenient source of energy is unavailable to carry out even the basic tasks (Parajuli, 2011).

Energy poverty also applies to households that rely heavily on biomass and who also depend on open fire and three-stone technology for cooking. In some other situation a household is described as energy poor if the income it spends on energy exceeds certain percentage of its total income after tax. In this regard income is the main determinant of whether a household is energy poor or not. In the United Kingdom for example government qualifiers fuel poverty households as any household spending more than 10% of income (after tax) on energy (Madden, Carmichael, Petrokofsky, and Murray, 2014).

From the definitions, energy poverty can be seen as an obstacle to economic development and socio-economic wellbeing of the people who experience it, but it is also associated with economic poverty. It concerns people that have low income, low energy consumption and no or limited access to modern energy services (Aguirre, 2014). Socio-economically, households that face energy poverty face problems that limit their opportunity to increase productivity, improve their living condition, fight poverty and enjoy life to the fullest. For these households, the day finishes much earlier than those with access to electricity and modern lighting facilities and must do almost all their economic activities during the day.

They spend precious hours grinding or pounding corn, wheat, millet, cassava, tomatoes, and pepper using stones or sticks (Birol, 2007). Sometimes they have to inconveniently travel several kilometres to towns where milling machines are available. They are unable to preserve food and essential medicines due to lack of electricity to power refrigeration equipment. Those appliances that they do have (e.g. radio and television) are powered by batteries, which eat up a large share of their incomes and time because they have to either constantly recharge or replace them when they cannot be recharged. The income generation efforts of the adults members of the household mostly women suffer as precious time is spent collecting firewood.

Thus the lack of access to modern energy services and use of charcoal and firewood turns to exacerbate the income loss and income inequality between and within households.

The UN 2030 Agenda for Sustainable Development adopted in September 2015 includes the goal to end global energy poverty by providing universal access to affordable, reliable, sustainable and modern energy for all. In the academic literature, rural electrification, defined as percentage of the rural population with access to electricity, has been found to be a crucial part of socio-economic development (Ahmed, and Munien, (2012). An increase in rural electrification is associated with higher youth literacy rates by upgrading in-school and domestic learning facilities (Kanagawa and Nakata, 2008). Furthermore, it has been found to enhance employment, especially among women (Dinkelman, 2011), enable additional agricultural and non-agricultural income generating activities, and advance rural productivity. Where complementary hard and soft infrastructure are present, access to

electricity is generally accepted to result in such positive health, education and income consequences (Elizinga, 2011).

Availing energy to rural communities provides numerous benefits towards development, through the provision of reliable and efficient lighting, heating, cooking, mechanical power, transport, and telecommunication services (Feron, 2016). Access to electricity can provide improved quality of life and economic welfare as productivity increases, with businesses substituting manual work with automated processes and thus leading to positive human development growth (Balachandra et al, 2015). Sustainable Development (SD) is not possible without sustainable energy, and this has been prioritized by devoting a stand-alone SD goal (No. 7) to sustainable energy, which aims at universal access to affordable, reliable and modern energy (United Nations Human Development Report,
2016).

2.4.3 Energy Poverty and Sub-Saharan Africa

Energy poverty presents a serious challenge in sub-Saharan Africa. Despite longstanding efforts to address energy poverty, in 2014, 633 million people lacked access to electricity and 792 million people relied on traditional biomass as their primary energy source for cooking (IEA, 2016). The result is drudgery, poisoning, fires, burns, limited economic opportunity, and premature death due to respiratory diseases.

Developing Asia contains the largest number of people without access to modern cooking facilities, while sub-Saharan Africa contains the largest number without access to

electricity. Sub-Saharan Africa is also home to the largest number of countries with the lowest rates of electrification, and has the highest rates of people forced to cook using traditional biomass, as shown in Table 2.2.

Table 2.2: Predicted changes in energy-poor populations in sub-Saharan Africa, 2014–2040

	2014	**2030**	**2040**
Number of people without access to electricity (millions)	633	619	489
Number of people reliant on traditional biomass for cooking (millions)	792	823	708

Morrissey, 2017

Asia is expected to see declines in the total number of people living in energy poverty, but in sub-Saharan Africa, population growth is outstripping the rate at which people are transitioning away from solid biomass for cooking.

Based on current trends, the number of people in sub-Saharan Africa who are forced to burn solid biomass in unimproved cook stoves is expected to rise to 823 million by 2030. Notably, however, recent efforts focusing on electrification are expected to drive down the number of people lacking electricity through to 2040.

2.5 ENERGY AND HUMAN DEVELOPMENT

2.5.1 Human Development

The term development is used here in the sense of sustainable development as defined in Our Common Future (Brundtland Report, 1978). Such a development goes beyond economic growth and strives for a development that is economically feasible, socially desirable and environmentally benign. This, in other words, calls for equitable, environment-friendly and balanced development. This departs from the traditional focus on income or wealth as the measure of development to better quality of life for human beings living in the economies (Bhattacharyya, 2012).

Human development, according to the Human Development Report (1990), is about expanding the richness of human life rather than that of the economy in which human beings live. Human development focuses on improving the lives people live rather than rather than assuming that economic growth will lead to their wellbeing. Human development is about opportunities, where people are given the freedom, they are afforded abilities and a chance to use them. The three foundations of human development are to live, a long healthy and creative life, to be knowledgeable, and to have access to resources needed for a decent standard of living (Human Development Report, 1990). When these basics are achieved, they open up opportunities for progress in other aspects of life. Human development also has the element of choice. The process of development/human development should create an environment for people, individually or as a community to develop to their full potential, and to have a reasonable chance of leading productive and creative lives that they value (Human Development Report, 1990). Human development

can be summed up as enlarging freedoms so that all human beings can pursue choices that they value. Such freedoms have two fundamental aspects freedom of well-being, represented by functionings and capabilities, and freedom of agency, represented by voice and autonomy (Human Development Report, 2016).

2.5.2 Provision of renewable energy technologies and human development

Access to electricity is closely linked with improvements in human development including productivity, health and safety, gender equality and education. Much of the research broadly describing quality of life and electrification stems from the pioneering insights of Goldemberg, (2004) who demonstrated a clear correlation between human development and electricity consumption. Access to modern energy services is fundamental to fulfilling basic social needs, driving economic growth, and fuelling human development. This is because energy services have an effect on productivity, health, education, safe water and communication services. Modern services such as electricity, natural gas, modern cooking fuel and mechanical power are necessary for improved health and education, better access to information and agricultural productivity (World Bank and IEA, 2015).

There are wide variations between energy consumption of developed and developing countries, and between the rich and poor within countries, with attendant variations in human development. Furthermore, the way in which energy is generated, distributed and consumed affects the local, regional and global environment with serious implications for poor people's livelihood strategies and human development prospects (Gaye, 2007).

Sapkota (2014) suggests that increasing access to electricity improve human aspects of development through increased time for studying by girls and boys in a rural area, saving time for fuel wood collection, increasing household income and reducing poverty that ultimately uplift the level of human development. There is wide consensus among scholars that providing access to electricity, and other modern sources of energy substantially contribute in increasing household welfare (ADB, 2010; World Bank, 2008; Cockburn,

2005; Martins, 2005).

Studies done by Bugaye (2006) in South Africa, Nigeria, Mali, and Egypt revealed that renewable energy resources, abundant in all the African countries, would provide a major breakthrough in proving a solution to energy crisis. Energy is indeed as catalyst for economic growth, and lack of adequate energy services is certainly a constraint to development. It limits the potentials of meeting basic needs of those who need energy to undertake essential domestic, agricultural, and educational tasks; to support health and transport services, and to initiate or develop manufacturing or trading enterprises. The use of the renewable resources to meet these developmental targets should be done in such a way as to make it sustainable, taking all the environmental factors into consideration.

The UN 2030 Agenda for Sustainable Development adopted in September 2015 includes the goal to end global energy poverty by providing universal access to affordable, reliable, sustainable and modern energy for all. In the academic literature, rural electrification, defined as percentage of the rural population with access to electricity, has been found to be a crucial part of socio-economic development (Aguirre, 2014). An increase in rural

electrification is associated with higher youth literacy rates by upgrading in-school and domestic learning facilities together with improved health facilities (Kanagawa and Nakata, 2008). Furthermore, it has been found to enhance employment, especially among women (Dinkelman, 2011), enable additional agricultural and non-agricultural income generating activities, and advance rural productivity. Where complementary hard and soft infrastructure are present, access to electricity is generally accepted to result in such positive health, education and income consequences (Ahmed et al, 2014).

Availing energy to rural communities provides numerous benefits towards development through the provision of reliable and efficient lighting, heating, cooking, mechanical power, transport, and telecommunication services (Feron, 2016). Access to electricity can provide improved quality of life and economic welfare as productivity increases, with businesses substituting manual work with automated processes and thus leading to positive human development growth (Balachandra et al, 2015). Sustainable Development (SD) is not possible without sustainable energy, and this has been prioritized by devoting a stand-alone SD goal (No. 7) to sustainable energy, which aims at universal access to affordable, reliable and modern energy (United Nations Human Development Report, 2016).

In summary there has been significant progress in the provision of electricity in developing countries. However, the majority of successful electrification has been taking place in urban areas, close to the cities, where the electrification rate is twice as high as compared to remote areas. In 2013, the United Nations Development programme (UNDP) launched the Sustainable Energy for All initiative to aid in accelerating the rate of increased energy access for the least developed countries.

2.5.2.1 Income generation and job creation

One of the main forces driving renewable energy policies and development is the potential to create new industries, particularly small and medium enterprises, and generate new jobs.

According to REN 21 (2014), renewable energy jobs are estimated to number 6.5 million globally, with many more indirect jobs linked to it. While many of these jobs have been created in developed economies, there is a growing role for developing countries, with China, Brazil and India taking the lead.

Case study evidence from developing countries shows significant potential for off-grid projects to create jobs and enhance local economic productivity, particularly in the sale, installation and operations and maintenance stages of the value chain. In Tanzania, the Rural Master Plan of 2005 surveyed electrified villages about the impacts of electrification (not off-grid in this case). It found that following electrification, new food processing units opened in 75 per cent of the villages, new metal construction shops in 60 per cent of the villages, new furniture maker shops in 55 per cent of the villages and new saw mills or oil seed presses in 10 per cent of the electrified villages. The survey data also indicated higher monthly incomes in electrified areas compared to similar non-electrified areas (International Energy Development (IED), 2013).

Such developments increase the attractiveness of rural energy markets and developing economies for potential investors. As new electricity connections introduce potential for income-generating activities, such as small service shops, there is a higher likelihood of returns on investment. These are activities that cannot function without electricity and are directly linked to the service provided. However, it is noteworthy that an increase in

income-generating activities is far from a guaranteed connection to the grid, and the benefits may also be lower if the off-grid scheme does not provide 24 hours, 7 days a week of power, or if the number of connections is restricted (ESMAP, 2010).

It is important for projects to be designed with the development of commercial activities in mind. This is because income-generating activities increase the ability for customers to pay tariffs and enabling of microenterprises can also have a large impact on poverty reduction.

2.5.2.2 Environmental and social benefits

Apart from the economic benefits, renewable energy-based mini-grids have environmental and social benefits. They generally replace the use of kerosene or diesel, reducing greenhouse gas emissions, as well as burning biomass in open stoves, which can have detrimental health impacts (such as respiratory disease) as well as be a fire risk in rural communities. Extended daylight hours afforded by electricity also allow people to continue working, or for children to study during the night or for schools to provide training on subjects that require electric tools, such as computers (UNDP, 2008).

2.5.2.3 Education

Education is one topic that is often overlooked when talking about energy access. It is important to realize that poor children do not have adequate time to focus on their studies when there is limited source of lighting. Kerosene lamps can be used but they are dimmer and can be more expensive than an electric light. Evidence in studies showed that electricity and lighting can significantly increase the time poor children spend reading and studying

(Khandker, Barnes, and Samad, 2009; Martins, 2005). One such location, where renewable energy provided children with electricity to study, was Bangladesh. Bangladesh established a Rural Electrification Board (REB) in 1977 to expand electrification and provide reliable, sustainable and affordable electricity to rural people. Since the establishment of REB, rural electrification has increased significantly. In 1977, less than ten percent of people were connected to the grid, while by 2007 more that 61 percent have received electricity. REB conducted a survey in 2004 to evaluate the implementation of the sustainable systems (Khandker, 2009).

This case study by Khandker (2009) on Bangladesh provides evidence that access to electricity improves rural economics, well-being, and education. An earlier study of Bangladesh residents found that the major use of electricity was for children's education at eighty-three percent. The findings were also conclusive in the more recent case study. In fact, families that were able to access an energy source had improved school completion rates as well as study time for both boys and girls. Girls had higher improvement in villages with electricity access than boys (Khandker, 2009). Not only did electricity improve education for children and education completion rates, but it also provided empowerment for female children.

2.5.2.4 Health

The health of the poor is drastically affected when there is no form of electricity or energy service available. The poor are prone to inadequate health, lack of health services, respiratory issues, increase cases of fire accidents, and incidents of women being violated. The World Health Organization (WHO) noted that thermal comfort, which can be attained

through access to an energy service, is directly linked to health. In one finding by the WHO, they found that forty percent of winter deaths, which amounted to 278,409 people, were caused by housing conditions (Sovacool, 2013). Use of traditional biomass for a fuel to cook and heat homes causes respiratory issues in women and children. Another report by WHO found that approximately two million deaths per year and forty million disability adjusted life years are caused by biomass use in marginalized countries (Bhattacharyya, 2012). Traditional fuels for cooking and heating are disadvantageous to the poor's health. There is an additional health concern that is not always addressed in energy justice case studies: women being physically assaulted. A case study that was conducted in South Africa on the impact of energy sources on the quality of life of poor communities found an alarming concern for women. Without access to a form of energy, women have to venture out into far distances to obtain biomass to use for cooking or other common household work. During their trips, women are physically attacked. Installing a form of electricity or lighting in communities decreases the occurrence of crimes in the dark. "There is evidence that the number of accidents in electrified areas is lower than those for non-electrified areas" (Martins, 2005). Lighting provides safer streets for the community and electricity also provides women with fuel for which they no longer have to travel far distances to obtain.

The study also found that there are significant improvements to well-being because of access to electricity. The study also found significant safety concerns associated with limited to no access to electricity. There is high incidence of fires in houses and burns to individuals. From approximately 2,750 individuals studied, eight people died from burns and six children died from drinking paraffin. Additionally, the study found that cases of

fires decreased drastically with increased access to electricity (Martins, 2005). Electricity removes the safety concerns for women, children, and the poor.

2.5.2.5 Equality

Inherent to the notion of energy justice is equity. Within that notion resides evidence for the need of renewable energy to meet the inequality of the current system. Individuals that are deprived of access to energy services will typically have limited education opportunities, terrible health, and limited economic growth (Sovacool, 2014).

These individuals and families also face another limitation that further adds a burden to their lives. As the energy poor are deprived of those basic needs they also spend most of their income and time on unreliable and inefficient energy sources (Sovacool, 2014; Sovacool, 2013).

Surveys conducted in different marginalized countries found that the poor pay more for energy based on their income than they use when compared to higher income classes. One survey found that approximately thirty-three percent of people with the poorest incomes were in energy poverty and those with the highest income had less than one percent in energy poverty (Sovacool, 2013). Another study found that within the countries analysed, the poor households consumed less energy but used more of their income to pay for it than other households (Sovacool, 2013). Sovacool (2013) found that middle and upper incomes pay three to four percent of their incomes on energy, while the poorest incomes pay twenty to thirty percent of it on energy. In addition, they spend another twenty to thirty percent on indirect costs associated with collecting and using energy. Survey after survey and analysis

after analysis come up with the same findings that the poor pay more for energy, but yet the energy that they pay for is harmful to their health, stability, and growth. The issue may not be entirely that more energy is needed, but that the type of energy, its manner of distribution of energy, and who has the privilege to receive access to energy must be addressed as well.

2.5.2.6 Economics

Affordable renewable energy can help alleviate poverty and help improve economics of marginalized countries. Energy services are a powerful driver of economic and social development. Countries cannot grow without ensuring minimum access to energy services for a majority of its populations (Fatema, 2005). Ensuring energy to populations is one form of development. Economic development also grows when energy consumption increases (Sovacool, 2014).

Another perspective is that while electricity is crucial to existing and well established micro-enterprises, it is not so much a contributing factor in the emergence of new ones. Following a literature review of international work on rural electrification, Gustave (2004) concludes that access to electricity encourages the "modernization" of existing rural SMEs but it exerts only a modest stimulus for the growth of new enterprises. This skepticism is echoed by Lolenzo (2002) who observed that "overall, rural electrification does not seem to have had significant impact on the growth of income generating activities in Namibia". They note that very few home-based businesses used electricity and when they did, they mainly made use of electrical "lighting only". In their view, access to finance and markets are more important for SMEs than electricity.

2.6 SUMMARY

The Capability theory that will be used to analyse data, and how energy access through renewable energy technologies will address energy poverty and enhance livelihood styles and human development have been introduced. The chapter provided an overview of the energy situation globally. It has given an overview of Namibia's energy situation and efforts being made by the Government of Namibia to address the energy situation in rural areas. Namibia as a country has undertaken various initiatives to address energy poverty and energy access in rural areas. Additionally, previous research on energy access and poverty have been reviewed and the main findings from the studies are that energy access through RETs have beneficial impact on social lifestyles and livelihoods of people in rural areas.

3. CHAPTER THREE: METHODOLOGY

This chapter provides an explanation on the materials and methods used in this study. It describes the research design, sampling approach as well as data collection and analysis methods used. It also describes how objectives were achieved in the study through the use of the instruments used in the study. It further outlines the limitations of the methodology employed and challenges encountered by the researcher during the study, and explains how they were dealt with. Ethical issues that were considered during the research are also discussed.

3.1 RESEARCH DESIGN

Kothari (2004) describes research design as 'a conceptual structure within which research is structured.' It constitutes the blueprint for the collection, measurement and analysis of data. It is an outline of what the researcher will do. According to Cohen et al (2001) a research design is used to describe the procedure for conducting a study, and its purpose is to help find appropriate answers to research questions. There are different types of research approaches which include qualitative, quantitative and mixed method approaches.

This study used the mixed method research approach, which is defined as a procedure for collecting, analysing and combining (or mixing) both quantitative and qualitative techniques, during the research process, within a single study, to understand a research problem more completely (Creswell and Clark, 2011). In this approach, the researcher

collects both numeric information and text information to answer the study's research questions. The term mixing implies that the quantitative and qualitative data are brought together in some way such as merged, connected and or embedded. The use of the mixed method approach entails the combination of quantitative and qualitative data in order to add depth and detail to the study (Swanson and Holton, 1997).

In this study the relation among variables was addressed through quantitative methods and, the people's feelings towards the provision of electricity through qualitative research methods. Questionnaires were used to extract quantitative data that was generalised to the population, whereas for qualitative data focus group discussions, and face to face interviews with key informants, were conducted.

Quantitative method entails the explaining of phenomena by collecting numerical data that are analysed using mathematically based methods, in particular, statistical. This data is used to test the relationship between variables (Teddlie and Tashakkori, 2009). The questions asked in relation to energy access, energy poverty, and benefits of using electricity, were intended to assist in determining if there exists a significant relationship between the provision of modern energy services and the enhancement of human development opportunities. In the study, a sample of fifty households, out of the estimated total of 100 electrified houses, was considered. A questionnaire was administered to one person per household in order to get an idea of the real picture as experienced by the beneficiaries of the photovoltaic mini-grid system, and after analysis, to generalise the findings to the larger community of Tsumkwe Settlement Area.

The qualitative research method is an inquiry process of understanding, where the researcher develops a complex, holistic picture, analysis of words, reports detailed views of participants, and conducts the study in a natural setting (Creswell, 2015). In this study the questions asked to the key informants and focus group participants answered the third objective, which assessed the benefits of solar energy to the community of Tsumkwe in terms of human, economic and social development order to have a clearer understanding of the participants' experiences in relation to the availability of electricity within their community. In the research, observation notes and pictures were taken to support and validate quantitative data.

3.2 TARGET POPULATION

The target population contains members of a group, that the researcher is interested in studying. The results of the study are generalised to this population, because they all have the significant traits in common. The target population according to Burns and Grove, (2003) is the entire aggregation of respondents that meet the designated set of criteria.

The main aim of the current study was to determine if the provision of electricity in Tsumkwe satisfies the definition of energy access and if it has adequately addressed the problems associated with energy poverty, and ultimately led to the betterment of the community with regards to human, economic, and social development. The target population constitutes all households in Tsumkwe Settlement, being served with electricity from the photovoltaic power plant. This will include business owners, and school heads

(Ministry of Education Arts and Culture), medical head (Ministry of Health and Social Security) and police head (Ministry of Safety and Security).

The target population, included 100 household heads because they would provide with data that relates to the demographic information, which allows generalisation of the population. They also provided with vital statistics that helped to answer the question on the definition of energy access, which needs to be benchmarked internationally, and whose content needs to be adopted at national level. The different key informants were from the 20 government institutions helped to provide information on detailed benefits of electricity to the Tsumkwe community. Such information assisted in explaining if the photovoltaic plant had contributed in alleviating the effects of energy poverty among the people of Tsumkwe Settlement Area. The business owners' responses also helped to further qualify the quantitative data from the questionnaires, regarding different variables, and to substantiate the appropriate definition of either energy access or poverty, in respect of communities in developing countries.

3.3 SAMPLING PROCEDURE

3.3.1 Sampling

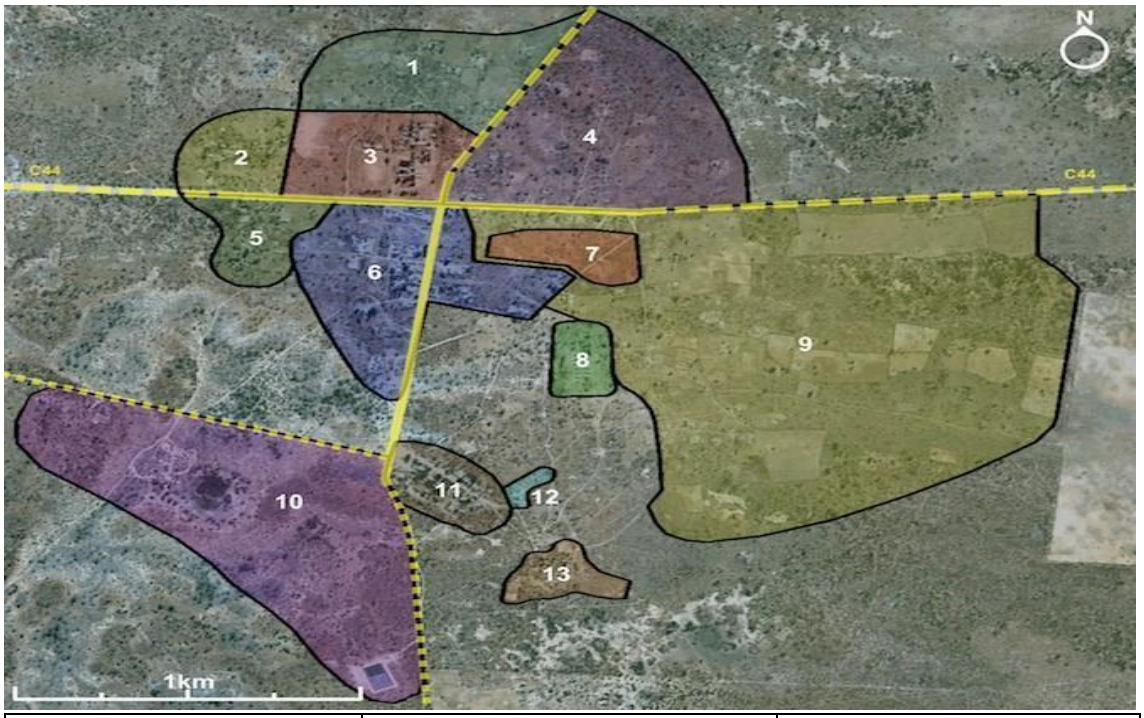
Sampling is the process of selecting a number of individuals for a study in such a way that the individuals represent the larger group from which they were selected. A sample is a smaller collection of units from the population used to determine the truths about that population. The population is the larger group from which individuals are selected to participate in a study (Creswell, 2013).

The purpose of sampling is to gather data about the population in order to make inferences that can be generalised to the population (Creswell, 2013). The sampling method used for sampling quantitative data was convenient sampling method, and purposive sampling method was employed for qualitative data.

3.3.2 Sample size determination

The rule of thumb for determining sample size is that when population is larger than thirty and less than 500, as appropriate for most research, a minimum size of sample should be thirty percent of the population (Hulley, Cummings, Newman, Browner and Grady, 2013). In this study one hundred households were connected to the power plant in 2012 when the power plant was in operation (Regional Electricity Regulators Association (RERA) of Southern Africa 2014. In the study thirty percent of the household population of one hundred household was thirty-three household heads. The study therefore sampled 50 households who responded to the structured questionnaires, employing face to face interviews specifically designed for this study. Since the settlement has six residential locations namely Damara, IIhara, Sewe Huis, Government Location, Owambo Location and Gauteng Location., the non-probability quota sampling method was to be used. In order to have a representative sample size of fifty respondents from these six locations, eight houses were expected to be conveniently sampled from across the locations. This was not possible on the ground because the distribution of people with electricity in the locations is not even. During the collection of data the last interviewed respondent informed the researcher of other houses connected to the grid. From these homes which are being served with electricity from the power plant, a self-administered, structured questionnaire was answered by the respondent.

Convenient sampling was selected as the appropriate sampling technique to use after considering the settlement pattern of Tsumkwe (see Figure 3. 1). The selected sample was spread among different locations namely; Tsumkwe North which is made up of the Kavango, Herero and Owambo people. The primary and secondary schools are also in this location. The Damara, IIhara, Sewe Huis and Gauteng, house mainly the Ju/'hoansi families together with other ethnic groups. The government location is mainly for the government employees. Central Tsumkwe is made up of businesses, institutions, and very few homes. The Owambo location is also known as Kolbooi.



1 Tsumkwe North	6 Central Tsumkwe	10 Tsumkwe South
2 Damara Location	7 Herero Location	11 Local Govt. Location
3 Schools	8 Sewe Huise (Seven Houses)	12 MET Housing
4 Tsumkwe Northeast	9 Owambo Location	13 ǁharas
5 Gauteng Location		

Figure 3.1: Map showing the different locations in Tsumkwe Settlement Adapted from Ashton et al (2014).

Through the use of the convenience sampling technique, the respondents who were easy to access were interviewed. Alvi, (2016) adds that, it is used when the target population is defined in terms of a very broad category; for example, men, women, youths, business people and others. As a type of non-probability sampling, convenience sampling was well suited for exploratory research intended to generate new ideas that could be tested later. The results will be used anywhere in rural Namibia where a project of this nature is to be implemented. Convenience sampling method was used to select a sample of 50 household heads, out of a total population of 100, (or representatives) from photovoltaic electrified households of Tsumkwe settlement area, for generalisation of data to the population.

Table 3.1 shows the selected key informant interviewees.

Table 3.1: Key Informant Interviewees at Tsumkwe Settlement Area

Department /Section	**Interviewee**	**Rationale for selection**
Tsumkwe Primary school	Principal	Establish the benefits of the PV plant on the learning activities
Tsumkwe Secondary school	Principal	Establish the number of learners disaggregated and the progression in enrolment of the learners
Tsumkwe Police Station	Officer in-charge	Identify the catchment area and the of the police station and the common crimes committed
Tsumkwe Clinic	Sister in-charge	Identify the catchment area and the main ailments treated
Ministry of Environment and Tourism	Chief warden	METs role in conservation issues and type of services that they offer to the community of Tsumkwe
Tsumkwe Settlement Office	Control administrative Officer	Services provided

Key informants and participants were selected using purposive sampling, which falls under non-probability sampling, in order to obtain in depth information on the benefits and impact of the utilisation of electricity on the Tsumkwe community. They were selected from the business community and local heads of all key government institutions closely involved in activities which related to human development indicators. In total, thirteen key informants were interviewed. For the group discussions, participants were also selected using convenience sampling. This way the participants provided with the best information relating to the benefits that they have realised from using electricity and where they feel there is need for improvement.

3.4 RESEARCH TECHNIQUES

3.4.1 Research methods

3.4.1.1 Questionnaire

McMillan & Schumacher (2010) describe questionnaires as data-gathering instruments used to obtain factual data, opinions, and attitudes as in the case of interviews. They could be used either for gathering quantitative or qualitative data.

In this study, structured questionnaires were used because large amounts of information can be collected from a large number of people in a short period of time, and it is relatively cost effective. Since this study was carried out with the assistance of a research assistant using a questionnaire will not compromise its validity and reliability. This study aimed to measure changes in the way of life of the people of Tsumkwe Settlement Area. The questionnaire addressed issues of energy access, energy poverty, and benefits realised from

the use of electricity as stated in the study's objectives. These objectives aimed to measure changes in the way of life of Tsumkwe Settlement Area.

3.4.1.2 Face to face interviews

According to McNamara (1999), an interview is a verbal conversation between two people with the objective of collecting relevant information for the purpose of research.

Interviews are important because they help to get the story behind a participant's experiences and the interviewer can pursue in-depth information around a topic.

Interviewing has emerged as the dominant resource for engagement between the social sciences, business, and the society concerning issues that matter to them (Rapley, 2001). An interviewer may utilize the technique to elicit information, or expression of perspectives, from interviewees regarding complex matters, as interviewees may also chance themselves to explicitly expound key issues that matter to them. In this study, interviews were the most appropriate method to unearth pertinent insights from group and individual interviewees (Gill, Stewart, Treasure & Chadwick, 2000.) Semi-structured and structured face-to-face interviews, guided by open-ended questions, with key informants and community members were used to obtain information regarding the potential and realised impact of the implementation of the solar PV mini-grid electricity on the community of Tsumkwe. The interviews helped to get in-depth information on all the three objectives, which addressed energy access, energy poverty and the benefits of using electricity to the people of Tsumkwe.

The interview questions were designed to capture social, economic and environmental issues, which addressed the objectives relating to benefits of electricity on the Tsumkwe community through accessing electricity and alleviation of energy poverty. Though all questions were in English language, the group interviews at the community level were conducted in the local languages which are Oshiwambo, Damara Nama and Herero with the help of the research assistant, where the respondents did not understand English. However this was at very few households because most of the members of the households are literate. Interviews with the key informants were conducted in English because all of them understood the language.

The interviews with the household heads were conducted in all the mentioned locations as shown in figure 1. In order to engage with the key informants in the government institutions and business owners' appointments were made prior to the interviews. For the small businesses run from home, these interviews were done immediately after the questionnaire. Through observation it could be noted that there was a business and permission was sought to carry out another interview which in most cases would last for about ten minutes

3.4.1.3 Focus group discussion

Focus group discussions were used for data collection at community level. According to Silverman (2011), and Krueger (1994), a focus group interview is a way in which qualitative data is collected by engaging small groups of people who bear certain harmonies or share similar characteristics.

Blaikie (2005) states that case study focuses on a social unit, a real individual, social event or group of people, which treats the individual, group or event as a whole. In practice, the case study keeps together as a unit, those characteristics that are significant to the scientific problem under investigation. The researcher decided to seek for collective, however, divergent views of respondents concerning the research problem from a larger population; hence, focus group discussions appeared extra dynamic and flexible to gather such data (Gill et al. 2008). The distinctiveness of a focus group discussions lies in its ability to produce information based on the group synergy (Green, Draper, & Dowler, 2003). The focus group discussions consisted of household heads or members, and people involved in different types of economic activities in Tsumkwe. In each focus group discussions, there was a maximum of twelve members (Krueger, & Casey 2000). All the group interviews in the settlement took place at neutral venues, which were familiar and convenient for all the participants, these were done at the community centre soon after normal working hours. The two group discussions were audio-recorded one after the other, with two recording devices, and concurrent brief notes were also taken.

3.4.1.4 Observation

Structured observation is a systematic technique, which a researcher employs to explicitly generate physical data from the behaviour of individuals, an environment, or events that appear naturally, from social settings (Bryman, 2012). Since this study relates partly to the environmental conditions of a community, the researcher observed in situ, the environmental conditions of Tsumkwe Settlement Area and captured photographs of the economic and social activities taking place, as well as infrastructural development in the area.

Creswell (2011) asserts that an important category of data collection in qualitative research, in a particular case study, is visual materials such as photographs and artefacts that can broaden understanding in relation to the case being studied. In observation, researchers can obtain data in a manner that may not necessarily be known to the inhabitants, for example, taking photographs and recordings. .

The photographs which were taken helped to augment the evidence of infrastructural development as a result of the provision of electricity. Observations noted helped to explain evidence of human development related to their activities, which showed that people had options to engage in difference economic activities to improve their lives.

3.4.2 Data presentation and analysis

Analysis of data was done with the main aim to evaluate the impact of Tsumkwe minigrid photovoltaic power plant on rural household and community development in Tsumkwe Settlement area, and recommend replication in similar settlements throughout the country. The Capability Theory helped to guide the study and evaluate if the community had their livelihoods enhanced through accessing modern energy. The following questions were addressed, namely:

- Has the provision of electricity to the settlement through a photovoltaic off-grid mini-grid, satisfied the definition of access to electricity?
- To what extend has solar energy usage had effect on reducing household and community energy poverty?; and lastly,

- What are the benefits of solar energy provision to the community of Tsumkwe Settlement Area in terms of human, economic, and social development?

After responses were collected, raw data was transcribed for analysis. Qualitative raw data was captured in MS word while quantitative data was processed and cleaned with the help of MS Excel. Both sets of data were analysed using a descriptive statistical analysis method. Descriptive statistical analysis is the method that involves the analysis of statistical data, and presentation thereof, in meaningful and easily understood ways. This method involves the derivation of patterns from the raw data collected (Williams, 2015;
Lund and Lund, 2013).

The data from the questionnaires was first coded and then entered onto a Microsoft Excel spread sheet. Graphs and tables were generated in order to present the data into meaningful information. The quantitative results were presented in the form of figures and tables. On the other hand qualitative data collected from the key informants and focus group discussions were categorised in themes and analysed as narrative text. The qualitative text analysis consisted of coding the texts segments by assigning labels and putting similar codes into themes.

The quantitative results were presented in the form of figures and tables, while the qualitative data was categorised in themes and analysed as narrative text. The qualitative text analysis consisted of coding the texts segments by assigning labels and putting similar codes into themes.

3.5 RESEARCH ETHICS

A set of ethical considerations such as privacy, confidentiality, storage and protection of data, which guided the researcher, so as not to violate the rights of the research participants was considered. According to Bryman (2012), privacy is defined as 'control over the extent, timing, and circumstances of sharing oneself (physically, behaviourally, or intellectually) with others.' In contrast, confidentiality is 'the treatment of information that an individual has disclosed in a relationship of trust, and with the expectation that it will not be divulged to others in ways that are inconsistent with the conditions of the original disclosure, without permission.' Privacy pertains to participants, and confidentiality pertains to data. Social and behavioural sciences research involves private behaviours, and protecting the privacy of participants' means giving them control over the information that they share with the researcher. This includes asking for permission and getting consent to carry out the study procedure with individuals, and allowing them to refuse to answer any question that they find objectionable, as well as ensuring that the platform in which the study runs, is private. Participants who wished to discontinue were reassured that no harm will happen to them on account of their decision to withdraw.

Confidentiality is important when carrying out research. Confidentiality of data takes more effort to maintain. All the information that was be collected in this study was considered as 'information that an individual has disclosed in a relationship of trust'. Since this is the case, participants had the right to expect that the information they shared would not be divulged to third parties, without their permission. In order to protect confidentiality during the collection and use of data, anonymous data was used. Anonymous data are data that are not connected to the information that can identify the individual participant. Nonexistence

of connection between the participant and their data ensures that most sensitive studies can qualify for exemption assuming that they are minimally at risk. In this study respondents were identified by codes.

The researcher ensured that participants were protected against any form of harm by ensuring that the identity of the participants who responded to questions was not revealed, through the use of pseudonyms.

Data storage was equally important because it reinforced confidentiality protection. Data was protected from physical damage, loss or theft. In this research data access was limited only to people who were directly involved in the collection and its processing. Questionnaires and notebooks were kept together in a safe and secure location away from public access, and locked in cabinet within the Settlement office in Tsumkwe Settlement Area. The research assistants were educated on data protection procedures. Regarding voice recordings and pictures taken, these were transferred to a hard drive on the computer where they were only accessed by a password. Where resources permitted, all questionnaires were scanned and sent to the researcher's email address. The data was kept until the completion of the study, whence the data becomes obsolete in the field of study. The questionnaires were to be disposed of by shredding them while the electronic questionnaires are only going to be gotten rid of after such a time that the data is obsolete in the field of study.

A camera was used to take photographs of features and people. The photographs of features were used to support the observation list. With regards to the taking of photographs, the researcher sought permission before doing this. Photographs of people were only taken after the signing of the consent forms by the participants. Photographs taken were of the

business key informants while engaged in their daily activities, which involved the use of electricity, and of focus group discussions participants.

Besides taking photographs, the research recorded the focus group discussions. Permission was sought to carry out the recordings and such permission was confirmed through the signing of the consent forms by the participants.

Permission to carry out the research was sought from the University of Namibia. General research ethics were also adhered to according to the University of Namibia, PGS guidelines. Permission to interview relevant people from the health, education and social security personal and all the other participants during the research was sought from the Otjozondjupa Regional Office.

Necessary authorisations were sought from Regional Offices in Otjiwarongo, Tsumkwe Constituency Councillor, and the Settlement Office in Tsumkwe, as well as consent from the participants. During interviews, the researcher introduced herself, handed out a written explanation, as well as provided a verbal explanation to the participants, to clarify the purpose of the research, and the principle of confidentiality of the interview outcomes, throughout, and after the study. Confidentiality, also applicable to recorded interviews and photographs, was established by ensuring that the identity of the research participants remains unknown since the study may have presented some sensitive questions to some participants. For that reason no names were written neither on the questionnaire interview schedule nor while carrying out the focus group discussions. Pseudonyms and codes were used while transcribing data. In relation to harm to participants, respondents were allowed to stop the interview at any time in case they felt uncomfortable for whatever reason, and they were assured that there would be no negative effects on them.

A consent form to inform the participants about the aim of the study and its process was developed and participants were asked to accept consent by signing the consent form. As already mentioned, the participants were allowed to withdraw from the study at any point, or to choose not to answer any question without penalty.

3.6 SUMMARY

The methodology, and research tools employed while evaluating human development through renewable energy provision in Tsumkwe Settlement Area has been described. The Capability Theory was applied to the analysed data to assess the benefits access to energy on the Tsumkwe community. To assess the impact of solar energy on poverty alleviation, a survey was undertaken in both households and income enterprises.

4. CHAPTER FOUR: PRESENTATION OF RESULTS

This chapter presents the results of the study carried out in Tsumkwe Settlement Area in Otjozondjupa Region, Namibia. The use of electricity from the hybrid power plant by households, local businesses and community facilities is analysed quantitatively and qualitatively by linking the research objectives and the collected data, using the aforementioned mixed methods research approach. Quantitative data have been useful in bringing out the demographic data and the descriptive statistics of variables related to energy use, electricity consumption and main sources of energy used. Qualitative data has been useful in addressing the beliefs and attitudes related to economic and social utilisation of energy.

4.1 QUANTITATIVE RESEARCH FINDINGS

4.1.1 Socio-demographic characteristics of the respondents

A total of 50 self-administered questionnaires were distributed household heads, and 47 of the questionnaires, constituting 94% of 50, were correctly completed. Welman, Kruger and Mitchell (2005) purport that a response rate above 50% is sufficient to obtain meaningful statistical analysis and obtain acceptable results.

Information collected through questionnaires responded to by forty seven Tsumkwe household heads between the ages of 21 and 60 years revealed the demographic and economic characteristics of the community, including the type of employment, and sectors they were involved in. Provision of electricity for 24 hours attracted people with skills to

go and work at the settlement. The household heads could also stay with their families, because the necessary services were available at the settlement. Such services included both primary and secondary schools, a clinic and supermarkets.

4.1.1.1Gender distribution

The 47 household heads interviewed, comprised of 17 (36%) females, and 30 (64%) males, conveniently sampled from the six locations of the Tsumkwe settlement, as shown in Figure 4.1.

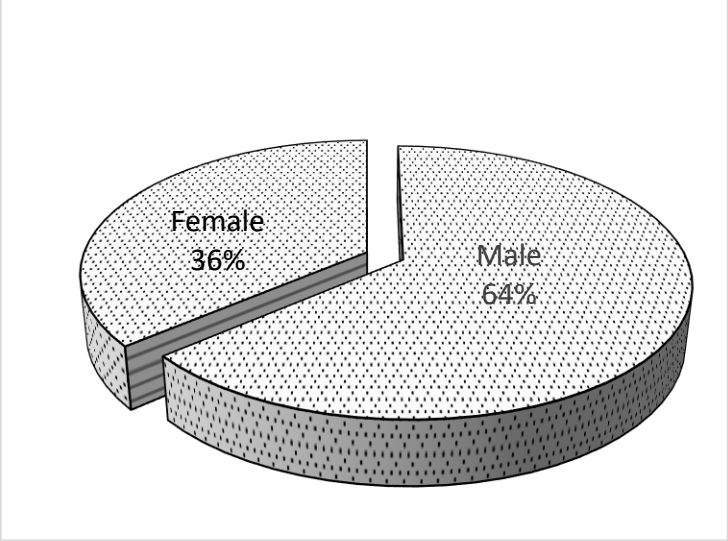


Figure 4.1: Gender distribution of respondents

4.1.1.2 Marital status

Table 4. 1 shows the marital status of women and men in Tsumkwe community. In the sampled community there were as many single headed families as those headed by married couples. The distribution was married 18 household heads (38%) and single 21 household heads (45%). There were no recording of the divorced. The separated and the widowed had

the same frequency which was 2 household heads for each (4%) and the household heads living with a partner made up 9% of the sampled population.

Table 4.1**:** Marital status of the respondents in Tsumkwe

Status	**Number of female household heads**	**Number of male household heads**	**Total number of household heads**	**Percentage of household heads**
Married	5	13	18	38%
Living with partner	1	3	4	9%
Widowed	1	1	2	4%
Single	9	12	21	45%
Divorced	0	0	0	0
Separated	1	1	2	4%
Total	17	30	47	100

4.1.1.1 Highest level of education

The community is made up educated people (Table 4.2), however this might not be attributed to the availability of energy. This is because the supply of electricity 24 hours per day had been effective for six years at the time of sampling. The bulk of the sampled population, constituting 88% of the population, indicated that they attained grade 10, 12 and tertiary level education. This gives the sampled population leverage when it comes to securing of jobs.

Table 4.2**:** Highest level of education

Status	**Female household heads**	**Male household heads**	**Total number of household heads**	**Response in percentage**
Cannot read or write	0	1	1	2%
Grade 1-7	1	4	5	11%
Grade 8-10	10	10	20	43%
Grade 11-12	3	6	9	19%
Tertiary	3	9	12	25%
Total	17	30	47	100

4.1.1.2 Age distribution

The age distribution of the male and female household heads in Tsumkwe community is shown in Table 4:3; about 72% of all household heads interviewed, were between 31 and 50 years old, and those between the ages of 21-30 were 21%. This is considered an economically active age group. There was no one above 60 years, which may suggest that when people reach this age and retire they go and live in in the rural areas since they can no longer be gainfully employed. In Namibia the legal age of retirement is sixty (NSA 2011).

Table 4.3: Age distribution of the sampled population

Age range	**Female**	**Male**	**Total percentage**
21-30	4	6	21%
31-40	6	12	38%
41-50	7	9	34%
51-60	0	3	6%
Above 61	0	0	0
Total	17	30	100

4.1.1.3 Location of residence of respondents

Most of the interviewed respondents lived in the Government Location which was 28%. This is a location specifically meant for government employees (Figure 4.2). The provision of electricity might have attracted more skills personnel to the area. Twenty percent were from the Sewe Huise location, where the ethic group was mainly the San Community. In the other locations, the population was mixed, and there were no specific dominant ethnic groups.

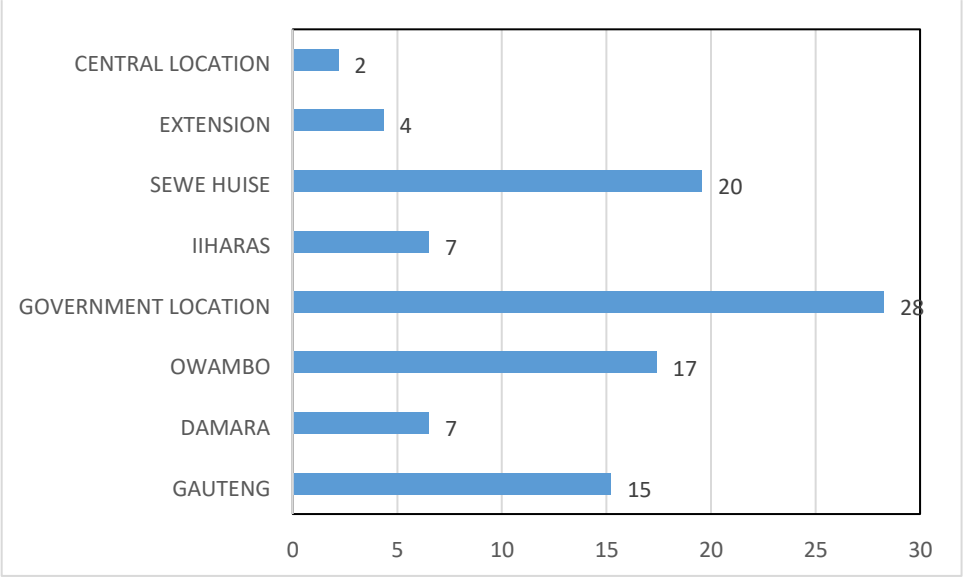


Figure 4.2: Distribution of respondents per residential area (% of total)

4.1.1.4 Family sizes, and relation to household head

Figure 4.3 shows that for most of the households though the number of persons ranged from 1 to more than twenty in a household, about 70 % of the households had one to nine per household.

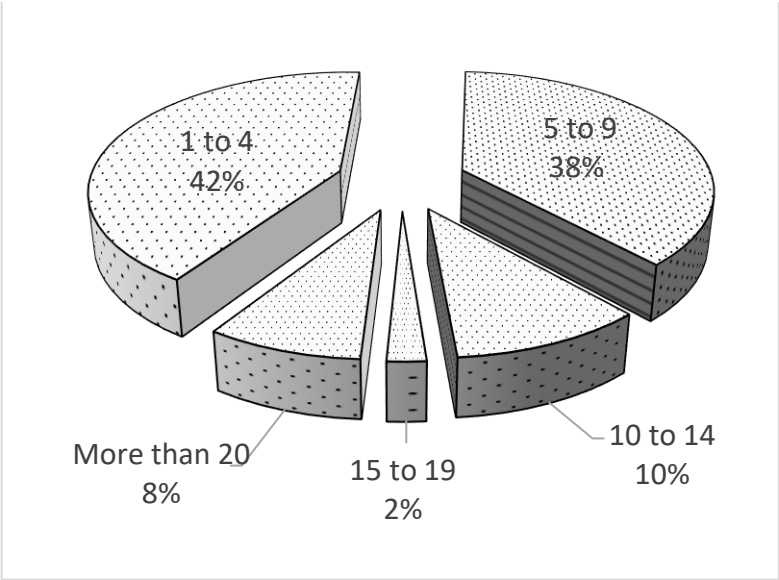


Figure 4.3: Number of persons per household

The lower number of persons per household of 1-4, was found mainly in the Government location, while 8% of the respondent households, mainly from Sewe Huis, had more than 20 persons. According the Census of 2011 the average number of persons per household in Otjozondjupa region was 4, but Tsumkwe had the highest number of 5. The average number of persons per household according to the current study was 7, showing a further increase. This might be because of migration of the economically active population into the settlement area looking for employment opportunities. This is further confirmed by the increase in new homesteads, and applications for electricity installations in the newly built houses. The settlement has plans to develop 400 plots for medium to high income earners for residential and commercial plots.

4.1.1.5 Relation to the household head

In relation to heads of household's relationship with people living with them (Table 4.4),

93% of the household heads lived with their children whose levels of education ranged from grade 1 to grade 12. All children who were of school going age attended school. There were household heads who lived with their parents, these made up 22% of the sample.

Table 4.4: Relation to Household head

Relationship to household head	**Total percentage from respondents**
Children	93%
Relatives	28%
Parents	22%

The age range of parents was 50 years and above, and most of them could neither read nor write. Those who lived with relatives were 28%, and they fell in the economically active age. Most of them went to Tsumkwe in search of employment. The settlement area has become the economic hub for the surrounding villages. This could be because the provision of electricity opened up wide opportunities for the locals.

4.1.1.6 Duration of stay in Tsumkwe Settlement

Table 4.5 shows the number of years that the interviewees had stayed in Tsumkwe settlement area by the time of the interviews (2018). The frequency of at least ten years, and more than ten to more than twenty years, was 44%, and 56% respectively, i.e., almost 80% of them had stayed for more than ten years in Tsumkwe Settlement area.

Table 4.5**:** Number of years the respondents had lived in Tsumkwe

Number of years living in Tsumkwe	**Frequency**	**Percentage**	**Cumulative frequency**
0-5	10	21%	21%
6-10	11	23%	44%
11-15	4	9%	53%
16-20	7	15%	68%
More than 20 years	15	32%	100%

4.1.1.7 Average monthly expenditure on food

The data collected on food expenditure (Figure 4.4) showed that the average amount spent by a household per month was N$1803. Households that spent between N$0-1500 were 50%, those who spent N$1501-3000 were 37%, while those who spent N$3001-6000 were 13%. Considering the average number, of seven persons per household, this translate to N$258 per month for food per person, and N$8.50 (about US$0.60) per day. Such a community is considered poor because according to the United Nations Development Programme Report, poverty is when one's expenditure on food is less than US$2.00 per day.

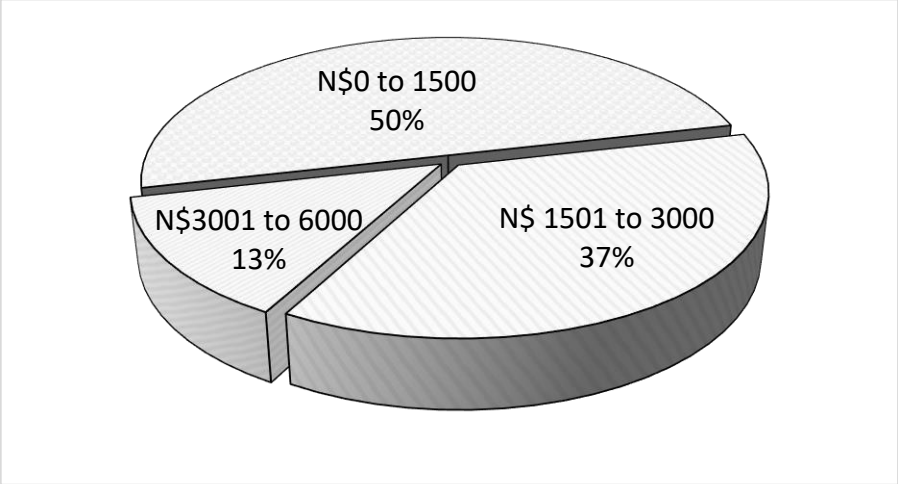


Figure 4.4 Monthly expenditure on food

4.1.2 EVALUATION OF ENERGY ACCESS IN TSUMKWE

The evaluation of energy access in Tsumkwe was aimed at responding to two objectives:

a) To evaluate the extent to which electricity provided to Tsumkwe settlement area, through a photovoltaic off-grid mini-grid, satisfies the definition of energy access, and

b) To determine the effect of solar energy usage on reducing household and community energy poverty.

4.1.2.1 Electricity costs in Tsumkwe

Most of the households (67%) paid monthly bills of N$200 or less for electricity, and 21% paid between N$ 201 to N$400; 8% paid between N$401 to N$600, while 4% paid between N$601 and N$800.

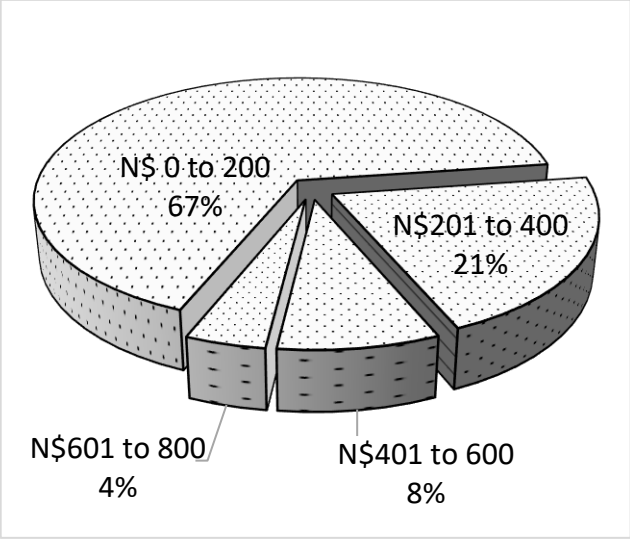


Figure 4.5: Distribution according to total monthly expenditure on electricity

There is a relationship between the monthly expenditure spend on food and the amount spent on electricity (Figures 4.4 and 4.5). A large percentage of the population spent the

minimum amounts of money both on electricity and food. They also fetched, as well as purchased fire wood for cooking, rather than using the gas stoves. This could also reflect of the type of stove that they use. Although gas was made available, such households had other priorities, and could not afford to buy the gas, given the option of gathering "free" firewood.

4.1.2.2 Energy for business in Tsumkwe

In Tsumkwe Settlement Area electricity is the popular source of energy used to run businesses as compared to other sources of energy. Sixty six percent of the respondents used electricity in the running of their businesses while 32% did not. Nineteen respondents said that they ran businesses from their homes, as shown in Figure 4.6 (a). The distribution of the population based on sources of energy used for business are as indicated in Figure 4.6 (b). Productive use of electricity for income generation included – the sale of ice, cold beer, and meat, preparation of fast foods, rice, chips and hotdogs, and sewing of clothes.

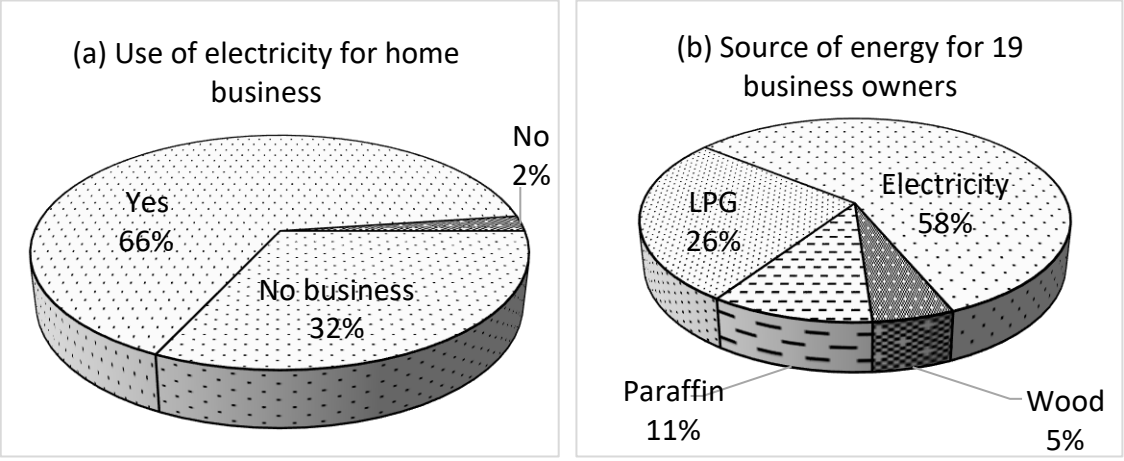


Figure 4.6: Distribution according to source of energy for business owners

Almost two thirds of the sampled population used electricity to run their home businesses. However it was also revealed that other sources of energy are used, for example, 5% of the sampled population were using wood to power their businesses, 11% used paraffin, and 26% used LPG. (Table 4.6)

Table 4.6**:** Source of Energy for Business Owner**s**

Type of Energy	**Frequency**
Wood	5%
Paraffin	11%
Liquefied Petroleum Gas	26%
Electricity	58%

4.1.2.3 Energy access and lighting

Most of the sampled population (96%) had fixed lights in their homes, only 4% did not have fixed lights (Figure 4.7). Households whose housing structures met the building standards were all connected to the solar mini-grid. The minimum lights that could be provided were two, and this was the reason why 49% had one to two light bulbs in their homes, 36% had three, and 15% had more than 4 light bulbs (Figure 4.8). Houses in the government location, in general, had more than four light bulbs each. The calculated average number of lights was three per household, which were used for more than 4 hours, daily. The Tsumkwe community members could, therefore have an extended day, where other activities, such as studying, could be done during the night. Most of the government employees mentioned their involvement in some form of distance education, and this was made possible because of access to lighting after working hours. Availability of electricity and lighting has led to the establishment of boarding hostels at some schools. This has afforded school children from the surrounding areas access to better education facilities.

This has also saved time, which would be spent by learners travelling to and from school, and thus, this has facilitated them to concentrate on their studies.

4.1.3.4 Number of lights per household

Most respondents were satisfied that the lighting that they had was adequate for their needs, although a few felt that their lighting could be improved upon. Such improvements, however, may not be possible because some of the non-formal housing structures did not meet building safety standards, hence electric wiring was not permitted.

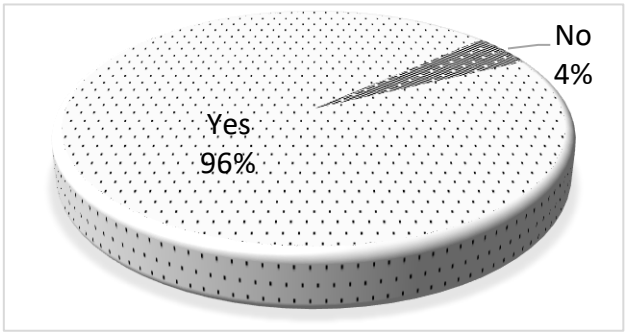


Figure 4.7: Fixed lights

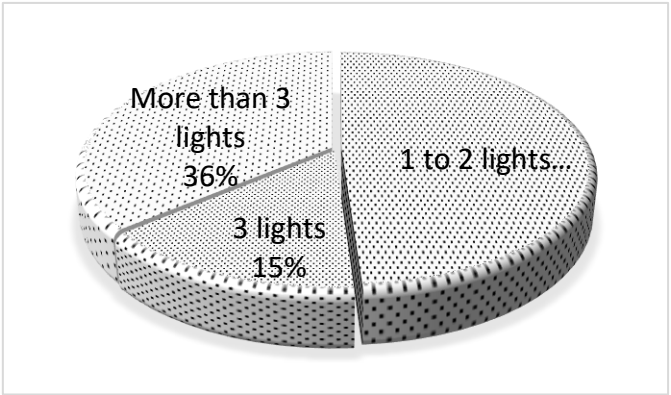


Figure 4.8: Number of electric lights per household

When responding to adequacy of lighting needs 43% of the respondents indicated that their lighting was adequate, and 39% said it was acceptable. For insufficient and not adequate it was 9% each, respectively, as shown in Figure 4.9.

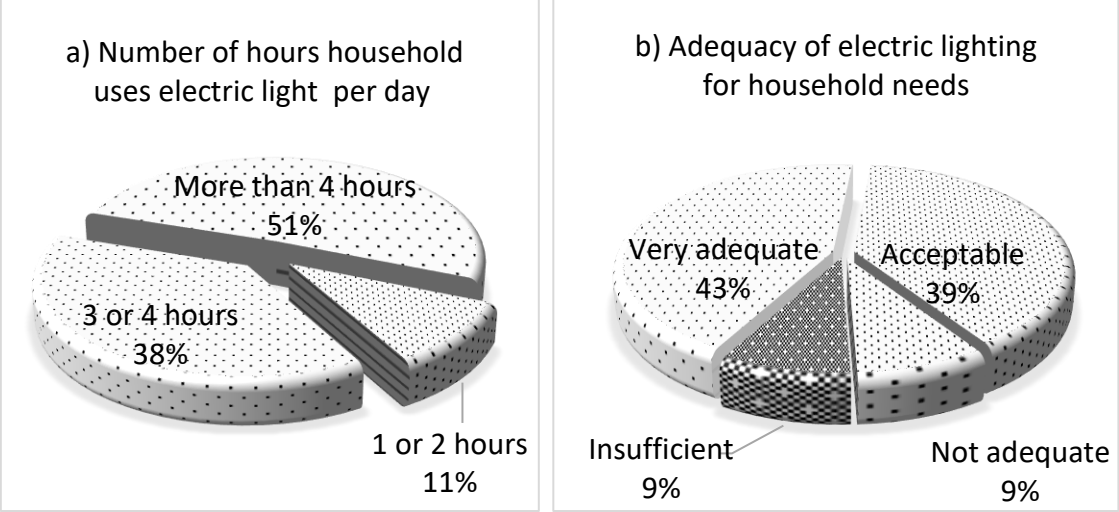


Figure 4.9: Adequacy of lighting services in Tsumkwe households

The 18% that felt it was not adequate wanted something to be changed about their lighting. This was not possible because of various reasons. Some household heads as much as they wanted to change they could not do that because they did not have the money to add more lights. There was also need to adhere to safety measures. Most house structures do not meet the safety standards so more lights cannot be added. One of the attributes of energy access is safety.

4.1.3 Cooking and heating

4.1.3.1 Energy for cooking

Findings from the respondents were that 30% used LPG for cooking, 66% used wood and 4% used electricity as shown in Figure 4.10. RE is all about efficiency. Solar photovoltaic

systems cannot be used for thermal applications. When the PV system was installed, households were provided with two, nine kilogram gas bottles. This was to cater for cooking energy. However there were some people who still used electricity, though this was not allowed.

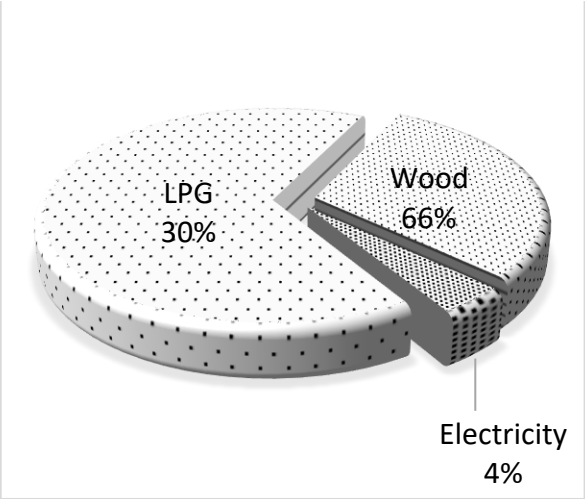


Figure 4.10: Source of energy for cooking

The results showed that 66% of the respondents use firewood for cooking. When asked why people continued to use fire wood, some said that when the power station was installed they would go for months without gas supplies. The other reason was that as much as they were gainfully employed their income was not enough to buy LPG regularly but would rather use the money to buy food and provide for other family needs. All the interviewed respondents who used firewood for cooking did not have improved wood cooking stoves.

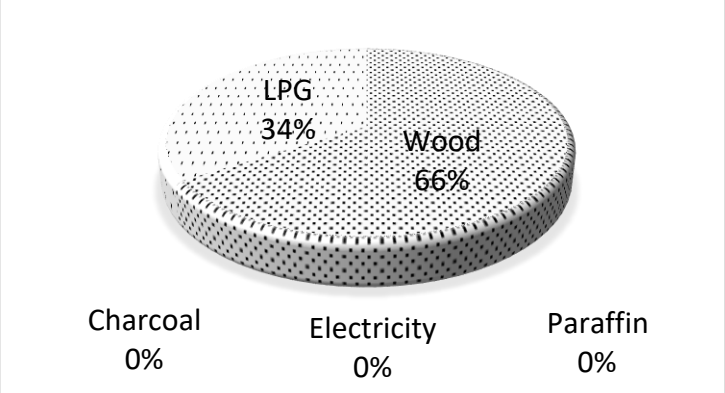


Figure 4.11: Main source of energy used for cooking

The two main fuels used for cooking in this community are firewood and LPG. As much as fire wood is the main source of cooking fuel the majority of the respondents still prepare more than two meals a day (Figure 4.11).

4.1.3.2 Energy source and cooking frequency

Although 66% of the respondents used fire wood for cooking, more people still afforded to have at least two meals a day (Figure 4.12). This could be attributed to the fact that the source of energy that they use is cheaper and easily accessible.

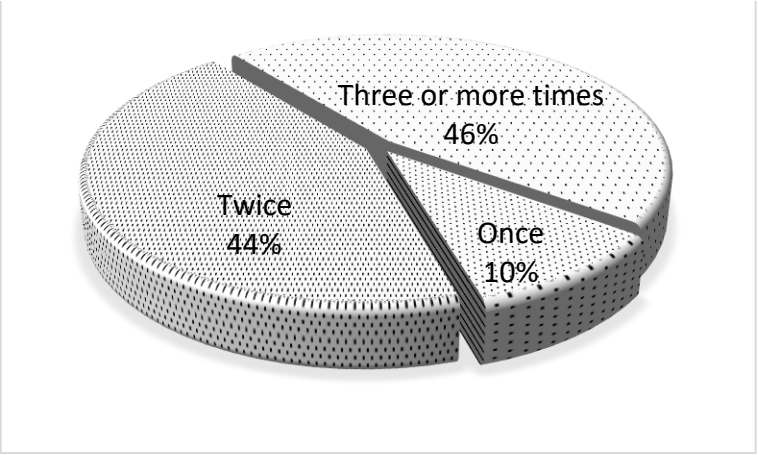


Figure 4.12: Number of times the household cooked meals per day

4.1.3.3 Energy source and type of stove

The type of stoves used in the households support the type energy used as presented in (Figure 4.13).

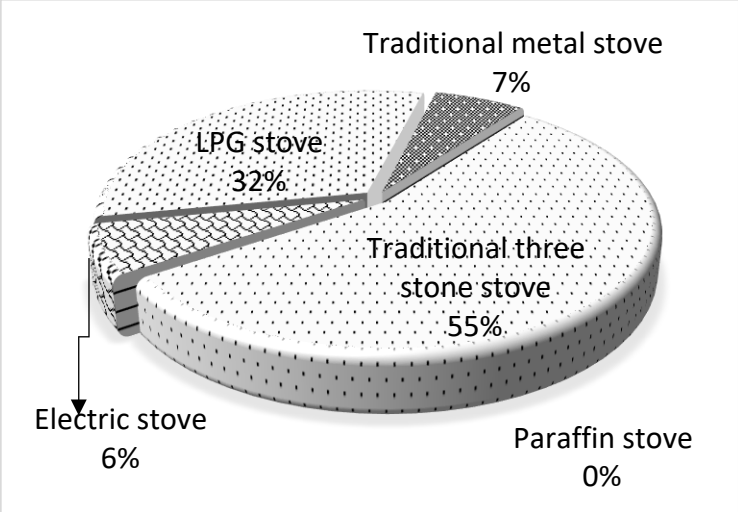


Figure 4.13**:** Type of stove used

Most of the households (55%) used traditional three stone stoves, and 7% used traditional metal stoves. No one used paraffin, while 32% used LPG stoves, and 6% still used electric stoves. This 6% might be a reflection that some people did not assimilate the education on the types of appliances that can be used for different type of RETs.

4.1.3.4 Ways of obtaining sources of cooking energy

Some household gather and purchase their cooking fuel (firewood) and they were 28%. Those who obtained their fire wood by gathering were 39%, 20% purchase and 13% did give definite answer (Figure 4.14). The 20% who purchase fire wood indicated that for a household with an average of 4-9 people they need at least five bundles of fire wood per

month which cost them at least N$100 unlike buying a nine kilogram tank of gas which cost N$380.00 and is used in one month.

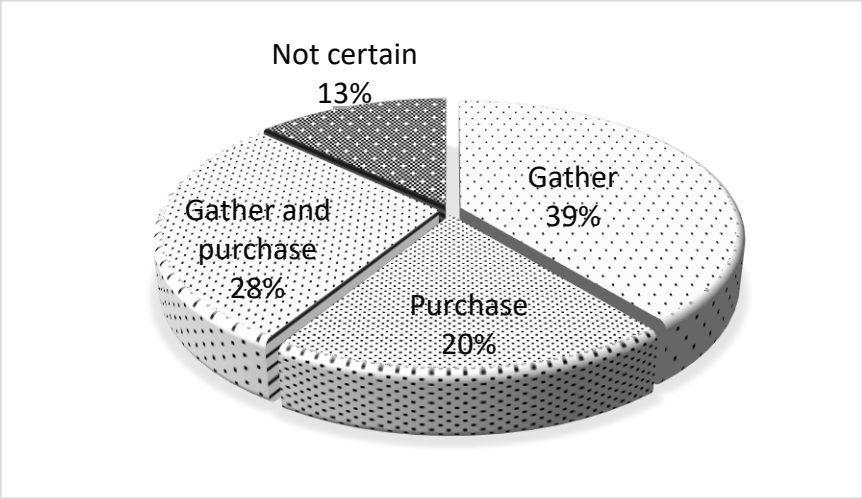


Figure 4.14: Ways of obtaining cooking energy

Interestingly, very few respondents wish to improve their source of cooking fuel. There is no marked difference between those who think that their source of fuel is clean and those who say it polluting, which is 43% and 46% respectively. This could be that they do not have other alternative and affordable sources of fuel that can substitute firewood (Figure 4.14).

4.1.3.5 Source of energy and its cleanliness and safety

The finding from Figure 4.15, showed that the respondents felt that their method of cooking was safe, possibly because they did not have other alternatives cooking methods to compare with. The people in the community of Tsumkwe have always been using fire wood as a source of energy, thus the introduction of another method may take time for them to adjust and accept.

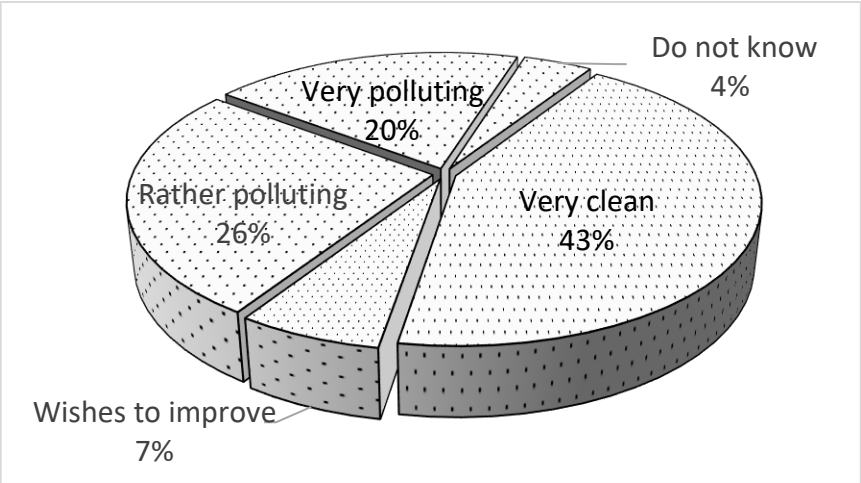


Figure 4.15: Perception on the cleanliness of cooking method

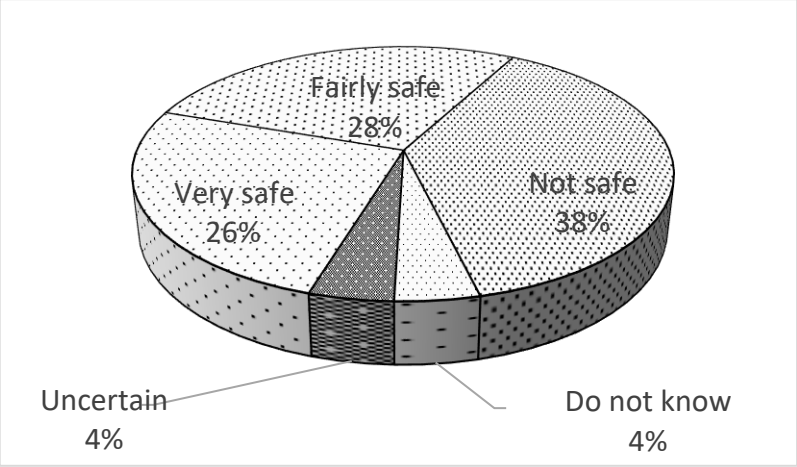


Figure 4.16**:** Perception on the safety of household's cooking method

4.1.4 Space Heating and Cooling

4.1.4.1 Availability of space heating and cooling devices

Electricity was in general not used for space heating and cooling in Tsumkwe, so most did not have any air conditioning devices (Figure 4.17).

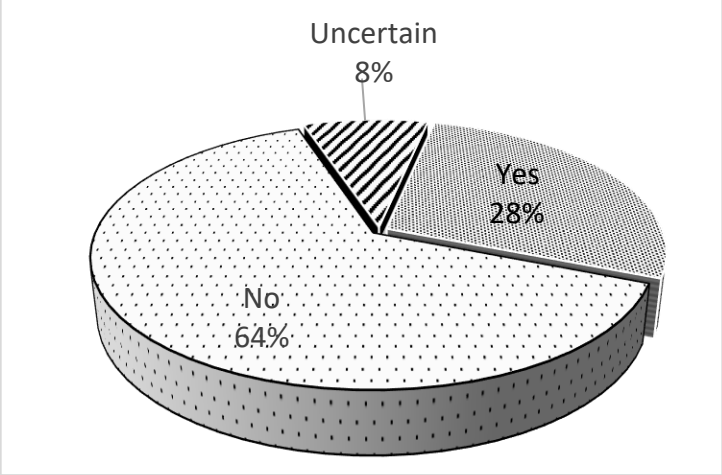


Figure 4.17**:** Room cooling device

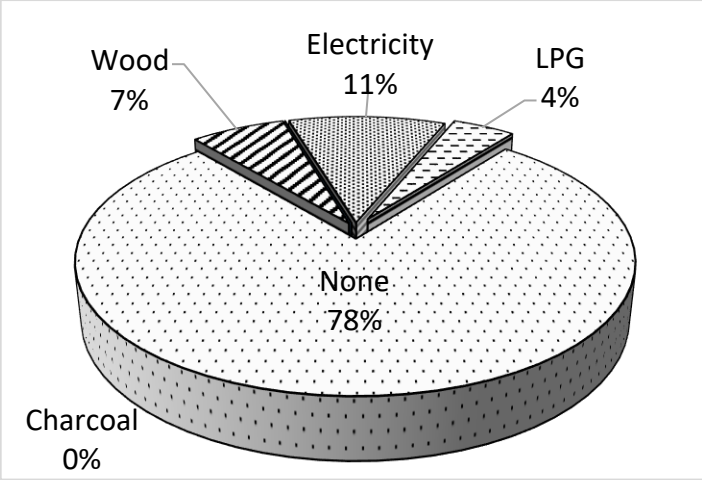


Figure 4.18**:** Fuel used for space heating

The responses in Figure 4.18 were that 78% do not use any form of fuel for space heating, 11% use electricity, 4% use LPG and 7% use wood. They said that during winter they use blankets to keep warm. Cost of electricity is expensive so they do not afford to use it for central heating. When considering the definition of energy poverty in relation to cooking and heating Tsumkwe community still experience energy poverty.

4.1.4.2 Methods of space cooling and their efficiency

In summer Tsumkwe experiences very high temperatures which are 32ºC-34ºC (Mendelson 2002).This makes it imperative to have good cooling system in the houses. When asked if the houses were sufficiently cool throughout the year 79% said no and 17% said yes (Figure 4.19). Of the respondents 44% had no way of keeping their houses cool such that the alternative way was to leave the windows open for those who had them which was 23% and 29% had electric fans (Figure 4.20). Those who had electric fans were of the opinion that it was more of a want than a need it use led to increased cost of electricity. They said that they can always stay outside under the shade and even sleep outside to keep cool.

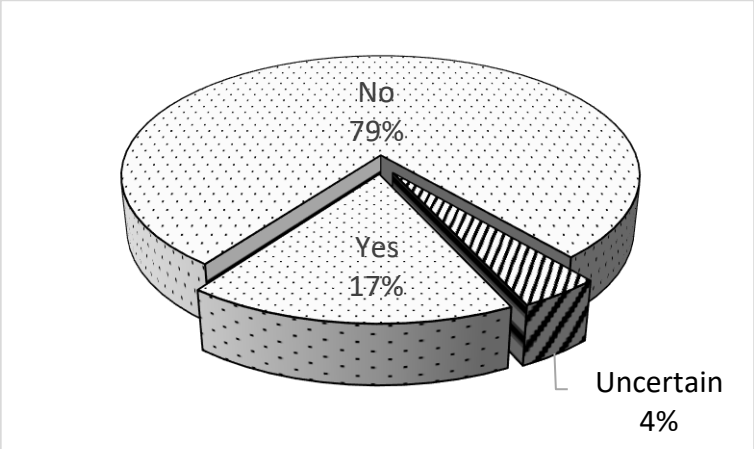


Figure 4.19**:** Perception on efficiency of room cooling

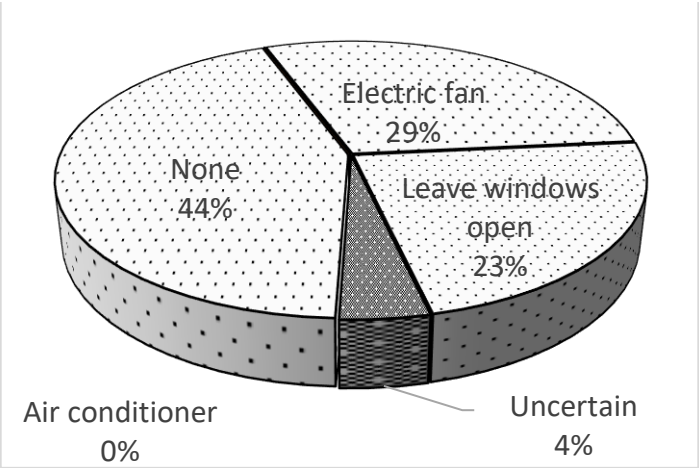


Figure 4.20**:** Method used to cool the room

4.1.5 Refrigeration

4.1.5.1 Appliances used for cooling food

It can be observed, from Figure 4.20, that most of the households (72%) had some appliance to keep food cool, while those who did not have were 24%. The 72% who had an appliance to keep food cool had an electric fridge. The people have access to fresh food and can eat different types of food that they want. Figure 4.21 showed that 72% had electric powered refrigerators and no one used gas for refrigeration since it was established that it is a rather expensive source of energy and difficulty to secure.

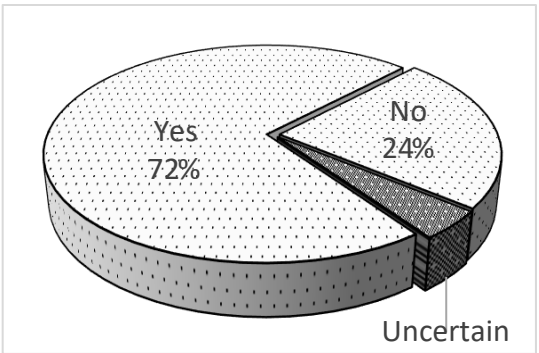


Figure 4.21**:** Respondents who owned some appliance for cooling food

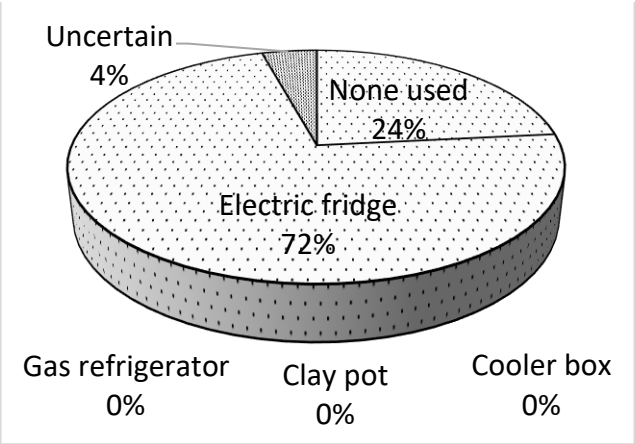


Figure 4.22**:** Type of appliance used for cooling food by the respondents

The general comment was that there was shift from dry foods to fresh food. They can buy food in bulk without the fear that it will go bad. Small businesses which utilizes domestic fridges are very common. People now sell soft drinks, ice coolies and fresh fish from their homes. There are several bars where beer is sold. This has helped to supplement families' income, and availing more functions and capabilities for the community of Tsumkwe Settlement.

Electricity which is provided for 24 hours a day led to establishment of a butchery, which supplies fresh meat to the community. Selling of meat under the trees is now a thing of the past. The cooling has also positive impact of the local clinic where they have a conditioned pharmacy, vaccination fridges and a functioning police mortuary.

4.1.6 Information and telecommunication services

4.1.6.1 Availing of information and access to telecommunication services

Access to electricity has led to connectivity to the external world, for the community of Tsumkwe. This is through television and radio, telephone, internet, and other media. The majority of the sampled population (81%) as shown in Figure 4.23 owned cell phones. This is easy and quick way of passing of information. Even those who did not own one still had access to a telephone either through their neighbour, work place or at the community centre.

Problems can be solved on the phone without spending a lot of money, people could now easily send and receive money using their cellular phone. It was also easy to make payments or to buy electricity using the phone. Everyone was very excited that they could now purchase their electricity without walking to the Central Northern Electricity Distribution Company (CENORED) office.

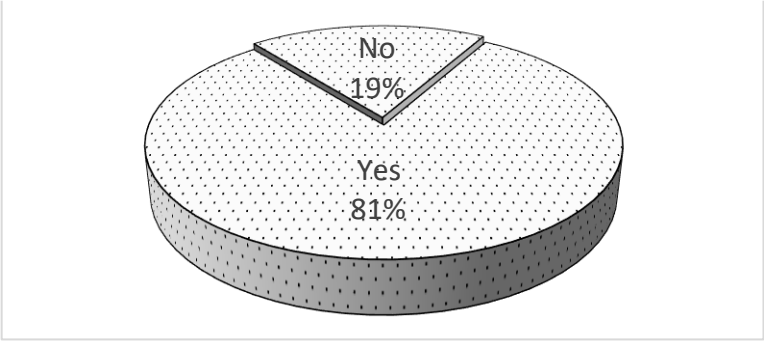


Figure 4.23**:** Availability of telephone at respondents' homes

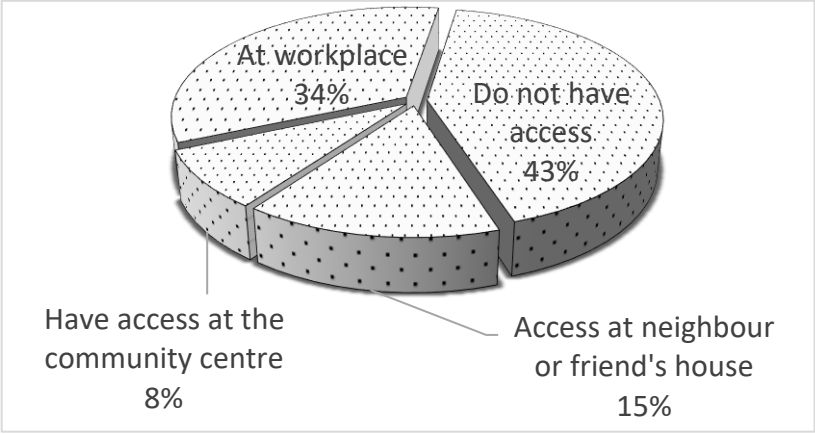


Figure 4.24**:** Modes of accessing a telephone

Besides owning a cellular phone people still have other options to communicate with others. There is a community centre where they can use the telephone, electronic mailing which is indicated by 8% of the respondents, others use the telephone from their work places which was 34% and 15% could access the phone from a neighbour. This translated to 57% of the respondents had access to a mode of communication, while 43%, did not have access to any of the mentioned alternatives (Figure 4.24).

4.1.6.2 Television

Eight-three % of the sampled homes had television sets, giving them contact with the outside world. They, therefore, celebrated with others special occasions like Independence Day, and got to watch soccer matches. Although people had televisions in their homes some enjoyed watching with friends so they went out to the bars with TV sets, or went to watch at a friend's house.

Most households owned a radio or a television set. This community has access to electricity under Tier 2 (Table 2.1) and this makes them to be abreast with what is happening around them. According to those who do not have access they can access this service by visiting friends or going to the community centre.

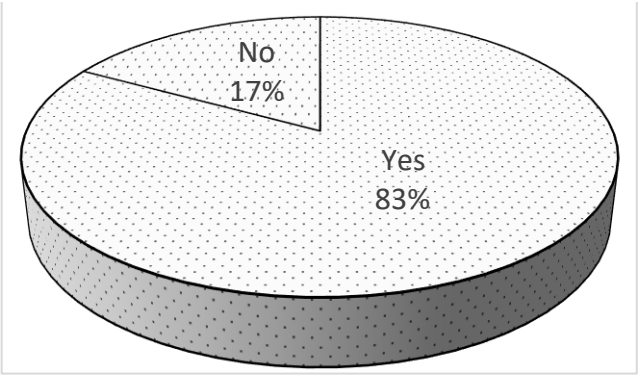


Figure 4.25: Ownership of television/radio

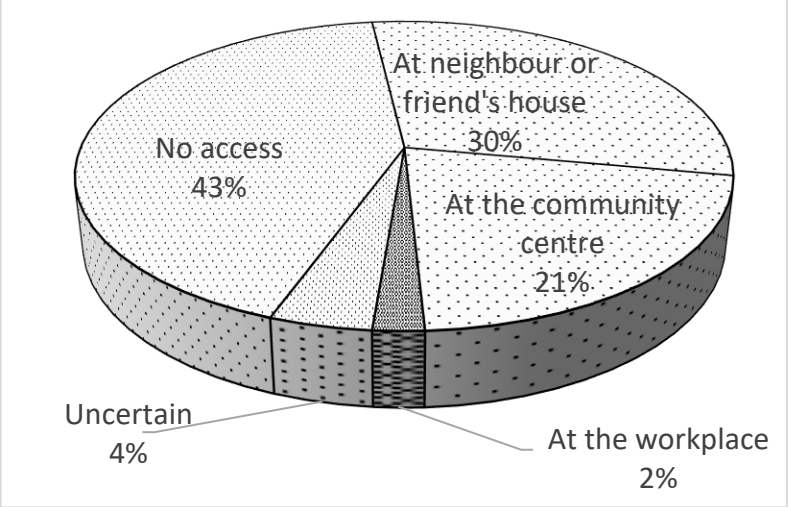


Figure 4.26**:** Access to television

Most households did not have access to the internet in their homes (Figure 4.27), but they utilised the library if there was need (Figure 4.28). Ninety eight percent of the sampled households said they did not have access to the internet.

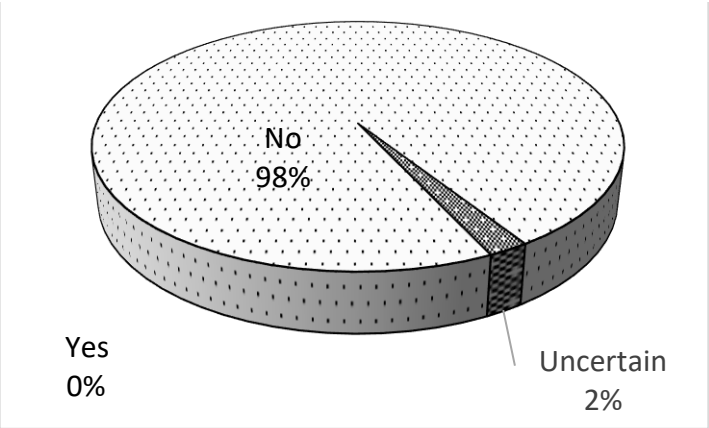


Figure 4.27**:** Access to internet at home

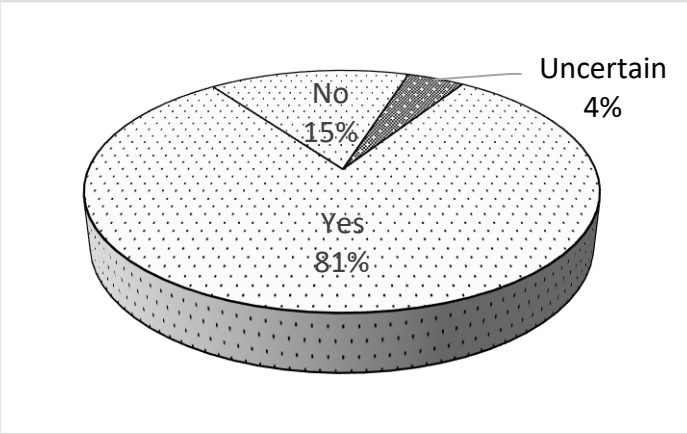


Figure 4.28**:** Availability of the library

4.1. 7 Health care services

4.1.7.1 Availability of health care services

The health services greatly improved because of the availability of electricity in Tsumkwe settlement area. According to the responses 49% said they had access to medical services for 24 hours and 47% said they did not have access to medical services.

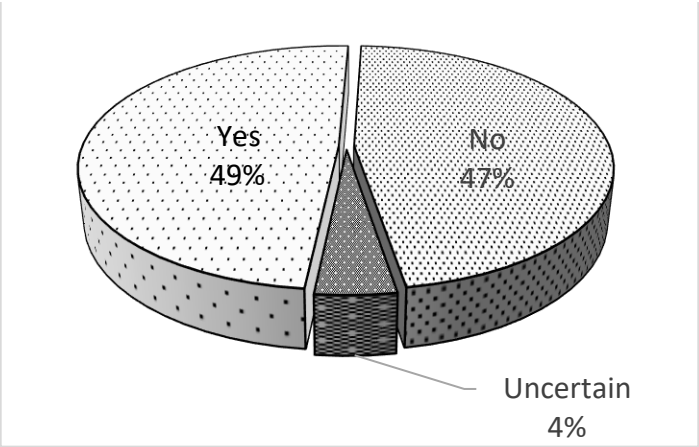


Figure 4.29**:** Availability of medical services

While talking to the Sister in charge at the clinic, indicated that the clinic's normal working hours were from 8 am to 5 pm. However if anyone needed help after hours, there was always a nurse on duty to attend to them. This could explain why 47% of the respondents said they did not have access to the health services. The clinic's time table for working hours also clearly stated the working hours were 8 am to 5pm and during weekends the attended to emergency hours from 8am to 5pm. It does not provide information that the clinic can be accessed after hours.

4.2 QUALITATIVE RESEARCH FINDINGS

In order to substantiate quantitative data, qualitative data was collected through interviewing local community members, upcoming business owners, and heads from different government institutions. An interview guide was used in the collection of indepth data from the key informants, and from the focus group discussions. The key informants were purposely selected so that they would give relevant information to answer the identified objectives of the study.

4.2.1 Employment opportunities

The provision of electricity 24 hours a day at Tsumkwe has enhanced employment opportunities. The distribution of people employed at different institution and businesses was as shown in Table 4.7.

Results from the key informants revealed that the institutions and businesses had 137 employees comprising of 79 males (57%) and 58 females (43%). These business and institutions had the affirmative action where the people of Tsumkwe community had the first priority when it comes to employment.

Table 4.7**:** Distribution of workforce and the number of years at the same work place

Entity	**Number of staff members**		**Longest time served by member**
	Male	Female	
Ministry of Environment and Tourism	4	9	6 years
Tsumkwe Clinic	2	2	2 years
Tsumkwe Police Station	16	7	16 years
Tsumkwe Settlement Area Administrative Office	7	4	10 years
Tsumkwe Lodge and Training	16	9	12 years
Tsumkwe General Dealer	9	1	3 years
Butchery	2		3 years
Bar	1	1	4 years
Take-away	1		2 years
Tuck shop	1		3 years
Primary school	11	16	5 years
Secondary school	9	9	5 years
	79	58	
Grand Total	137		

The provision of electricity may also have attracted skilled personnel to come and work at this settlement. There are some employees who have stayed at their work stations for a maximum of 12 years and the shortest is two years. At the government institutions those who have the shortest period are coming from university and very young, and the reason that has attracted them to this area is the availability of social amenities found in other urban areas and also available in this community.

4.2.2 Execution of duties

4.2.2.1 Schools

All the key informants, whether they are business owners or officials from the government institutions, acknowledge some improvement in the execution of their duties. The school heads mentioned that they could operate all their electrical appliances such as printers, computers and projectors and this has also enhanced the teaching and learning process. Instead of just explaining ideas, they could also teach using audio visuals aids such as short documentaries. These teaching methods cannot, however, be linked to improved pass rates for the senior secondary learners.

4.2.2.2 Police Station

At Tsumkwe police station they have reported a decrease in house-breakings and this they attributed to street lighting. Trends are as follows in 2014 is was 125 and in 2015 it has dropped to 83 cases. In 2016, they recorded 57 cases and in 2017 it has dropped to 48.

Although it is not as significant as between 2014 and 2015 but the settlement as continued to experience a drop in crime cases (Crime Statistics Tsumkwe: Crime Investigation Unit, 2017). The availability of electricity for 24hours has led to the sprouting of bars which sell alcohol within the community. These have created a social problem within the community where there is a rise in crimes related to common assault and assault with grievous bodily harm (assault G.B.H). Availability of electricity has also made it easy for them to respond when a crime has been reported because of faster methods of communication especially the use of cell phones.

4.2.2.3 Small and Medium Enterprises

People in the community of Tsumkwe are engaged in different types of small business enterprises. Most of the use appliances which do not consume high electrical power. Most sell drinks and alcohol which are kept cold in the home and business fridges. In the community it was identified that nineteen businesses are operated and run from home.

This has helped to increase the household's income. The businesses that sell perishables mentioned that their products now stays fresh longer and they no longer incur losses due to power outages. Those who prepare food mentioned that it is now faster and easier because of the use of appliances like the deep fat fryers for chips and the micro-wave ovens.

4.2.2.4 Health care services

The nursing staff were able to attend to patients during the night, without having to use lanterns or torches. Electricity had improved the rapid testing system for HIV/AIDS as well as TB testing because they now had refrigerators where they could store the testing kits.

This had seen forty nine patients tested, and being treated for Tuberculosis (TB). The clinic had an air conditioned pharmacy which had resulted in well stocking of the clinic, and patients could access all the services they needed without having to travel to Mangetti Duin or Grootfortein Hospitals.

Generally the people in this community could access medical services for 24 hrs. This also supports the notion of improved quality of life. The existence of this clinic also means that people within the area can easily access medical help. In instances where the clinic cannot offer help patients are referred either to Grootfortein or Mangetti Duin Hospitals, where there are some general physicians.

Statistics showed that the clinic attended to an average up to 600 patients every month. The clinic provide HIV/AIDS testing, malaria and tuberculosis. At the time of the research forty nine patients were receiving treatment from the clinic. A study carried out in Tsumkwe Constituency in 2016 and Tsumkwe Settlement Area included had the highest number of infections of 38 patients (Thomas, 2016). Statistics from the clinic, showed an increase in the number of patients being treated. The clinic has a soup kitchen providing patients with food so that they would not take medication on an empty stomachs, and also as a way of monitoring the taking of the drugs and avoidance of relapse.

Infant mortality rates: No death had been recorded from ailments like diarrhoea or any other diseases. The sister in charge at the clinic said that they did not have such records because they referred the serious cases to the two main health centres.

4.2.2.5 Energy access and cooking

When the community was availed with electricity efficient methods of cooking were also provided to the people. Households were provided with a gas stove to replace the electric stoves and a nine kilogram LPG gas tank. This was meant to provide with clean and efficient cooking solutions. However for most households this was not sustainable because of the costs attached to acquiring the gas. Most of the households went back to the use of firewood after they had used up the gas. Others mentioned that they used gas, in winter and when it rains, to prepare and warm water for the children when they are going to school. Most households gather or purchase their firewood. It must be noted that those who use fire wood said it is a safe and cheaper source of energy for cooking. Although they said that is also becoming difficult to get the fire wood because they now have to travel long distances to gather the fire wood.

Most of the households did not have efficient cook stoves since they used the traditional three stone fireplace as stoves (Figure 4.29 (a)). Cooking with fire wood had always been the way of providing for cooking fuel. Besides that, to them the gathering of the firewood did not bother them because it was “a normal chore”. They also agreed that they now spent more time looking for the fire wood unlike in the past (Figure 4.29 (b)). More time spend on the collection of fire wood is lost for other productive activities.

(a) (b)

Figure 4.30: (a) Typical three-stone fireplace commonly used by Tsumkwe households, and (b) typical bundles of firewood observed at one of the households. Source: Author

4.2.2.6 Energy access and water heating

Houses in the Government location had solar water heaters installed, however other locations did not have this facility (Figure 4.30). The community revealed that it was difficult for them to have hot water during winter, and they relied heavily on fire wood to warm their water for bathing during the morning.

(a) (b)

Figure 4.31: (a) Houses with solar water heaters in Government Location;
(b) Houses in Sewe Location did not have solar water heaters. Source: Author

4.2.2.7 Energy access and lighting

The discussants said that the number of lights that were provided in their homes was generally sufficient for their needs. However, some felt that they would need more lights fitted in their homes. When light fittings were done the minimum that a household could get were two lights. However, since 2012 some homesteads have grown and more structures have been built. The new rooms need more electric lights fitted. They said what was now difficult was that, the inspectors condemned those structures as not meeting the required standards to have them fitted with electricity.

(a) (b)

Figure 4.32: (a) Homestead provided with electricity (2012); (b) New homesteads that need to be installed with electricity. Source: Author: Field Data

The discussants were very pleased that they have electricity 24 hours a day because that they no longer experienced power outages since the taking over of the running of the power plant by Central Northern Electricity Distribution Company (CENORED) in July

2017. The company is responsible for the maintenance of the power plant and the procurement of diesel for the stand by generators. There were technicians on stand-by in case an emergency.

The community could now buy electricity using their cell phones, a thing which was praised by the community because this saved time, which could be used for other productive activities. Those running small businesses said this was very convenient because they did not have to close their shops. They also had a constant supply of cold beers. These were also the sentiments of the butchery owner.

4.2.2.8 Energy access and space cooling and heating

Tsumkwe constituency experiences extreme temperature both in summer of 34˚C and 14°C winter (Mendelson, 2002). This spells the need for efficient methods for space cooling or heating and enhancing thermal comfort. Most of the discussants said that electricity was costly for them to power either electric fan or heaters. Alternative strategies are used to keep cool or warm. Some of the houses were built using corrugated iron sheets as walls and roof, making the dwellings very hot during summer and very cold during winter. In summer, during the day people stay outside, and during the night they prefer to sleep outside. In winter people bask in the sun during the day. They are not able to make fire in the house to keep it warm in order to save the fire wood. They normally wear warm clothes.

4.2.2.9 Energy access and communication and entertainment

Almost all the respondents interviewed had a cell phone and had also access to some means of communication. Before the installation of the power plant people used to use the public

telephone but they have their own cell phones since it is now easy to charge them in their homes. They could access national and international news through the radio, which broadcast news and documentaries in their local languages, from the radio station located in the settlement. For those who did not have access to television, the community centre and most of the bars dotted within the community had television sets where they go and watch news, and soccer matches of popular teams.

4.2.2.10 Energy access and safety

The provision of street lights along the main roads of the settlement has led to the improvement of safety during the night (Figure 4.33). Most women had the sentiments that they were able the work until late and felt safe to travel back home because of the street lights. Visibility during the night had led to decreased muggings, as was also supported by the data provided by the Tsumkwe Police Crime Investigation Unit.

(a) (b)

Figure 4.33: (a) Electrically lit street in the Tsumkwe settlement during the night; (b) Street during the day. Source: Author

4.2.2.11 Energy access and public communities

Availability of electricity 24 hours a day without interruption enabled public communities to use all their electrical appliances. Community members could have their documents scanned or photo copied at the police station or community centre, something that could take days to do before, because of power outages. The police station has a functioning mortuary which was a relief to the community when the relatives pass on. They could wait for relatives one to come and pay respect to their loved ones.

Availability of electricity 24 hours a day without interruption has led the community to fully utilise the local library. Various young men and women working in various government institutions said they had been able to continue with their studies without having to travel to the nearest town, which was 250 km away, using facilities at the library. This has been an incentive for some people to stay at the settlement because they did not feel left behind.

4.2.2.12 Youth and employment

Most youth felt that more should be done in order to provide for employment opportunities. As much as they had attained some technical skills the community institutions seemed to provide jobs to people with professional skills. A number of young men and women who had acquired skills in welding could not start their own enterprises because they could not access funds to buy the equipment or afford to buy LPG as the source of fuel in the running of their businesses.

4.3 SUMMARY

The impact of renewable energy provision, and availability, on human beings, was evaluated through a survey that was undertaken in households, business enterprises and public institutions. Data was collected, and the capabilities theory was applied to analyse the social and economic benefits realised from such intervention, and generate the findings.

5. CHAPTER FIVE: DISCUSSION OF RESULTS

The main aim of providing electricity through the installation of a mini-grid at Tsumkwe settlement area was to provide uninterrupted electricity for 24 hours per day, which in turn was to provide significant socio-economic benefits and improved service delivery to the community of Tsumkwe and surrounding communities. From 2012, the photovoltaic mini-grid energy access and use has had an impact on the lives of the users. In order to evaluate the impact of this initiative the Capabilities Theory has been applied. The main assumption of the Capabilities Theory has been that the provision of a resource or service will widen the people's freedom and choices to enhance their livelihoods and quality of life.

5.1 ENERGY ACCESS IN TSUMKWE

The community of Tsumkwe has benefited from the provision of electricity. The impact is felt when it is viewed from household consumption (lighting and powering of less energy consuming appliances) communication, entertainment and safety (ESMAP, World Bank, 2011). The provision of electricity has also increased employment opportunities and extended working hours during the night. Some of the respondents indicated that provision of electricity, and availability of communication facilities had drastically reduced costs especially for sending money to their relatives, through the use of their cell phone as supported by studies carried out by Feron, (2016) and Elizinga, (2011) Access to the internet has also helped to facilitate distance learning as highlighted by other interviewees. However provision of efficient and sustainable thermal energy for cooking and heating has

not been very inclusive because some people still do not use efficient methods of cooking and heating (Von Oertzen, 2016).

In reference to the Multi-tier Framework Table 2.1, World Bank, (2011) and electricity consumption as regards the attributes of energy access, the community of Tsumkwe can be classified as having reliable, affordable and convenient electricity. More than 80% of the sampled population had electricity for more than 22 hours and Tsumkwe falls under tiers 3 and 4, as described below:

- **Tier 3 -** offices are fully equipped, power for computers, the secondary school has computer lab. The clinic has a fridges for vaccinations, TB sputum and a cooled pharmacy. The government institution have all the necessary electrical appliances such copiers at all government institutions and amp plugs which has made work more efficient and faster.
- **Tier 4 –** comprehensive electrical energy services: this service tier provides complete coverage of all relevant electrical energy services in all buildings, thereby rendering it fully functional in terms of lighting, communications and IT services. However, all thermal needs are excluded in Tier 4, as it is assumed that these will be provided by non-electrical means, except refrigeration of essential medicines for clinics.

The provision of RE in Tsumkwe Settlement can be evaluated and justified through the MTF and its comprehensiveness in answering energy access by comparing the attributes of energy access to Tier 3 and 4. Maximum realisation of energy availability is measured if electricity is available for more than 12 hours. The community of Tsumkwe enjoys availability of electricity 24 hours a day. This fall under Tiers 3 and 4. The electricity

provided in Tsumkwe Settlement in terms of convenience, has proved be so since they do not experience any power outages. In term of health and safety the electricity in Tsumkwe is health because it clean unlike the diesel generators that were used before.

The fact that 51% of the sampled population used electric lights for more than 4 hours, while those who used lights for 1 to 2 hours were 11% and those who used for 3 to 4 hours were 38%, supports the ESMAP MTF's new definition of electricity access in Namibia, whether using the micro-grid or mini grid as default off-grid (EMCON, 2017). Access is defined as when the electricity supports, hour day lighting, phone charging, fan, television, fridge, and low power appliances. Such appliances that were owned by the sampled Tsumkwe households.

There is progression in the appliances that can be used in the energy ladder: in the past people could have light and fewer appliances while they were receiving electricity from the generator. The Tsumkwe community now has electricity 24 hrs a day without interruptions. The standard definition in Namibia for energy access is 12hrs a day, but with the installation of the power plant and the takeover by CENORED this confirms that Tsumkwe Settlement Area is in tier 4 Multi-Tier Framework, Table 2.1 supports this assertion.

5.2 ECONOMIC IMPACT

The provision of electricity, to a greater extent, has provided economic opportunities to the community of Tsumkwe. From the respondents interviewed, nineteen businesses were identified, and were running businesses at home while using electricity, besides other established businesses. Provision of electricity has motivated people to start small businesses and to expand the existing ones. This supports the Capabilities Theory where people are given more opportunities and choices through the provision of a resource. Feron, (2016); Balachandra, (2016) and the United Nations Human development Report, (2016), also support this theory, where businesses and services have increased due to the provisions of electricity.

5.3 EDUCATION

All homes had at least two lights and that has extended the working day of the community of Tsumkwe. At the secondary school learners and adult learners can go and attend classes during the night. The school heads also confirmed the diversified use of teaching aids and information and communication technology (ICT). The shortage of teaching materials such as textbooks is no longer experienced at both primary and secondary schools. This has improved the quality of educational materials being offered to the learners. However this could not be directly related to the pass rate at the school. Sapkota, (2014), and studies done by Bugaye, (2006) in various African countries South of the Sahara state that provision of electricity in schools extends the study hours through the provision of electricity for 24

hours. A study done in Peru in 2005 revealed that school attending children from households with electricity spend an average of 65 minutes per night reading/studying, whereas students in households without electricity spend 51 minutes on the same activities (Aguirre, 2005). This can also be supported from the result obtained from this survey where 89% use electric lights two hours and more.

5.4 ENERGY POVERTY AND COOKING

Energy access must include clean cooking alternatives. However, at Tsumkwe settlement the majority of the population do not have access to clean cooking methods. They use firewood for cooking and for warming their water. Von Oertzen, (2016), also revealed that the use of fire wood is still prevalent in both rural and urban areas of Namibia. The reason the respondents raised for still using fire wood was because it was easy to get and also cheaper than using LPG. Solar water heaters are found at the government houses, and those households are also the same that use gas stoves for cooking. The provision of sustainable energy for cooking was not taken into account. Many people still use unreliable and inconvenient methods of cooking. This shows unlimited choices in terms of cooking fuels. UNDP/WHO, (2009), and Morrisey, (2017) mention that more than 2.7 million people in the world still use biomass for cooking. The use of unclean means of cooking jeopardises the achievement of the aim of Sustainable Energy for All (SE4LL) by 2030.

The use of firewood also takes up time and leads to drudgery when people go and collect the fire wood. This is a task which is usually done by women and girls. In the study it was revealed that the health of some of the community members is compromised due to carrying heavy loads especially on their back or shoulders. Money which is supposed to be used for

other purposes like buying food is often used to buy medicine and food for the sick. The use of fire wood has also led the girls in not having equal opportunities as boys.
They spend more time cooking instead of studying as their counterparts (Sapkota, (2014); ADB, (2010) and Cockburn, (2005).

5.5 IMPROVED SOCIAL WELFARE

Poverty is multidimensional, including energy poverty (Reddy 2015). The provision of electricity at Tsumkwe has led to enhancement of livelihoods and life styles. Utilisation of electricity from the power plant brought general happiness and comfort among men, women and children of Tsumkwe community. This was evidenced by assertions during the current study where the community highlighted that, due to availability of street lighting, they feel safe to walk during the night.

Access to electricity has enabled the users to access media from the television or radio because the availability of the NBC and uninterrupted power supply has kept the community abreast with news happening in Namibia and around the world. People with electricity are informed and educated about the current affairs in the country and beyond its borders. Besides access to the world information, the community is now continuously provided with clean water from NamWater, because the plant is connected to the power plant. At the clinic, reported cases of water borne diseases such as diarrhoea are very few and community during group discussions reiterated that they no longer eat stale food, their food does not go bad because of the availability of electricity.

The community also felt that the provision of electricity had made it possible for them to get and eat fresh foods. It was noted by Azimoh et al (2017) that there was an influx of people buying fridges both for their businesses and for home use. Since the provision of the power plant, selling of meat under the tree is now a thing of the past. There is a butchery that has been operating for three years proving the community with fresh meat.

Energy can be a means out of poverty for these families and communities. Providing them access to affordable energy services will be required (Pachauri, 2004; Practical Action, 2014). Energy can reduce poverty, create jobs and spark economic growth. IEA has identified energy sources as a necessity for economic and social development. Electricity to impoverished areas would provide lights, heating, and potentially appliances. However, it is important to realize that in order to improve the lives of the poor it is necessary to improve access to energy efficient resources and an adequate supply of energy at an affordable rate (Pachauri, 2004). This has been the case in Tsumkwe community, where people can purchase electricity for their household needs.

Studies conducted in South Africa, on impact of energy access on the quality of life of poor communities, showed that women travelled long distances to obtain fire wood (Dinkelman, 2011). During these trips women were physically attacked. Installing a form of electricity or lighting in communities decreases the occurrence of crime in the dark. Furthermore, Martins, (2005), mentions that there is evidence that the number of accidents in electrified areas is lower than those for non-electrified areas. Electricity reduces safety concerns for women and children. There is significant improvement to the well-being of the community due to access to electricity.

5.6 ENERGY ACCESS AND INFRASTRUCTURE DEVELOPMENT

Electricity access has resulted in the development of infrastructure in some areas in Tsumkwe. Tsumkwe secondary school was constructed and the general dealer in the community was expanded. The general dealer has a division which sells LPG to the community. Bank Windhoek has installed an Automated Teller Machine (ATM). People no longer travel long distances to buy LPG or access their money.

Due to the increase in population at the settlement, the local authority has been building low cost houses, and the master plan for home and commercial stands has been approved. However electricity availability seems to not have attracted big investors to come and build either a shopping mall or an industry related to tourism, since this community is found within one of the largest conservancies in the country (Tsumkwe conservancy). It can be concluded that that provision of electricity is not always accompanied with industrial development, rather the improvement of already existing infrastructure
(Wamukonya and Mark, 2001).

Bhattacharyya (2012) states that, electrification does not necessarily lead to poverty reduction or economic development. Adding on to that, an evaluation of the World Bank rural electrification projects found out that the benefits of rural electrification continue to accrue to non-poor households and that productivity application of electricity is rare (World Bank, 2008). As electricity is mostly used for lighting and operating a television, its direct impact on income generation or economic growth is limited. In addition, the quality of

supply often remained unsatisfactory and rural consumers did not receive reliable supply when they needed it.

Contrary to the assertions by Bhattacharya, (2012), and World Bank, (2008), the provision of renewable energy in Tsumkwe has helped to address the multi-dimensional nature of well-being. The Capabilities Approach has helped to show that after being provided with a resource (electricity) a person can do various things (functionings) and together with the ability to choose (capabilities) they can improve their education health, and employment opportunities. If a person possesses such capabilities they can choose a specific functioning to escape poverty (energy poverty and other dimensions of poverty).

5.7 SUMMARY

Although provision of electricity in rural areas has managed to improve the general wellbeing of Tsumkwe community, energy access has remained a challenge for productive economic development, which consumes high load of electricity. The promotion of offgrid mini-power plants have revealed a number of unsustainable features, including in ability to meet the present and future needs, and continued reliance on conventional traditional fuels which is already posing problem as the community members indicated that they now travel long distances to collect firewood. Therefore there is need for sustainable solutions in order to realise the desired objective of Sustainable Energy for All by 2030.

6. CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

The previous chapter has provided the discussion of the findings using the Capability Theory. This chapter will provide the conclusions drawn from the findings that have been presented in chapter 5 and provide recommendations of how this research could be improved, as well as recommendations on the replication of mini-grid power plants to other rural areas in Namibia.

6.2 CONCLUSIONS

Access to modern carriers of energy such as electricity and liquid petroleum gas has improved human development to the community of Tsumkwe Settlement Area. There were enhanced income opportunities for economic activities, through the establishment of enterprises that consume low energy. Provision of electricity at the community centre, secondary and primary schools, has helped people widen their means of acquiring knowledge and e-learning. The availability of electricity has widened the services provided by the primary health centre at Tsumkwe Settlement, which includes the screening for HIV and TB. The community of Tsumkwe does not have to travel long distances to get tested either for HIV or TB. This has also improved the quality of life of residence of Tsumkwe Settlement Area health wise an attribute of human development.

Electricity has helped the community to connect to the outside world. There is an improved access to information, facilitating knowledge gains, and enhanced social status with ability to participate and interact, and ability to take informed decisions. All these significantly enhanced the adaptive capabilities of individuals as well as the community of Tsumkwe as a whole. Since the community is informed they have the freedom of doing what they value.

One of the objectives of the study was to provide an appropriate definition of energy access in the context of Namibia. The definition of energy access was satisfied to a greater extent in Tsumkwe settlement area of Namibia. The people in the community are able to access the electricity which suffices main needs such as lighting, productive use, using low energy consumption appliances, and communication.

The photovoltaic power plant provides electricity 24 hours without interruptions and is safe to use. The community member now live in a safe environment because of street lighting. The people can access fresh food and have a wide choice of where to get it. The availability of electricity has made people to buy food in bulk and not worry that it might go bad.

However, the electricity provided cannot meet thermal heating needs for some of the community members because they cannot afford the alternative source of energy which is LPG neither for cooking, nor to drive heavy machinery. This has made people with skill like welding not to be able to start their own businesses. In this respect some of the community members are still energy poor. However, people's quality of life has improved to a greater extent in relation to safety, health, education, communication and provision of employment opportunities.

6.3 RECOMMENDATIONS

The research showed that provision of electricity through the power plant had afforded the community of Tsumkwe access to electricity. However some of the attributes of energy access were not met like affordability and quality. Replication of such off-grid systems is strongly recommended for similar communities, but there is need to have an in-depth needs analysis before such type of project is implemented in other rural areas of Namibia. This study did not quantify the economic impact of the availability of energy, this requires further research. Besides economic impact there is need for a critical appraisal of challenges the community may face due to the provision of electricity and its effects on the interruptions of social norms. A comparable study can further be done which looks at comparisons between pre-electricity periods, and conditions after its provision on health provision in Tsumkwe Settlement Area. For the policy makers, there is need to consider a holistic framework for the provision of energy services so that there is effective economic growth through renewable energy technologies. As much as electricity is provided, it must be affordable and easy to access. People should be afforded the opportunity to access alternative efficient cooking facilities and energy for productive use in order to get them out of energy poverty and give them choices to engage in various economic and human development activities.

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APPENDICES

8. APPENDICES

A1 Ethical Clearance Letter

University of Namibia, Private Bag 13301, Windhoek, Namibia
340 Mandume Ndemufayo Avenue, Pioneerspark
☎ +264 61 206 3111; FAX: +264 61 206 3791; http://www.unam.edu.na

UNAM
UNIVERSITY OF NAMIBIA

08 August 2018

The Research Supervisor: **Ms E Kimaro**
Department of Geography, History and Environmental Studies
Faculty of Humanities and Social Sciences
University of Namibia
Windhoek

Dear Ms Kimaro

Re: Ethical Clearance for Research Project of MA Student Theodora Chiguvare (201410254))

It is with great pleasure that the Faculty of Humanities and Social Sciences' Research and Publications Committee wants to inform you that your student's ethical clearance for the research project titled:

"AN EVALUATION OF HUMAN DEVELOPMENT THROUGH RENEWABLE ENERGY PROVISION IN TSUMKWE RURAL AREA OF OTJOZONDJUPA REGION IN NAMIBIA"

has been granted by the Faculty.

The details of this study that Ms Theodora Chiguvare intends to do have been reviewed during an ethics meeting on 03 August 2018.

The FHSS FRPC wishes you and Ms Chiguvare all the best with this noble project.

Kindly,

Dr M Janik
Chairperson: FHSS FRPC
University of Namibia
mjanik@unam.na

A2 Research Permission Letter - UNAM

University of Namibia, Private Bag 13301, Windhoek, Namibia
340 Mandume Ndemufayo Avenue, Pioneers Park
☎ +264 61 206 3111; URL.: http//www.unam.edu.na

UNAM
UNIVERSITY OF NAMIBIA

RESEARCH PERMISSION LETTER

Student Name: Theodora, Chiguvare

Student number: 201410254

Programme: MA (Geography)

Approved research title: Supporting human development through renewable energy provision in Tsumkwe rural area of Otjozondjupa Region in Namibia

TO WHOM IT MAY CONCERN

I hereby confirm that the above mentioned student is registered at the University of Namibia for the programme indicated. The proposed study met all the requirements as stipulated in the University guidelines and has been approved by the relevant committees.

The proposal adheres to ethical principles as per attached Ethical Clearance Certificate. Permission is hereby granted to carry out the research as described in the approved proposal.

Best Regards

22/09/17
Date

Dr M. Hedimbi
Director: Centre for Postgraduate Studies
Tel: +264 61 2063275
E-mail: directorpgs@unam.na

Centre for Postgraduate Studies
Office of the Director
2017 -09- 25
University of Namibia
UNAM

A3 Research Permission Letter - OR

Otjozondjupa Regional Council

MKWE MEN

TSU SETTLE T OFFICE

TEL: 067 244030/2/20 PRIVATE BAG 2070
FAX: 067 244031 GROOTFONTEIN

A3 Research Permission Letter - ORC

Our Ref:
Enquiries: **Ms.A.T Vries**

Your Ref:

TO WHOM IT MAY CONCERN

20 August 2018

This serves to confirm that Otjozondjupa Regional Council, the Settlement Area Authorities granted permission to Ms Theodora Mutauro Chiguvare, Student Number 201410254, a Master's student in Geography and Environmental Studies from the University of Namibia, to carry out research in the Tsumkwe settlement area and to collect data for her research, from the 21st of March to the 30th of March 2018.

Yours sin ely

L M
C A r

Mr. .N. asheshe
ontrol dministrative Office

Otjozondjupa Regional Council
Settlement Office
2018-08-29
Tel:
Box 1682
Grootfontein

A4 Consent Form

Consent Form for Participation in a Research Study

University of Namibia

AN EVALUATION OF HUMAN DEVELOPMENT THROUGH RENEWABLE ENERGY PROVISION IN TSUMKWE RURAL AREA OF OTJOZONDJUPA REGION IN NAMIBIA

You are invited to participate in a research study conducted by Theodora M. Chiguvare (student number 201410254). The purpose of this research is to find out if the provision of electricity in Tsumkwe has resulted in significant changes in human development. This includes improvement in availability of electrical energy, and its benefits in education, health, and social status, availing of jobs and economic activities and safety.

This study has been approved by the Research Ethics Committee at The University of Namibia and will be conducted according to the ethical guidelines and principles of the Namibian National Research Ethics Guidelines.

Your participation will involve provision of answers to questions from an interview schedule. Your responses may be recorded in order to capture your feedback accurately, and I kindly ask for you permission to record the interview. If you are not comfortable with that, your responses will be written down. There might be instances where photographs have to be captured and this is going to be done with your consent since they are going to be included in the research report. There are no known risks associated with this research. There are no known benefits to you that would result from your participation in this research in the form of gifts or money. However this research may help us to understand if the provision of the mini-grid has helped in the improvement of the standards of living for

the community of Tsumkwe, and if so, such projects can be implemented in other rural areas of Namibia far from the conventional electricity grid.

During and after the research we will do everything we can to protect your privacy. Your identity will not be revealed in any publication resulting from this study. The recordings will be kept safe by the researcher and later discarded after the study has been approved by the academic committee. When transcribing the recording, no identification will be used.

Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

Consent

I have read this consent form and have been given the opportunity to ask questions.

I give my consent to participate in this study.

Participant's signature_____ Date: _____

Acceptance pertaining voice recordings (Optional)

Participant's signature_____ Date: _____

Acceptance pertaining photographs (Optional)

Participant's signature_____ Date: _____

A5 Checklist during observation

Observation checklist

Place	What to observe	Comments
	Availability of street lights	
	State of the roads in the settlement	
	Frequency of people seen buying and selling different charcoal or firewood	
	Types of informal and informal business	
	State of housing structures and the type of material used for construction	
	Availability of private businesses in communication	
	Types of stoves used for cooking	
	State of the library	
	Methods used to keep food fresh in the shops	

A6 Interview schedule for the secondary school head

Date				
Gender				
Age				
Highest level of education				
Total number of members of staff	Female		Male	
Total number of ancillary staff	Female		Male	
Total number of learners at the school	Female		Male	

1	What are your roles and responsibilities?	
2	For how long have you been working at this school?	
3	Is Tsumkwe your home area	
4	For how long have you been working at this school	
5	Is electricity available 24hours a day, every day?	
6	If not, how long are the outages	
7	Since the establishment of the power plant how satisfied are you (rank from 1-4) (1) less satisfied (4) very satisfied. Circle the most appropriate answer	1 2 3 4

8	Has the availability of electricity improved the execution of your duties at work for you and other staff members?	
9	In what way(s)?	1 2 3
10	Do all students have the ability to study at home	
11	Does the school offer evening classes	
12	Whose cost are these lessons	
13	Does the school have a soup kitchen and which source of power is used for cooking	
14	Does he school have any electricity powered audio visual teaching aids- computers, projectors television	
15	Are there adult classes at the school	
16	Does the school have a school garden	
17	Does it have running water	
18	What has been the trend of the pass rate for the grade 10 and 12 learners from 2012 to 2016	
19	If there has been an improvement what are the attributes	
20	Since 2012 how has been the staff retention at the school	

21	How many learners are enrolled in junior and high school respectively	
22	How do you rate absenteeism at the school, is it very high or low	
23	What are the common reasons given by learners for being away from school	
24	Which gender is mainly absent	
25	Do you have anything to share that might add value to the study being carried out	

Thank you for your cooperation.

A7 Interview schedule for primary school head

Date				
Gender				
Age				
Highest level of education				
Total number of members of staff	Female		Male	
Total number of ancillary staff	Female		Male	
Total number of learners at the school	Female		Male	

1	What are your roles and responsibilities?	
2	For how long have you been working at this school?	
3	Is Tsumkwe your home area?	
4	For how long have you been working at this school?	
5	Is electricity available 24 hours a day every day?	
6	If not how long are the outages?	

7	Since the establishment of the power plant how satisfied are you (rank from 1-4) (1) less satisfied (4) very satisfied. Circle the most appropriate answer.	1 2 3 4
8	Has the availability of electricity improved the execution of duties at work for you and other staff members?	
9	Do all students have the ability to study at home, during the night?	
10	Does the school offer evening classes?	
11	Who pays for these lessons	
12	Does the school have a soup kitchen and which source of power is used for cooking	
14	Does the school have any electricity powered audio visual teaching aids- computers, projectors, televisions?	
14	Are there adult classes at the school?	
15	Does the school have a school garden	
16	Does it have running water?	

17	What has been the trend of the pass rate for the grade 7 learners from 2012 to 2016?	
18	If there has been an improvement what are the attributes?	
19	Since 2012 how has been the staff retention at the school?	
20	How many learners are enrolled in junior and high school respectively?	
21	What is rate absenteeism at the school?	
22	What are the common reasons given by learners for being away from school?	
23	Which gender is mainly absent?	
24	Do you have anything to share that might add value to the study being carried out?	

Thank you for your cooperation.

A8 Interview schedule for sister-in-charge at the clinic

Date				
Gender				
Age				
Highest level of education				
Total number of members of staff	Female		Male	
Total number of ancillary staff	Female		Male	

1	What are your roles and responsibilities?	
2	For how long have you been working at this school?	
3	Is Tsumkwe your home area?	
4	For how long have you been working at clinic	
5	Is electricity available 24hours a day	
6	If no how long are the outages	

7	Since the establishment of the power plant how satisfied are you (rank from 1-4) (1) less satisfied (4) very satisfied. Circle the most appropriate answer	1 2 3 4
8	Has the availability of electricity improved the execution of you duties at work for you and other staff members?	
9	How do you refrigerate your medication	
10	Does the clinic operate at night	
11	How far is the referral hospital	
12	Does the clinic have an electric powered mortuary	
14	Which are the common diseases treated at the clinic	
14	Since the installation of the power plant what are you observation on the infant and mortality rates.	
15	What type of health advice do the community usually seek from the clinic	
16	Does clinic have running water	
17	Do you do out on outreach programs and if you do which ones	
18	How large is the catchment area of the clinic	
19	Since 2012 how has been the staff retention at the clinic	

20	On average how many patients do you attend to per month?	
21	What is the clinic's bed capacity?	
22	How frequent does the doctor visit the clinic?	
23	Is the hospital staff provided with accommodation?	
24	Which gender frequencies the clinic and what are their needs?	
25	Do you have anything to share that might add value to the study being carried out?	

Thank you for your cooperation

A9 Interview schedule for officer-in-charge at the police station

Date				
Gender				
Age				
Highest level of education				
Total number of members of staff	Female		Male	
Total number of ancillary of staff	Female		Male	

1	What are your roles and responsibilities?	
2	For how long have you been working at this school?	
3	Is Tsumkwe your home area?	
4	For how long have you been working at clinic	
5	Is electricity available 24hours a day	
6	If no how long are the outages	
7	Since the establishment of the power plant how satisfied are you (rank from 1-4) (1) less satisfied (4) very satisfied. Circle the most appropriate answer	1 2 3 4
8	Has the availability of electricity improved the execution of you duties at work for you and other staff members?	

9	Has the provision of electricity reduced crime	
10	10 Does the police station operate at night	
11	Are the people safer than before after dark due to the installation of the power plant	
12	What are the common types of crime reported	
14	What are the trends of crime statistics from 2012 to 2016	
14	Is the settlement provided with light during night time	
15	Is there interruptions of power supply at the station	
16	Does the police station have running water	
17	Do you do out any outreach programs and if you do which ones	
18	How large is the catchment area of the police station	
19	Since 2012 how has been the staff retention at the clinic	
20	On average how many crime reports do you attend to per month	
21	Are the police staff provided with accommodation	
22	Who reports crimes and what is the gender frequency the clinic and what are their needs	
23	Can you distinguish crime reported by gender	
24	Do you have any reports which might help in the study	

Thank you for your cooperation

A10 Interview schedule for business owners

Date				
Type of business				
Gender				
Age				
Highest level of education				
Total number of members of staff	Female		Male	
Total number of ancillary of staff	Female		Male	

1	What are your roles and responsibilities?	
2	When was this business established	
3	Is Tsumkwe your home area?	
4	For how long have you been operating this business	
5	Is electricity available 24hours a day	
6	If no how long are the outages	

7	Since the establishment of the power plant how satisfied are you (rank from 1-4) (1) less satisfied (4) very satisfied. Circle the most appropriate answer	1 2 3 4
8	Has the availability of electricity improved the execution of you duties at work for you and your employees	
9	Has the provision of electricity helped in the operation of the business	
10	Does the business operate after normal working hours (after 6 o'clock)	
11	Has the 24hours availability of electricity helped to improve the business	
12	Which electrical appliances do you use for your business	
14	How much do you do you pay for electricity	
14	What are the operating hours of the business	
15	Is there interruptions of power supply at the station	
16	Does the business have running water	
17	Do you see yourself expanding the business and will this include electrical appliances	
18	How much do you pay for electricity	

19	How far do people come for services you provide from your business	
20	Besides the pay you award the workers do the enjoy other benefits	
21	Do have dependence (can you give figure) in what way do you assist them	
22	Are you happy with the quality of power provided by the power plant	
23	Which group of the community utilises your services	
24	Do you have any reports which might help in the study	

Thank you for your cooperation

A11 Interview schedule for focus group discussions

Date				
Number of members				
Gender Description	Female		Male	
Age Details				
Highest level of education (for each Member)				
Code name for each member				
Type of productive and economic activity each is involved in				

1	Please describe your normal daily activities	
2	What are the income generating activities you are involved in and do they use any form of energy?	
3	In the family who is responsible for the provision of fire wood and food	
4	What are the main activities you engage in as entertainment?	

5	Since the provision of the hybrid power plant what can you say about crime in Tsumkwe?	
6	Are there some types of economic activities that you wish to do but you are restricted with the quality of electricity?	
7	Are you satisfied with the type of services that are provided in Tsumkwe?	
8	Are you happy with the type of energy that you use for cooking and are they easy to get?	
9	Which type of energy do you prefer for cooking and why?	
10	How satisfied are you with the quality of education that the learners are getting at their respective schools?	
11	Does the settlement provide with jobs for the school leavers?	
12	How difficult is it for you to get money for school uniform and to pay for your medical bills?	

13	Do you think the installation of the hybrid power plant has improved your standard of living?	

Thank you for your cooperation

A12 Household questionnaire

UNIVERSITY OF NAMIBIA

Questionnaire on human development through the provision of renewable energy

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

AND HISTORY

MA THESIS

SUPERVISORS: Prof M. Matsa and Ms M. E. Kimaro

TSUMKWE 2017

This is an anonymous questionnaire – it does not require your name or any other information, which would identify you individually. The information you give will be treated as strictly confidential.

Your participation is voluntary.

INSTRUCTIONS:

WE ASK YOU TO ANSWER ALL QUESTIONS AS HONESTLY AS POSSIBLE.

CIRCLE THE MOST APPROPRIATE ANSWER.

Demographic data

1. Sex of respondent

1.	Male	2.	Female

2. Marital status of respondent

1.	Married	4.	Single
2.	Living with partner	5.	Divorced
3.	Widowed	6.	Separate

3. Please indicate your age range by ticking in the space provided

Age range	20-30	31-40	41-50	51-60	Above 61
Please tick	1	2	3	5	6

4. Please indicate your level of education

Level of Education	Cannot read or write	Grade 1-7	Grade 8-10	Grade 11-12	Tertiary
Please tick	1	2	3	4	5

5. Please indicate the name of your location

1.	Gauteng	4.	Government settlement
2.	Damara	5.	llHaras
3.	Owambo (Kolbooi)	6.	Sewe Huise

6. Please indicate the number of persons in the family

7. Please indicate the number of household members and relation to the household head

1.	Head: female/male	4.	Grandson/daughter
2.	Husband/wife	5.	Son in law/daughter in law

3.	Parents/parents in law	6.	Wife/husband
7	Other relatives	8	Helper
9			

8. Please indicate the ages of household members
9. Please indicate the level of education of household members
10. Please indicate their form of employment
11. For how long have you been staying in Tsumkwe Settlement Area?
12. State the average amount of money you spend on a monthly basis on food and other basic needs

Amount spent per month	N$0-1500	N$1501-3000	N$ 3001-6000	N$6001 - 10000	Above N$10001
Tick in the appropriate box	1	2	3	4	5

Objective 1

To evaluate the extent to which electricity provided to Tsumkwe Settlement Area, through a photovoltaic off-grid mini-grid, satisfies the definition of energy access;

13. How much does the household pay for electricity per month?

Electricity cost per month	N$0-200	N$201-400	N$ 401-600	N$601-800	Above N$801

Tick in the appropriate box	1	2	3	4	5

14. Do you use electricity in your house for home business purposes?

0	Yes	1.	No

15. If you are running a business, which source of energy do you use?

Source of energy for my business	Paraffin	LPG	Charcoal	Electricity	Wood
Tick in the appropriate box	1	2	3	4	5

Objective 2

To determine the effect of solar energy usage on reducing household and community energy poverty;

Lighting

16. Do you have a fixed or portable electric light?

0	Yes	1.	No

17. Do you use this light for more than 4 hours?

1	1 or 2 hours
2	3 or 4 hours

3	More than 4 hours

17. How many electric lights do you have?

1	1 to 2 lights
2	3 lights
3	More than 4 lights

18. Do you feel that the lighting you have is adequate for your needs?

1	Very adequate
2	Ok , but would like a bit more
3	Poor
4	Very bad

19. In what way would you like to change your lighting?

20. What prevents you from changing?

Cooking and heating

21. What energy do you mostly use for cooking?

1	Electricity	2.	LPG

21. If not, do you have an improved stove which uses less fuel than open fire?

0	Yes	1.	No

22. Do you have a chimney over the stove or fire?

0	Yes	1.	No

23. Does your household spend less than 30 minutes a day collecting fire wood?

0	Yes	1.	No

24. What fuel do you use most of the time for cooking?

1	Wood
2	Charcoal
3	Paraffin
4	Electricity
5	LPG

25. How many times per day do you cook using this fuel?

1	Once
2	Twice
3	Three times or more

26. From the list below indicate the type of stove you use for most of your cooking?

1	Traditional metal stove
2	Traditional three stone stove
3	Paraffin stove
4	Electric stove
5	LPG stove

27. How do you obtain your main fuel for cooking?

1	Gather
2	Purchase
3	Gather and purchase
4	Produce at home

28. If you use LPG (a) how big is the fuel tank?
b) How much does it cost?
c) How much do you use per month

29. Using response for question 28: (a) estimate the cost of your fuel
b) Estimate the quantity used per month

30. Do you feel that the stove in your house burns cleanly or is it polluting?

a1	Very clean
2	Ok, but would like to improve
3	Rather polluting
4	Very polluting

5	Do not know

31. How do you feel about the safety of your cooking facilities in your household?

1	Very safe	2	Fairly safe
3	Not safe	4	Do not know

Space heating and cooling

32. What fuel do you use for space heating?

1	None
2	Wood
3	Charcoal
4	Electricity
5	LPG

33. Do you use and appliance to keep your food cool in your house most of the time e.g. refrigerator or cooler box?

0	Yes	1.	No

34. What appliance do you use to keep food cool in your home?

1	None used
2	Electric refrigerator
3	Gas refrigerator
4	Cooler box

5	Clay pot
6	Other (specify)

35. Is your house cool enough all year round without cooling?

0	Yes	1.	No

36. If no do you use any cooling device e.g. an electric fan or air conditioning?

0	Yes	1.	No

37. What method do you use to cool air in your house?

1	None	2	Air conditioner
3	Electric fan	4	Leave the windows open

Objective 3

To assess the benefits of solar energy to the community of Tsumkwe Settlement Area in terms of human, economic and social development.

Information and communications

38. Do you have a fixed or mobile phone in your house?

0	Yes	1.	No

39. Do you have a radio or television in your house?

0	Yes	1.	No

40. Do you have internet access in your house?

0	Yes	1.	No

41. Do you have regular access to a fixed or mobile phone outside your house?

1	Do not have access	2	In a neighbour or friend's house
3	At a local shop/kiosk or community centre	4	At your workplace

42. Do you have regular access to a radio or television outside your house?

1	Do not have access	2	In a neighbour or friend's house
3	At a local shop/kiosk or community centre	4	At your workplace

43. Is the local library available for public use?

0	Yes	1.	No

44. Can medical services be accessed for 24 hrs?

0	Yes	1.	No

Thank you for your cooperation