WILLINGNESS TO ADOPT RENEWABLE ENERGY AS AN ALTERNATIVE ENERGY SOURCE AMONG HOUSEHOLDS AT MATHEBETHI IN KWANYUSWA-ETHEKWINI MUNICIPALITY

by

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DECLARATION

"I hereby declare that the dissertation submitted for the MSc: Agricultural Economics degree, at North-West University, is my own original work and has not previously been submitted to any other institution of higher education. I further declare that all sources cited or quoted are indicated and acknowledged by means of a comprehensive list of references.

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DEDICATION

With a grateful heart, I dedicated this dissertation to my departed father, the visionary, my hero. Ndlangamandla!

ABSTRACT

Relative energy poverty is still rife at Mathebethi, a semi-rural outskirts of industrialised Pinetown about 47 km west of Durban, eThekwini Municipality. The area is characterised by socio-economic indicators namely low revenue base, poor infrastructure, limited access to services and low economic base. Owing to its undulating terrain, households are sparsely distributed. A combination of purposive and simple random sampling design was used to investigate the dynamics of energy consumption in the area to understand the influence of socio-economic variables when households make adoption decisions regarding the type and form of energy voted favoured the household. The null hypothesis suggested no significant relationship between the two. The basis of the study is based on Von-Neumann-Morgenstern utility theory, which underlines that consumption, or buying decisions depend on affordability and willingness purchase. It pronounces that when consumers are faced with dichotomous choices, the decision made based on expected benefit of the alternative. The Probit model isolated the 23 determinants of willingness to adopt renewable energy (as outlined by the objectives of the study). Willingness to adopt, the subject of the study, is the threshold value between 0 and 1. Knowledge of renewable energy, attitude of households, sources of information for renewable energy, gender of the household heads, rate of employment per households, land ownership by the households, farm size of the households, current use of crop residue by the households, monthly spending on energy (conventional) by households, monthly cost of lighting for the household and membership affiliation or social belonging were significant in the final decision to adopt renewable energy. Therefore the null hypothesis was rejected. Based on the six themes underlined by the objectives the recommendations were (a)education was needed as an intervention to assist household heads to make informed decisions regarding developing sustainable alternative energy sources,(b)knowledge develops on the first one (c)local economy must be taken into consideration (d) involvement of local heroes credibility of sources of information (e) attitude normal good (f) constrains – normative beliefs or trends took precedence over intuition. The study is undertaken to investigate the attitude of households towards renewable energy on two levels; awareness and willingness to adopt them as an alternative energy source.

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CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Relative energy poverty is prevalent in the African continent (Sibisi and Green, 2005; Amigun, 2008). The Sub-Saharan region underwent a colossal economic crisis in the early 2000s. Subsequent to South Africa, the net energy supplier in the region, failure to meet the rising energy needs. Alleviation of energy poverty and creation of alternative sustainable energy sources are embellished in the Millennium Development Goals. The shift from traditional sources of energy promises numerous benefits such as reduced indoor smoke, elimination of drudgery for women and generation of employment. All these welfare benefits are immediate for the local community, meanwhile the conservation of environment and reduction of gas emissions are more enjoyed at a national level and generations to come (Amigun, 2008; Amigun, 2010; Pegels, 2004; Paulsen, 2013).

The Reconstruction and Development Programme policy paradigm set of targets such as mass electrification is still underway (Winkler, Marguard and Matibe, 1999; Jooste, 2010). This policy framework saw the numbers of electrified houses doubling between 1994 and 2004 from 36% to 72% respectively (Winkler, 2009). Meanwhile Pegels (2010) observes that 4 million South African households still use paraffin (kerosene) as a source of energy. This noxious source has reportedly been responsible for most fatalities in the country especially during the colder months of the year. A further 40-50% of households still use fuel wood according to the 2001 census report (Bond, 2011). These factors not only exacerbate global warming challenges, but also undermine the achievement of the Reconstructions Development Programme framework policy as well as that of Millennium Development Goal's as prioritised by government's effort for economic and social development. It is not surprising that energy efficiency has recently become a standard item on the agenda of most energy conferences (Amigun *Et al.*, 2008, Ruhiiga, 2012).

The potential of generating energy from biomass cannot be overlooked or discounted since biomass-derived fuels naturally share many characteristics with their fossil counterparts. Literature is adamant that renewable energy is preferred for its renewable

nature, which augurs well with the sustainability mandate (Winkler, 2005). In addition, biomass-produced kinds of energy can be customised to suit the local economy. In fact, renewable energy thrives on local economy. Therefore, the pair needs careful consideration and must be complementary. Currently the widespread renewable energy source in South Africa is solar photo-voltaic and to some extent wind generated energy. Photo-voltaic specifically is rife in low-technology environments. However, numerous site specific challenges have been reported in widespread distribution of this technology. To complicate it further, photo-voltaic technology is not locally produced, therefore does not stimulate local economy (Charkravarty and Tavoni, 2008; Morini *Et al.*, 2008; Amigun and Blottniz, 2010). The use of photo-voltaic is limited in the household since it is limited only to lighting and powering low-voltage appliances (Karekezi and Kithyoma, 2002). The size of the challenge is evident through the short span of the jobs created during the implementation of a project, which are usually limited to the installation period of the photo-voltaic technology (Bugaje, 2006). During the experimentation, investigation and development of reliable renewable energy, a simple cost-benefit analysis test needs to be performed to measure the level of contribution of these energies towards the stimulation of the local economy as well as the relief it brings for individual households. Swilling (2005), affirms that sustainability should be the key determinant in any kind of development in this century which means pooling resources in order to support mitigation efforts while putting ecological matters in the forefront. This can facilitate the economic flows from local to national financial circuits. Without a doubt, adopting renewable energy in South Africa promises to promote and stimulate economic development where it matters the most, the household (Winkler, Howells and Baumert, 2007). Therefore, renewable energy is not just desirable, but practical, immediate, accessible, and readily available to most households, and in various forms (Sibisi *Et al.*, 2005). Renewable energy is all encompassing as it includes all kinds of clean bioenergy technologies e.g. biogas, biomass, etc. Biogas, for example, is a predictable and immediate natural gas (Morini *Et al.*, 2008; Oslaj *Et al.*, 2010; Arthur *Et al.*, 2011).

This natural gas can be produced from a variety of feedstocks; mostly waste material. Also, biogas is cited across four objectives of the Millennium Development Goals.

Evidently, a plethora of literature cites tangible environmental benefits of adopting renewable energy (Winkler, 2005). So if the benefits of adopting renewable energy outweigh the current energy source challenges - why are vast renewable energy sources currently not fully exploited? Von-Neumann Morgenstern utility theory prescribes that there is no sophistication required in order for consumers to make an adoption (consumption) choice (Asante, Otoo, Wiredu, Acheampong, Osei-Adu and Nsiah-Frimbong, 2011). Therefore, the idea of experimenting with different kinds of renewable energy especially in rural/low-tech areas is crucial in developing and eventually adopting a customised innovation of renewable energy (Third Quarterly report, 2012).

Access to reliable energy or the lack thereof is directly linked to economic and social development (Sibisi *Et al.*, 2005). Traditional global experience depicts other forms of renewable energy such as biogas technology as an energy source that does not require complicated systems to construct and manage independently. The African continent has embraced this technology to a certain extent in countries such as Uganda, Tanzania as well some parts of South Africa such as a few in KwaZulu-Natal (Amigun *Et al.*, 2010). South Africa specifically presents an ideal market that matches the sparsely populated nature of most peri-urban homesteads, considering the amount of energy required for cooking alone which ranges between 90% and 100% of the energy source per household (Karekezi, 2002). A major benefit of adopting renewable energy is linked to the capital outlay required for the installation of the technology. The investment requirement is only expended for installation, with running and maintenance costs ranging from zero to relatively very low costs (Amigun *Et al.,* 2010; Stenglein *Et al.*, 2011).

Biogas digesters are fairly popular in the sub-Saharan countries as they use various organic substrates as feedstock from waste to cow dung to even to faecal matter (Akinbami *Et al.*, 2001; Arthur *Et al.*, 2011; Jiang *Et al.*, 2010). Oslaj *Et al.,* (2010) and Bond *Et al.,* (2011) caution that local economy drives the success of the technology, so therefore energy is important to consider during the planning stage. Availability of technical support for the end user is also of utmost importance (Sebitosi and Pillay, 2008).

South Africa has hosted numerous energy conferences, which indicates the country's readiness to explore and embrace renewable energies with respect to sustainability. Among the conferences that have been hosted, was the Johannesburg summit on renewable energy held in 2002 that was 100% green electrified (Karsloon and Aporaocha, 2003). At the local level Austin (2003) reports on three biogas technology success stories in KwaZulu-Natal. (a) Two renewable energy projects fed through a toilet and a kraal that produce $3m^3$ of biogas daily. The biogas produced here is enough to cook for a family of eight in Ndwedwe outside Durban. (b) A rural school that adopted the technology and their energy costs were projected to be lower than those of solar electrification and obviously grid power over a 15-year cycle. (c) Lastly, another rural school in Durban adopted biogas technology to complement electricity supply and the results are positive (Sibisi *Et al.,* 2005).

In view of these incredible developments, two pertinent questions surface as pointed out by Aylett (2013): Are there externalities inhibiting the processes of inclusion and distributing renewable energy? Alternatively, is it the deficiency of relevant forms necessary to create capacity needed to maintain sustainable innovation in the context of changing circumstances? Predictions paint a gloomy picture on the efforts to eradicate energy poverty considering the current actions in terms of scale and pace against the rising demand for energy in general. Other pronouncements have been made against the "snail" development programmes. If drastic steps are not taken, even more households will still be without access to modern technology services by 2030 (Bazillian *Et al.,* 2011; Kanagawa & Nakata, 2007).

Ownership of appliances cannot be used to measure the efficiency of using the conventional energy, since ownership of these items largely reflects the economic status in respective rural households (Davis, 2000). The efficiency of electricity as the cleanest of all fuels for the end user has contributed to the lack of appetite for most renewable energy (Inglesi and Pouris, 2010). Electricity's ability to be versatile, easy to transfer, susceptible to fractional use and precision of a kind makes it to be the most preferred form of energy by far (Karekezi, 2002).

Evidently, the extent to which any kind of renewable energy technology can be adopted depends on its ability to meet basic energy needs such as lighting, space heating, water-heating, cooking and productive use (Winkler, 2005). There seems to be a gap between the type of energy available in the market that works for the local economy and the energy that is readily available yet intermittent and grossly unreliable. For this reason, this study seeks to explore and investigate household's willingness to adopt renewable energy as an alternative energy source at Mathebethi in KwaNyuswa – eThekwini Municipality.

1.2 Statement of problem

As early as 1998, the national government made provisions for the inclusion of renewable energy into the energy mix. Reinforcing this declaration, recently, is the Policy Document of South Africa. The document asserts a target of 15% renewable energy by 2020 (Bugaje, 2006; Winkler, 2007). Mathebethi is on the outskirts of urban Durban (eThekwini Municipality), and is said to be the economic hub of KwaZulu-Natal (Robbins and Delany, 2005). Along with the rest of the country, the municipality had to deal with the energy crisis. The city employed a smart-switching programme with substantial financial and staff time implications. As the distributor of electricity that is obtained from Eskom, the municipality remains the intermediary. Although there is an energy efficiency strategy that is currently underway, it is only set on luring large amounts of clients from other sources of energy such as coal and gas and very little, if anything at all, is done regarding developing renewable energies. The energy supply is under a tremendous amount of pressure. In addition, to the execution of the mass electrification policy, scores of households have been "lit up" for the very first time (Aylett, 2016). This policy has even put more strain on the energy supply vs. demand for energy (Spalding-Fescher, 2003; Sebitosi, 2009; Pegels 2010). Aylett (2016) further investigated the rationale behind inactivity or reluctance towards renewable energy development by the municipality that seems incongruent with the current energy needs. The municipality seems to be set on protecting established corporate assets and practices despite challenges that eventually led to expensive power outages. Managing this eventuality was expensive for the municipality in terms of money spent on running

special schedules and keeping staff on standby all the time. Beck, Kempener, Cohen and Petrie (2008) highlight that the top-down approach on decentralising energy supply has strong links with high levels of abstraction. This has proven that superficial potential solutions, that often ignore complexities and contexts of energy consumption at household level are therefore impractical, which is enough reason for Bazillian and Kammes (2012) and Brew-Hammond and Kemajsuor (2009) to speculate that by 2030 even more households will still be without access to modern energy services if finding renewable energy is not prioritised. Mathebethi, a village not far from a well-documented Maphephethi, shows many similar characteristics such as high levels of unemployment, low revenue base and limited resources (Green *et al.*, 2001). Households are locked in an unstable position to depend on limited and unpredictable sources of income. The provision of new renewable energy has to be achieved within these bounds. Development of renewable energy as a multi-pronged approach to economic empowerment has many benefits that include improved health, clean environment and relief from drudgery involved with traditional forms of collecting resources for energy creation (Howells *Et al.,* 2005, Green *Et al.,* 2006 and Inglesi *Et al.,* 2008). Despite the potential of large production capacity some green technologies adopted by government are imported (Bugaje, 2006). However, the household's position, as a client on diversifying energy specifically, experimenting with local renewables remains a mystery. At a deeper level Hansla *Et al.*, (2008) outline three attributes namely values, beliefs and environmental concern that underlie the willingness to adopt renewable energy as a dependent variable. At a superficial level this equates to meeting daily energy demands that are pertinent to individual households. If municipality grapples with numerous strategies to alleviate energy poverty, understanding a household's position and readiness to experiment with alternative renewable energy is crucial. Are households, the end users of energy aware of the magnitude of energy deficiency as it is? Or are households aware of renewable energy as a sustainable alternative? If yes, are they willing to experiment with different local forms of alternative energy accessible to them? The economic backdrop to consumption is willingness to pay and affordability. So understanding the attitudes of households to renewable energy is instrumental in this study.

1.3 Objectives of the study

The specific objectives for the study are to:

- Identify personal characteristics of household heads ,
- Elicit and ascertain level of knowledge of renewable energy by household heads as an alternative energy source,
  Determine the level of willingness to use renewable energy as an alternative energy source,
- Identify sources of information on renewable energy as an alternative energy source,
- Determine attitude towards renewable energy as an alternative energy source,
- Identify constraints to the adoption of renewable energy as an alternative energy source.

1.4 Hypothesis

The hypothesis is stated in the null form as:

There is no significant relationship between socio-economic characteristics and willingness to use renewable energy among households.

1.5 Significance of the study

Energy poverty has been reported to undermine the efforts aimed at realising the Millennium Development Goal's. Yet access to a reliable energy source is fundamental to social and economic development (Davidson *Et al.*, 2004). Quality scientific data paucity on the other hand hinders progress of the development of renewable energy (Bazillian, Nussbaumer, Roner, Brew-Hammond, Foster, Pachauri *Et al.*, 2011). The study purports to make a contribution, to the pool of knowledge directly needed to advance these technologies e.g. biogas technology. Biogas technology as one of the easily attainable renewable forms of energy can be locally-produced and is easily adaptable (Amigun and Blottnitz, 2010). Naturally, energy access initiatives are directly linked to agricultural activities (Hammond *Et al.*, 2009). Mathebethi is a farming community (Vorster, van Rensburg, Jansen, van Zijl and Sonja, 2007). The development

of a reliable renewable energy source and agriculture are juxtaposed in the Millennium Development Goals. For example the four socio-economic sectors defined clearly namely Social well-being, Health, Education and Environment (Brew-Hammond *Et al.,* 2009). The top-down development theory had failed dismally in the African continent. The obvious route is that communities are forced to turn inward in the quest of "liberation" from the poverty trap. Local Economic Development has been identified as the realistic development option to facilitate development in a poverty-stricken community. Its aim is to "stimulate local employment opportunities in sectors that improve the community, using existing human, natural, and institutional sources". With the sustainable development concept already gaining traction in most farming communities, it is appropriate to investigate the willingness to adopt an alternative, sustainable energy source (Binns and Nel, 1999). Besides the obvious creation of energy, another benefit that the community stands to enjoy without expending anything is bio fertiliser. Bio fertiliser is the high-in-nutrient effluent (by-product) that results once organics have been cycled through the digester. Other benefits include pathogen and odour mitigation, weed seed reduction (some of the weed can be utilised as feedstock). A major benefit is directly linked to global warming, because methane as this natural gas is completely destroyed through combustion, 21 times better than carbon dioxide (Ochieng and Kaseje, 2014; White *Et al.*, 2011). Both Bazillian *Et al.*, (2011) and Brew-Hammond *Et al.*, (2009) speculate that by 2030 SSA will still be trapped in the claws of energy poverty if drastic measures are not embarked upon. Actors and commentators are invited to carve a viable future in terms of finding alternative sustainable energy sources such as renewable energy (Eggertson, 2002).

1.6 Definition of terms

Household - refers to both detached houses (with single kitchen) and several houses attached to a common homestead (several kitchens in one homestead) (Mtshali, 2002).

Poverty (energy) - inability of households to command sufficient resources to satisfy a socially acceptable minimum standard of living (Shackelton, Shackelton, Buiten and Bird, 2007).

Renewable energy – energy that is derived from a natural process that is replenished constantly e.g. biomass from waste materials (kitchen, agricultural, etc.), solar energy and biogas (Bonnet and Andrew, 2003).

Sustainable development – pattern of development that delivers basic environmental, social and economic services without threatening the viability of natural, built and social systems upon which these services depend.

Tarpaulin or tarp – is a hard, plastic material used to harvest biogas in a bio digester device.

1.7 Chapter summary

Relative energy poverty is still prevalent in Africa. The Sub-Saharan region has had a lion's share following South Africa's power rationing. Alleviation of energy poverty and creation of alternative sustainable energy sources are embellished in the Millennium Development Goals, which promise numerous benefits. All these benefits are to be enjoyed by local communities with more running conservation of environment and reduction of gas emissions, which could be farther enjoyed by the rest of the country for generations to come. A policy such as mass electrification has perpetuated the situation. Other sources of alternative sources of energy currently in use by households are not as clean. Resolutions from conference' discussions at the upper level need to be communicated clearly through proper channels to households at the grassroots level to permeate experimentation to full fruition of finding reliable renewable resources for relevant environments. The potential of generating energy from biomass cannot be overlooked or discounted. Biomass-derived fuels naturally share many characteristics with their fossil counterparts. Literature shows that renewable energy is preferred for its renewable nature, which is in line with the sustainability mandate. Numerous site-specific challenges have been reported in widespread distribution of this technology.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter provides the context that underlies the aim of the study. The scope of the subtitles covers the energy consumption patterns in South Africa, prospects of renewable energy, as well as the status quo in low-tech environments in the country. The chapter investigates and explores what the existing literature suggests about energy consumption with respect to the objectives of the study.

2.2 Energy consumption patterns in South Africa

About 2.5 billion people still depend on traditional biomass around the world such as wood, charcoal, crop residues and dung to meet their daily energy needs. In sub-Saharan Africa between 80% and 90% still depend on biomass fuels, 75% for fuel wood, of household in general (Jumbe *Et al.*, 2009). Projections proclaim that by 2030, 26% of the rural households will still be dependent on traditional biomass. In South Africa alone, 4.5 tons per annum is an estimate of fuel-wood consumption (Ferrer-Marti *Et al.*, 2012).

Paraffin, also known as kerosene is used in over 4 million households. On average up to 60% of un-electrified households rely on paraffin to meet their daily energy needs. Unfortunately the use of paraffin causes fatal damage in many cases that range from injuries, death, destruction, property loss, economic consequences and burden on government resources (Spalding-Fecher, 2005; Paulsen, 2013). Furthermore paraffin is by no means better than other biomass produced energy considering health problems associated with its use. Meanwhile the balance of the population inadequately, continually depends on electricity.

Electricity in South Africa is predominantly produced from coal. Ironically this fact contributes to its price being the lowest globally. However, coal is notorious in contributing immensely to carbon emissions. Intensifying electricity productions to meet the growing energy demand would mean compounding the latter (Gaunt, 2005; Menyah and Wolde-Rufael, 2008). To complicate this matter further, the country is the major supplier of energy to sub-Saharan African countries. However, energy reserves are falling short to meet the country's demand. Electricity remains the most desirable source of

energy by far because of health benefits and extended productive, hours therefore contributing positively to the economy of the country. Electricity supports local economy as well and widens the scope of communication base (Ferrer-Marti, 2012).

Mass electrification and rapid urbanisation led to 2008's predicament. In 2008 the whole country woke to the reality of power rationing (Odhiambo, 2009; Sebitso *Et al.*, 2008). Essentially load shedding confirmed long-term energy planning problems and limited investments in the energy sector (Ruhiiga, 2012). Originally the country had enjoyed a 55% reserve margin due to overbuilding in the 1980's (Bekker *Et al.*, 2008). At the beginning of the power outages episode, electricity reserves margins had decreased from 25% in 2002 to 20% in 2004 and to a further 16% in 2006. Already the reserve margins were ranging between 8% to 10%, way below the country has set target of 15% (Winkler, 2003 and Menyah *Et al.*, 2010). The frightening arrest of the mining industry, the economy's backbone, due to energy deficiencies proved that South Africa's economic and social development is heavily dependent on the energy sector (Winkler, 2003; Menyah and Wolde-Rufael, 2010; Sebitosi *Et al.*, 2008). In fact, the loss made amidst power outages cannot be covered. Clearly benefits (cheap, clean and convenient) derived from coal-generated electricity South Africa do not outweigh the burden cast on the environment (carbon emissions) (Eggertson, 2002). Whilst strategies aimed at redistribution of resources such as mass-electrification are implemented, it is vital to consider sustainable methods. Swilling (2005) argues the importance of considering ecological sustainability in the 21st century. In fact the importance of considering sustainability in developing infrastructure is of paramount importance. There is no evidence of mass electrification to meet social objectives such as poverty alleviation. In as much as the inverse is true, that social development and poverty alleviation can drive electrification. The new challenge in South Africa is finding sustainable electrification strategies (Gaunt, 2005). In the long-term sustainability is the key in energy production (Spalding-Fescher, 2003).

2.3 Renewable energy; an alternative energy source for rural communities

Electrification based on renewable energy is idealistic for providing decentralised electricity to secluded communities globally (Ferrer-Marti, 2012). Options include biomass-derived energy which can be utilised to meet various energy needs including heat (through burning), steam electricity, hydrogen, ethanol, methanol, biodiesel and methane. The method of energy generation is prescribed by the need of direct heat or steam, conversion efficiencies, energy transport, conversion and use of hardware energy, economies of scale and environmental issues due to conversion process steams and product use. Biogas produced through anaerobic digestion is generally an acceptable fuel (Amigun *Et al.*, 2010). Common various feedstocks' that have been utilised for biogas production involve cow dung, poultry droppings, pig manure, kitchen waste, grass faecal matter and algae. In countries where agriculture is prominent biogas is a promising renewable energy source. In countries like Italy biogas has successfully widened the scope of renewable energies (Tricase, 2008). Biogas is a clean fuel that burns without leaving soot (Arthur, 2010). It is structurally lighter in terms of carbon chain length; therefore releasing less carbon into the atmosphere. Because biogas is an anthropogenic product, it is harvested through a self-sufficient method, in that way making the process relatively low. The biogas is harvested within biogas, and no further purification is expected (Bond, 2011). Energy is at the heart of economic and social development (Xiaohua and Jingfei, 2004). Biogas as a form of energy can also serve this purpose and furthermore unlock opportunities to embark on economic activities. Biogas promises to decentralise approaches to mass-electrification by empowering rural communities to be involved in energy generation and in return create sustainable livelihoods, improve lifestyles and promote cost saving (Arthur *Et al.*, 2011; Third-Quarterly Report, 2011). These gains usually cannot be expressed in monetary terms, but are usually expressed in benefits from economies of scale and opportunity cost of decision-making (Arthur, 2011). Solar energy has the greatest potential in South Africa as a renewable energy source (Pegels, 2010). Compared to grid-green technologies biogas technology can be easily adaptable. Success of biogas technology is driven by the local economy. Natural resources available in the areas are considered in design for ease of operation (Third-Quarterly, 2011). Some of these resources include water and organic material (Amigun *Et*

al., 2010). For example designing a digester (Tarpaulin) that is site specific has a number of advantages. A study was conducted on the efficacy of utilising the tarpaulin covers on pig manure in order to control odour and air pollution mitigation. The findings reported an approximate 95% of odour control ability. NH3, H2S, VOC, CH4 and N2O gases were completely sealed off from escaping manure storage facilities. In fact because the airspace under the cover is limited, the gas concentration builds up quickly and increases pressure. Its supple nature capture allows it to store all the gas produced and can be carefully released efficiently through a low pressure valve (Stanglein, 2011). Because of this desirable trait. Tarpaulin digesters are a far better biogas technology that can easily be adapted to different environments. Photovoltaic systems have been used in various parts of the world specifically at a pilot project at Mathebethi in KwaZulu-Natal. Its usage includes advantages such as modular components that can provide small amounts of energy at the point of demand, it plays an important role in the mitigation of the harmful gases emitted to the atmosphere energy, the absence of the harmful pollution at the place of use, relatively simple operation and maintenance, durability and economic viability (Green *Et al.*, 2000). Electricity for a programme in Durban was developed around 300kWh per month consumption, however new users averaged less than that. The first users preferred using their traditional stoves and not to employ the 2-plate cookers that were provided during connection. The study done in Ivory Park for instance, found that the average demand of electricity increased with an increase in the number of appliances owned. Ownership of appliances cannot be used to measure the efficiency of using the conventional energy but largely reflects the economic status in most of the rural households (Davis, 2000).The acquisition of different appliances by household is of interest since those appliances are not fully utilised in the first place as there is a notion linked to prestige (Thom, 2000).

2.4 Trends of bio-digester and renewable energy in Sub-Saharan Africa

Biogas technology is not a new technology in the African continent. South Africa and Kenya were the first countries to install renewable energy in the 1950s, with Malawi producing bioethanol from sugar cane molasses in 1982 (Jumbe *et al.*, 2009); Tanzania installing its first renewable energy in 1975, more recently, was South Sudan in 2001. Most installations were promotional efforts of various international organizations and

foreign agencies (Amigun *Et al.*, 2010). Biogas technology promises to provide a sustainable energy supply together with effective treatment of organic wastes. Literature records that 48, 6 minutes per day of cooking time is saved (from other forms of biomass such as fuel wood- this include time to collect generate and eventually use the energy source productively) by using biogas and as result women have engaged in income generating activities and subsequently have an improved standard of living (Third Quarterly Report, 2012). Biogas is cited four times across all the Millennium Development Goals (Pearson, 2002). Biogas amongst other green technologies is the most desirable because of its characteristics (Amigun *Et al.*, 2006). The Energy White Paper is adopted from the South African Constitution itself, since it recognises the right to a healthy environment, which is congruent to all what biogas offers. However in the past there were hindrances regarding drafting of the policy conducive for further development and the implementation of biogas. Instead, more emphasis has been put heavily on polluting energy generation technologies (Krupa *Et al.*, 2011). Recently Eskom in partnership with the Department of Energy have embarked on revising of the national energy policy (Sebitosi *Et al.,* 2008). It includes enhancing economic metrics of energy performance by progressively decreasing carbon-intensive conventional sources and renewable energy deployment (Krupa *Et al.*, 2011). At the moment Eskom owns three hydro facilities and coal-fired bagasse plants less than 10MW. Invariably a large hydro facility indicates technology maturity. On the other hand photo voltaic as well as cooking and water heating are off-grid renewable energies. By default photo voltaic used in remote areas are however expensive compared to grid-connected electricity (Winkler, 2005). There are still challenges identified in the energy innovation system and economics as far as green technologies are concerned (Pegels, 2010). Again this infancy state means there are risk and cost factors involved in uncertain terms. Convincingly no technology can compete with coal-fired power stations for two simple reasons since power stations were built in the 70's and 80's at the time when exchange rates were favourable. However this scenario works at renewable energy's advantage because the fleet of electrical plants are overwhelmed today by the growing demands of electricity which means the search and distribution of renewable energies must be accelerated. Odhiambo (2009) demonstrates that from a policy viewpoint a causal relationship

between energy consumption and economic growth has far reaching implications since energy is the engine of all economic activities. In line with the latter statement Nasery (2011) defines urbanisation as not merely development but an increase in productivity and attaining self-sufficiency by communities on which universal electrification was developed originally.

2.5 Prospects of renewable energy adoption in South Africa

Most of electricity infrastructure has depreciated over the years as already mentioned (Karekezi, 2002). Biogas technology needs to have a sustainable competitive edge in order for it to create enough appetite in the country. Naturally the capital investment of biogas technology is competitive to that of electricity, since it is expended for installation costs only with low to zero running costs (Amigun, 2009). Government and investors are likely to favour a technology that is cheaper but still efficient and sustainable than the one with limiting factors (Pegels, 2010). In the African continent biogas technology's widespread application has been stifled by lack of support from government through a focused energy policy (Arthur, 2011). Yet South African government has ensured that conditions are somewhat conducive to the creation and development of renewable energies, since the commitment to introduce competition into the energy supply sector. The completion of Technical Standard Certificate in 2003 (Bugaje, 2006), the green powering of the Johannesburg summit, are salient milestones the country has made (Eggertson, 2002). Major implications of inclusion of biogas technology into the energy mix directly affect the environmental regulation and promoting energy efficiency positively (Spalding-Fecher *Et al.*, 2003; Sebitosi and Pillay 2008). Integrated resource planning is characterised by increased penetration of distributed energy resources particularly from renewable energy sources and other supply-side alternatives (Sebitosi and Pillay 2008). Most renewable energy' success stories are attributed to this "principle". China as the world's pioneer of anaerobic digestion owes its success to Eco-House Project the government's brainchild. The main feature of biogas progressive growth is due to policy support and legal protection the project obtains from the state (Feng, 2012). South Africa is predominantly a free market economy (Sebitosi *Et al.*, 2008). This in fact outdates Eskom's monopolistic supply of electricity in the country.

True to Swilling's assumption that public investment in infrastructure has a positive impact on economic growth since it stimulates related private sector investments and in return eradicates poverty by providing the basis for social development. The Small Medium and Micro Enterprise's approach could also contribute immensely. Commentators and actors are needed to take part and drive the motion forward as pointed out by the Johannesburg summit (Eggertson, 2002). In fact incorporating the natural production of biogas by means of anaerobic respiration will have exponential benefits keeping the infrastructure renewable energy relatively unsullied since:- (a) less sludge is processed compared to other forms of aerobic treatments (b) successful in treating wet wastes of less than 40% dry matter (c) more effective pathogen removal (d) minimal odour emissions (e) implemented to regulate bio gradable waste entering landfills (f) the by-product produced is a much better fertiliser (Ward, Hobbs, Holliman and Jones, 2008). As long as the integrated resources approach eliminates deficient current methods of producing energy in SA, the efforts are set in the right direction (Pegels, 2010). Also pressure from the rise in oil prices and the state of conventional energy facilities are reasons to fast track the search for green technology strategies. The sugar cane industry for one has been under scrutiny lately due to global use of fossil fuels and low sugar price. If they could find a niche in the creation of renewable energy the industry could be economically viable again (Wienese and Purchase, 2004).

2.6 Energy consumption status quo in low-tech environments

The South African government adopted a free basic electricity policy in 2001 in the quest to expand the mass electrification resolution. However the adjudication of who qualifies for the subsidy was not accurate. As a result all consumers regardless of the income level were granted subsidy. There is a proportion of electricity that is not connected to price but the community that consumes it (Inglesi, 2010). In general households opt to adopt a convenient alternative source of energy. For example the household might have a primary source of energy that is usually earmarked for cooking main meals and a secondary source is kept for afternoon tea/snacks (Brew-Hammond *Et al.*, 2009). Another contributing factor in areas that have conventional energy results from the erratic nature of electricity and lastly is because electricity is relatively expensive. Therefore,

households that are electrified yet fall into a low-income class are still predominantly rural. They still have a large prevalence of fuel wood, paraffin and candle usage (Louw *Et al.*, 2008). Without a doubt access to reliable modern energy is imperative especially because of its direct link to reduction of poverty (Davidson *Et al.*, 2004). Another strategy that could be added onto the decentralisation of access to energy is coupling biogas programmes with agricultural production. In countries such as Rwanda this has helped them increase their efforts (Brew-Hammond *Et al.*, 2009). Since the launch of the mass electrification policy, the new challenge is now finding a sustainable source of energy for rural communities (Gaunt, 2005). Naturally a household's choice of energy consumed largely depends on the size and diversity of the household, the income of the household and other underlying factors e.g. literacy level, distance to supplier and availability of natural resources. Another viewpoint adds the cost and availability of suitable appliances, relative prices and the number of services that the appliance can provide. Furthermore neoclassical theory suggests that the primary economic variables in determining the demand for any product or service are tastes and preference of individual households (Louw *Et al.*, 2008). Households in low-tech environments engage in a diverse array of informal activities to support their livelihoods, including arable agriculture, home-gardens, livestock husbandry, collection of natural resources (thatch grass, fuel wood, medicinal plants), casual work, migrant labour and small-scale enterprises (Madubansi, 2007). It is clear that eradication of energy poverty requires a sustainable modern energy that is affordable and reliable as conventional energy to be identified and explored (Davidson and Mwakasonda, 2004). In a study conducted in Bushbuckridge, South Africa, most households predominantly utilised biomass. Other types include paraffin, candles, gas, coal, dry cell batteries, dung, lead acid batteries and some electricity (Madubansi, 2007). Although literature records a decline in the use fuel wood, however these studies are based on observed differences between electrified and un-electrified households.

2.7 Adoption renewable energy among rural households in South Africa

The first national income and living standards survey conducted in South Africa post 1994 showed that half of the majority in the country, which is mostly found in rural areas are caught in the poverty trap, remarkable material deprivation and inequalities in upper middle-income groups (Michael *Et al.*, 2001; Ngobese *Et al.*, 2013)). On this backdrop, rural households in general make adoption decisions of new developments. Adding to this dynamic is the stubborn lucidities of change and statis that rural development tends to follow (Murdoch, 2000). A legitimate expectation in a democratic South Africa is that the state should maintain a fine balance between lighting up and keeping light on in respective cases of the scenario (Kroukamp, 1999). On the other hand, the private sector also contribute to economic emancipation of rural households through social responsibility strategies. Either way the adoption process of development such as new technologies follows these basic steps namely (a) awareness – dissemination of information stage (b) persuasion – the provider attempts to convince the community about the new development (c) decision stage – using the information provided now the household can make an informed decision about the new technology (d) implementation stage – this stage can also be known as "trial and error" or customization and (e) confirmation – finally when households are loyal to new development and can now choose it over conventions. The adoption or rejection of renewable energy will depend on the utility derived from using the new development (Premkumar and Roberts, 1999).

Devine-Wright (2007) argues that in rural areas credible sources of information plays an important role in the adoption process more than other source. Since it achieves the first two stages of the process; awareness and persuasion. Another component will be for households living close to actual developments. Naturally, households in the surroundings might have spiked interest. Another twofold phenomenon is that older households maybe aware of renewable energy but are not willing to install compared to the younger cohort. Other exogenous factors however close to respective household include place attachment, perceived fairness and levels of trust, political beliefs and environmental beliefs and concerns. On a more advanced level spatial factors in terms technical support being located locally, regionally or nationally, institutional factors

involving sole ownership and access to individual support as well as technological factors in terms of scale and type. The ascent of the energy ladder is thought to be associated with better and increased levels of urbanization (Martins, 2005). Electricity is at the top of the rung. Martins (2005) continues to attest that households might respond to the increase in purchasing power by using more energy or expanding consumption of other goods, leading to an improved economic welfare.

2.7 Chapter summary

The majority of households worldwide still rely on traditional biomass. The sub-Saharan Africa has recorded figures between 90% for biomass and 75% for fuel wood. Daunting assertions have been made for 2030 already stating that about 26% will still be dependent on biomass. South Africa alone consumes approximately 4.5 tons per annum of solid fuel-wood. Strides have been made since the universal electrification policy implementation. However, some households still use the noxious paraffin. Renewable energy provides secluded communities with the opportunity to decentralise electrification while stimulating local economies. Biogas technology is not a new technology in the African continent.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter covers the methodology used to conduct the study. The subtopics include the area of study, population of the study, sampling procedure, theoretical framework, data collection, validity and reliability and data analysis. The chapter gives character to the data as it purports to achieve the objectives of the study.

3.2 Area of study

The study was conducted at Mathebethi (Ward 2) situated approximately 47 km west of Durban (eThekwini Municipality) in the "Valley of a Thousand Hills" in KwaZulu-Natal; in the outskirts of Pinetown. Mathebethi is characterized by socio-economic indicators such as low revenue base, poor infrastructure, limited access to services and low economic base. The main economic sectors in the area are agriculture and beading for tourism. The area is generally sparsely populated and difficult to reach because of the mountainous profile.

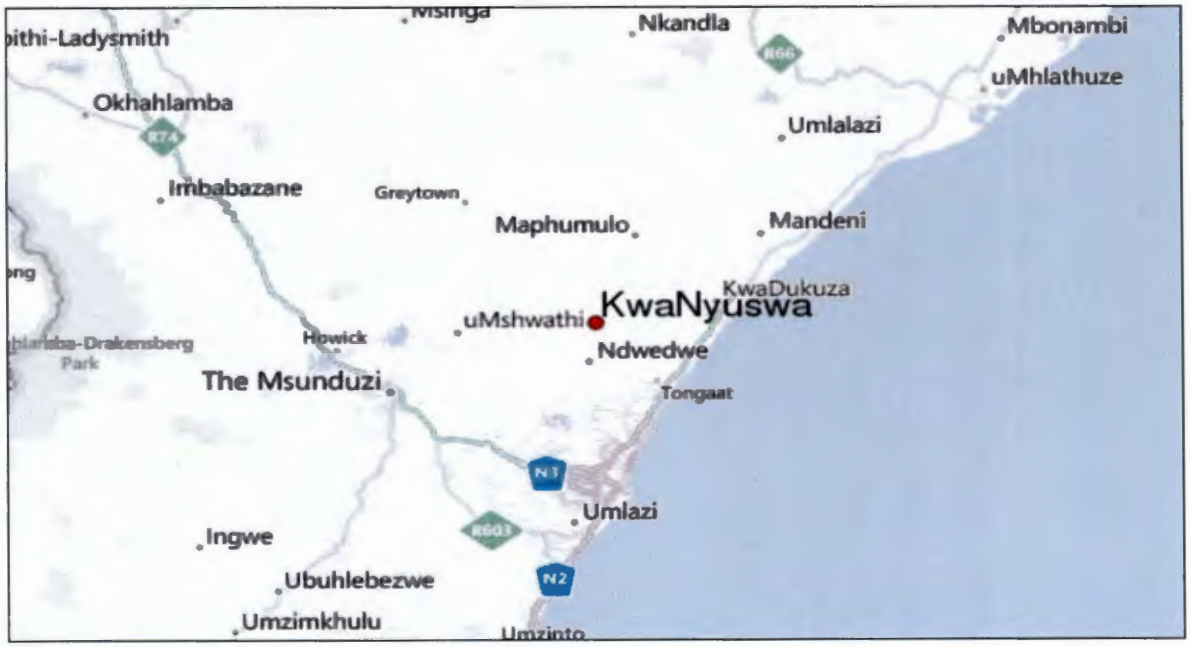

Figure 1. A map showing kwaNyuswa where Mathebethi is situated, eThekwini report (UDMP, 2011)

3.3 Population of study

The Census Municipal Report (2011) and UDMP (2011) estimate the Mathebethi population to a total of 1 056. A large proportion of the community depends on social grants with a fair number working in the neighbouring suburbs as unskilled labour.

3.4 Sampling procedure and sample size

A combination of purposive and simple random sampling designs was employed in the study. Mathebethi was purposively selected because of its semirural classification. All households were considered for the study. The community has a population of 1 056, that was considered, a sample of 284 households was then further drawn from 1 056 total population as guided by Raosoft sample size calculator (Raosoft, 2014). A database of existing energy prevalent in the area was solicited from the eThekwini municipality' electricity department so as to build the energy consumption context of the study.

3.5 Theoretical framework

Households view electricity as a normal good, therefore pushing renewable energy down the "energy ladder" to inferior good classification. Perceptions about renewable energy are directly informed by how well it can meet the anticipated benefit. On the other hand, consumption of inferior goods relative to electricity provides the basis that, as income of the households increase the consumption of it will decrease (Carter and May, 1999; Louw *Et al.*, 2008). Intensifying the complexity are preferences of households. Electricity itself, has price inelastic demand, it does not respond that much to price changes (Ziramba, 2008). Considering that electricity is in mix of energy sources consumed in the household adds another complexity.

Consumption or buying decisions are underlined by affordability and willingness to purchase. Asante *Et al.*, (2011)'s referral to von-Neumann-Morgenstern utility theorem is applicable. The theory argues that when consumers are faced with dichotomous choices in this case either to adopt the use of renewable energy or to continue using their current energy of their choice, the expected benefits associated with the alternative choice are thoroughly assessed before the decision is made. As mentioned there are a number of

underlying factors that might affect the decision for households to adopt renewable energy, however, the study hypothesized no significant relationship between the decision to adopt and socioeconomic factors. The study aims to investigate these socioeconomic factors and to ascertain if they have any bearing in the decision making process.

3.6 Data collection

Data was collected using a structured energy questionnaire based on the six objectives of the study as outlined in Chapter one. The questionnaire was divided into six sections commensurate with the number of objectives. The questionnaire is comprised of open and closed ended questions. The six objectives are elucidated as follows:

Section 1 – Elicited personal characteristics including age, gender, level of education, employment, level of income, the ownership of any gadget to determine the level of technology acceptance. Open and close-ended questions were employed.

Section 2 –A total of 25 knowledge statements were formulated to test the level of knowledge of renewable energy as alternative energy. Respondents chose between True or False to the statement.

Section 3 – Measured the willingness to adopt renewable energy. Respondents indicated by answering Yes or No to the willingness to adopt renewable energy.

Section 4 – Determined the credibility of different sources of information on renewable energy. Information sources such as radio, TV, were listed and respondents were required to select sources of information applicable to them.

Section 5 – Examined the respondents' attitude to renewable energy. This was measured by using a 5-point Likert scale of Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree. The attitude scale consisted of 25 statements with a maximum score of 125 and a minimum of 25.

Section 6 – Respondents had to choose constraint(s) applicable to their context to adopting renewable energy from list of 10 constraints in the questionnaire.

3.7 Validity and reliability

The questionnaire was pre-tested on a group of 20 households at Mathebethi, before the survey was extended to the rest of the community. This was done for face validity. Split-half technique was used to ascertain the reliability of the questionnaire.

3.8 Data analysis

Data was collected, sorted, coded and entered into SPSS version 22 (2015) spreadsheet for analysis. Frequency tables, percentages and mean standards were used to describe the data for all the objectives of the study. A combination of descriptive and inferential statistics was used to analyze data. The Probit regression model was used to isolate the determinants of willingness to adopt renewable energy. Willingness to adopt is the dependent variable; that is dichotomous in nature with a number of underlying factors. This model is ideal for isolating latent variables, as it can resolve the heteroscedasticity challenge with ease. For example, the willingness to adopt renewable energy ($y1 = 1$) or unwillingness to adopt renewable energy ($y1 = 0$) was based on a comparison of gains associated with both choices respectively. All the socioeconomic factors were considered as outlined by the objectives (Asante *Et al.*, 2011). Therefore, willingness to adopt renewable energy is not an isolated phenomenon. Since Y is a binary output variable and a conditional probability needs to be modeled $\Pr(Y = 1|X = x)$ as a function of x and all unknown parameters in the function are to be estimated by the maximum likelihood.

Following Maddala (2005), the Probit model adopted for the study is specified as:

$$Yij = a_j + \beta j \sum_{j=1}^{n} \text{Xíj} + \text{e}\acute{\text{i}}$$

Figure 2: Probit model to be estimated.

Where $P_{i\ is}$ the probability that an individual will make a certain choice (is willing to adopt or not); s is a random variable normally distributed with mean zero and unit variance; y_i is the dependent variable (willing to adopt); $y_i^*$is, the threshold value of the dependent variable. All variables will be represented as follows:

P(Y) = is the probability of a household to be willing to adopt renewable energy as an alternative energy source as the independent variable;

E =base of natural logarithm;

β0 = Constant;

β1 = AGE – age of the household head;

β2 = GEN – gender of the household head;

β3 = MARS – Marital status of the household head;

β4 = LED–Education level of the household head;

β5 = HOUS – Household size;

β6 = EMPH – Employment of the household head;

β7 = DESW – Designation at work of the household head;

β8 = FARMA – Farming activities of the household;

β9 = NUML – Number of livestock kept by the household;

β10 = OVER – Where energy livestock is kept overnight;

β11 = ANIM – Current use of animal manure energy;

β12 = ARAF – Arable farming by the household;

β13 = LAND – Land ownership;

β14 = SIZE – Size of land;

β15 =CURR – Current use of farming residue;

β16 = HOUM – Household monthly fuel for cooking;

β17 = MEMA – Membership of affiliation to a group or association;

β18 = Use of social media by the household head;

β19 = KNOW – Knowledge statements;

β20 = SOUR – Sources of information of renewable energy;

β21 = ATTI – attitude towards adopting renewable energy;

β22 = CONST – Constraints that could hinder the adoption process;

β23 = COSTL – Cost of lighting

β1 – β23 = Coefficients for all underlying variables.

To obtain an estimate of the index Z_i the inverse of the cumulative normal function is used:

$\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_i X_i + e_i$.

Figure 3: The inverse of the cumulative function.

The parameters estimates β_i of the Probit apart from the information on the effect of changes in the explanatory variable on the probability of adoption, and also provide information on the relative effect of each explanatory variable on the likelihood that a household will prefer an alternative energy source.

3.9 Chapter summary

The study was conducted at Mathebethi just outside Pinetown in eThekwini Municipality. This semi-rural area is typically rural with various challenges. Households depend on non-formal economic activities to generate livelihoods. These kinds of activities range from agriculture to beading, (tourism) to any other transactional barter trading. A large proportion of the community depends on social grants with a fair number working in the neighbouring suburbs as unskilled labour. This community is sparsely populated. A combination of purposive and simple random sampling designs was employed for the study. A database of existing energy prevalent in the area was solicited from the eThekwini municipality' electricity department so as to build the energy consumption context of the study. The hypothesis suggested that there is no significant relationship between willingness to adopt and socioeconomic factors. These socioeconomic factors were organized into six objectives and developed into a questionnaire. Since it was a quantitative study, the questionnaire was tested for reliability using the split-half technique. Data was collected, sorted, coded and entered and analyzed using SPSS

version 22 (2015). Frequency tables, percentages and mean standards were used to describe the data for all the objectives of the study. The Probit regression model was estimated, and factors were isolated to determine the level of influence since the study aims to investigate the influence of socioeconomic factors in the decision to adopt renewable energy.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the inferential and descriptive statistics results as obtained from the SPSS output. The discussions are organized according to themes based on the objectives of the study including; socio-demographic factors, monthly income, knowledge of renewable energy, willingness to adopt, sources of information, constraints on adoption of renewable energy, awareness of renewable energy and social membership. The Probit model regression was run to test the hypothesis. The results showing the significance of latent factors are presented in Table 14.

4.2 Socio-demographic characteristics among respondents

The results show that the majority, (88%) of the respondents were more than 50 years old. Other age groups that may be considered economically active have been ravished by HIV/AIDS, and have therefore died, leaving the young ones in the care of the elderly (Reid and Vogel, 2006; Hiralal, 2010). Sex-selective demographic ageing such as widowhood is also a huge contributing factor to this effect (Chant, 2011), obviously leaving women as household heads. In the study, about 78% of households are female-headed. Leatt (2006) confirms that far more children are living with women. Women consider themselves generally unemployed even when involved in informal, unquantified activities despite the amount of time invested in these tasks and the fact that some kind of livelihood is generated (Hiralal, 2010). These duties may include agricultural activities and any handiwork such as beading or taking care of the household. The emigration of men to nearby industrial areas (*de facto*) to find employment leaves women as household heads for significant amounts of time (Mtshali, 2002 and Terry, 2009). Added to their reproduction role, asserts Mtshali (2002) they are "teachers" of the next generation, therefore it is imperative for women to be abreast about latest energy consumption preferences and options discussions although, misconceptions suggest that women are non-technologists (Cecelski, 2000). Energy issues are not only confined into domestic issues as they affect the economic and social development immensely (Bonnet *Et al.,* 2003). Sustainability issues affect women to a large extent because of their all-round

responsibilities in the household. However, there are still restrictions in terms of access to meaningful resources for women due to cultural and social pressures. The fact that women cannot make decision at community level means some households, that are women headed, cannot be involved in sustainability discussions. The controversy around rightful persons to plant trees on unclaimed piece of land and what planting a tree signifies is not only a gender inequality issue but a direct socioeconomic factor negating poverty alleviation efforts for women (Murphy, 2001). More than half of the respondents (54%) were married. Considering that majority of household heads are women this dynamic means that these women might gain access to meaningful resources through marriage, however they were also subjected to similar challenges as other women in the area when their husbands leave the household to seek employment or when they pass away (Amigun *Et al.*, 2008). A strategy as simple as the introduction of new stoves could make a huge difference since it meets women's practical gender needs (Sagar, 2005, Mtshali, 2002).

One-tenth (10%) had tertiary education. Contrary to the relatively low percentage education in Table 1, education is generally highly esteemed by the households. It is believed to have long-term benefit and often regarded or the lack thereof as the main obstacle to economic freedom (Reid *Et al.*, 2006). Secondly, the very 10% that is highly skilled has emigrated to join the elite groups in the cities for better employment purposes (Mtshali, 2002; Madubansi, 2005). As Han (2009) argued that household heads with relatively high education level were likely to adopt green technologies. Perhaps because the level of receiving and processing innovations information is somewhat developed, sophisticated, and so are their needs. However, these households are left inevitably indifferent and to some extent indecisive in the absence of the educated family members and therefore enter the vicious cycle of relying on the members of the household left behind to make these decisions.

Table 1: Socio-demographic characteristics among respondents (n=284)

Variables	Frequency	Percent
Age of household head		
Under 20	2	0.7
20 – 35	15	5.3
36 – 50	21	7.4
51 – 65	172	60.6
Over 65	74	26.1
Gender of the household head	**Frequency**	**Percent**
Male	63	22.2
Female	221	77.8
Marital status of the household head		
Single	55	19.4
Married	153	53.9
Divorced	9	3.2
Widowed	67	23.7
Level of education of the household head	**Frequency**	**Percent**
Primary school education	99	34.9
High school education	94	33.1
Tertiary education (diploma/degree)	28	9.9
Postgraduate study	63	22.2

Source: Field survey data (2014)

4.3 Socioeconomic characteristics among respondents

With regard to respondents' household information, about three quarters (74%) of the households, had members between three and seven members as shown in Table 2. The household is generally complex in the South African context because of rural-urban migration that could range from temporary, intermittent to permanent. Whatever the case, these immigrant household members are still regarded as part of the household in the rural areas (Mtshali, 2002). It gets complicated with the division of labour dynamic since immigrant household members may not be present to carry out their respective duties manually. So the numbers of household members fluctuate throughout the year. Practical gender needs remain women's responsibility for example labour intensive chores such as the collection of fuel wood (Howells, Alfstad, Victor, Goldstein and Remme, 2005). These time-consuming duties are generally done for no pay at all but simply as a contribution to the sustenance of the household, this often leaves women to try emerging

projects (Reid Et al., 2006). More than half (57%) of the head of the households were unemployed. Poor rural women struggle for income generating opportunities because of various reasons (Behrman, Meinzen-Dick and Quisunmbing, 2012). Old age pensions and social grants contribute largely to the household income. A few other women-headed households do beading and have sent children to school and bought additional resources for the household from that income (Case et al., 2005 and Reid Et al., 2006). Above 75% of the households were unskilled workers. The emigration of skilled labour to the cities leaves behind the local economy with skills shortages (Wilk, 2002). Experimenting with renewable energy presents the opportunity to unlock different opportunities aimed at activating the local economy and developmental programmes such as Local Economic Development have provided the ecosystem for this to occur. It is argued that is it not up to the local government to create employment and that communities themselves must find their own solutions (Buhlungu Et al., 2007). In fact the electrification programme provides for private companies the rights to establish off-grid utilities and there is a proviso to government subsidies to cover most capital costs for five years (Prasad and Visagie, 2005).

Table 2: Socio-economic characteristics among respondents (n=284)

Variables	Frequency	Percent
Household size	**Frequency**	**Percent**
Less than three members	4	1.4
3- 5 household members	108	38.2
5- 7 household members	101	35.7
7- 9 household members	37	13.1
9- 12 household members	21	7.4
>12 members	12	4.2
Employment of the household head	**Frequency**	**Percent**
Studying	3	1.1
Unemployed	163	57.4
Employed	91	32.0
Self-employed	19	6.7
Renewable remittance dependent	8	2.8
Designation at work of the household head	**Frequency**	**Percent**
Unskilled	201	76.4
Administration	6	2.3
Skilled/ Professionals	35	13.3
Management	21	8.0

Source: Field survey data (2014)

4.4 Number of livestock owned by households

With regard to livestock ownership, Table 3 shows the results of 61% of the households owned small stock. Households kept livestock for various reasons, from sustenance to prestige. Rural households are involved in agriculture mainly to diversify or to create livelihood strategies regardless of their employment status (Mtshali, 2002; Dovie *Et al.*, 2005). Creating these options is important for sustenance of households. Dovie *Et al.*, 2005 argue though that livelihoods options are not similar to cash income diversification, which cover the other aspects of keeping livestock by households. By default, livestock rearing is associated with men in rural areas; this complicates the dynamics of women-headed household. Firstly, they might lack access or sometimes the ability to tend to any kind of livestock associated with experimenting with different forms of renewable energy (Terry, 2009). This may be due to gender-based commitments in the household or the inability to be involved with ownership that forces women to operate at community level. Meanwhile, more than a third (35%) had between six to nine livestock in individual

households. This figure is below 11 and 20 range reported by Kunene and Fossey (2006) for the Northern region of KwaZulu-Natal. Agricultural production on a small scale involves a mixture of livestock and crop production (Mkhabela *Et al.*, 2000) Almost all the livestock were kept in kraal (92%). Kunene *Et al.,* (2006) and Bayer et al., 2004 agree on that although livestock graze freely during daytime it is safely kept in the kraals within the homestead at night for security reasons.

Table 3: Livestock owned among households (n=284)

Variables	Frequency	Percent
Farming activities by the household		
Livestock keeping	22	10.0
Small stock (goats, sheep, pigs and poultry)	134	60.9
Large stock (cattle ranching, studs, paddocks and milking cows)	64	29.1
Number of livestock owned by the household		
< 3	6	2.8
3 to 5	38	17.6
6 to 9	75	34.7
9 to 12	53	24.5
≥12	44	20.49
Where is livestock kept overnight		
Kraal	194	92.4
Paddocks	2	1.0
Other	14	6.7

Source: Field survey data (2014)

4.5 Current use of agricultural farming residues among households

Almost all the respondents (92%) reported that they use the animal manure for fertilizer/compost and almost all households produced at least one crop for consumption. As mentioned in the before agriculture is a livelihood strategy for most households in rural area. Women are commonly involved in agricultural activities despite their daily households responsibilities and the strenuous nature of agriculture (Terry, 2009). On the other hand, Ahla, (2006) reports that women are often viewed to be risk averse in other words they are reluctant to embrace innovations. This innate factor stems from psychographic determinants. This in its own presents a new challenge of skeptism in terms of receiving innovations of any kind. It gets complicated when women lack access to essential non-land inputs (Behrman *Et al.*, 2012). This combination contributes to the

lack of capacity for decision making in women. Mtshali (2002) explores the option of providing women with necessary skills so they can identify innovations that will meet their respective needs directly. Additionally Vogel *Et al.*, (2006) also advocate for education formally (evening schools such Adult Based Education) or informally (workshops, trainings and etc) that will empower everyone to become better at decision making. Essentially, a comprehensive intervention that empowers and elevates women as equal stakeholders in society is of crucial importance. Most of the participants (90%) mentioned that they used the land for horticultural farming.

With regard to land ownership, Table 4 show the majority of the respondents (87%) highlighted that they privately owned the land. Literature shows that even though there are women who own land independently or jointly with other family members, overall women are disadvantaged in both statutory and customary land tenure systems. It becomes complicated even when women are older because of property grabbing from widows, which is a common occurrence in many contexts, but they still play a role in a wide range of agricultural activities (Behrman *Et al.*, 2012). Hon (2012) notes the poor conditions of women's land access and ownership that further limits poor rural women's opportunities for income generation. Agricultural activities have dwindled recently due to the rise of livestock feeding on the crops in the fields (Reid *Et al.*, 2006). Wilk (2002) argues that cultural theorists view consumption as a symbol that creates and expresses meaning and identity. Evidently, when women own physical assets such as land, physical assets and financial assets; there is an increase in child health and nutrition and increased allocation towards education (Behrman *Et al.*, 2012). About 92% of respondents use animal manure for agricultural production. Modi (2010) defines organic farming as farming without chemicals and the Mathebethi community is already involved in organic farming without realizing it. It may be circumstantial (because of lack of inputs); however, it is enough to build upon going forward in terms of entrenching in sustainability as a way of life. Therefore manure remains vital in small-scale farming as it is attainable to rural households (Mkhabela and Materechera, 2000). Only 7% use it for activities such as energy generation despite the fact that cow-dung is popular for its ability to combust and crops residue is used to feed livestock as aftermath. Small-scale

production in agriculture involve both crop and livestock production (Modi, 2010). Manure and crop residue are often used interchangeably to enrich the fertility of soil. In addition, the aftermath of crops is fed to the livestock. About 90% is involved in arable farming either in privately owned land or communally owned land. About 87% own land and 0, 4% do not own any piece of land. About 88% use crop residues as compost. . Only 4, 2% use crop residue for other activities such as generating open fire.

Table 4: Current use of agricultural farming residues among households (n=284)

Variables	Frequency	Percent
Current use of animal manure		
Energy generation	3	1.5
Fertilizer/Compost	184	92.0
None	13	6.5
Arable farming by the household		
Agronomic farming (Field crops, sorghum, potatoes)	9	3.8
Horticultural farming (Garden crops)	212	89.8
None	15	6.4
Land ownership		
Privately owned	209	86.7
Communally owned	31	12.9
None	1	0.4
Current use of farming residue		
None	15	7.0
Energy generation	9	4.2
Compost	191	88.4

Source: Field survey data (2014)

4.6 Monthly income and proportion spent on the current energy source

Almost all the respondents, (94 %) presented in Table 5 mentioned that, less than R1000 is spent on fuel for cooking purposes. Martins (2005), argues that most households in rural areas spend economically unacceptable amounts to meet energy needs. Due to relatively large family sizes and the fact the migrant workers are still considered members of the household as they usually leave their children behind. Most households are dependent on monthly payouts such as remittances sent home by the migrant workers' pension and social grant (Jiyane and Ocholla, 2003). Even when there is a formal salary earned by the household, it is often too little. Mtshali (2002) attributes this

to low productivity employment that people in rural areas are locked into (Mtshali, 2002). Bonnet *Et al.*, (2003) established R1 392 monthly income in a neighboring community to Mathebethi, Maphephethi that is generally the pension grant for the elderly. Relative to cooking energy needs in the households, about 98% used less than R1000 per month for lighting purposes. Cooking and lighting are inseparable as they are the most basic and constant energy needs. Only 2% could spend more than R1000 on energy consumption. Results showed that more than half, of the total population (54%) of the household get socials grant as a means of income. A social grant is a comprehensive term including pension payout in the study.

Table 5, shows that almost all households received the contribution from the combination of the two (pension and social grant). This resulted in the prevalence of multi-kitchens in the homesteads with underage or elderly persons being the household head. However, there is a view that households do not act in a unitary manner when acquiring various household resources (Behrman *Et al.*, 2012). About 4% of the households lacked an identifiable source of income and subsequently relied on the local authority for survival. Because the data was collected around Christmas time, food parcels were allocated to indigent households. Therefore, it is not far-fetched to assert that poor households may not have the means to finance the premium required by conventional energy (Oliver *Et al.*, 2011). Hence, the continuous reliability on fuelwood.

Table 5: Monthly income and proportion spent on the current energy source (n=284)

Variables	Frequency	Percent
Household monthly fuel for cooking purposes per household		
None	13	4.6
Less than R1000	263	93.6
R1001 - R3000	5	1.8
Household monthly cost for lighting purposes		
None	4	1.4
Less than R1000	275	97.5
R1001 -R3000	3	1.1
Monthly household income		
No income	15	5.3
Social grant	151	53.5
Less than R1000	11	3.9
R1001 - R3000	39	13.8
R3001 - R7000	42	14.9
R7000 and above	24	8.5

Source: Field survey data (2014)

4.7 Social membership or affiliation and current source of energy

The majority of households (83%), as shown in Table 6, used church as a means for networking. Haddad and Maluccio, (2003) advocate that affiliation to a social group has important economic benefits even when the function of the association is noneconomic since a decision to "belong" is based on trust, norms and rules. The most important outcome from being part of the group is reputation or status. Households with similar characteristics are likely to belong together, and then they will naturally challenge, compete and concede with each other. Sharing of information becomes easier as members of the group are familiar with each other. Naturally, households share their experiences, new acquisition and innovations. Renewable energy will also form part of this talk if churches can be used as a platform to disseminate and educate households about its benefits and what it promises to do for households. Churches can also be used as experimental sites for easy reference, as most households have not seen options of

renewable energy in operation. So seeing renewable energy used in the local context will inspire households to explore and customize accordingly to meet their energy needs.

Table 6 also shows very few (less than 10%) used social media. The fact that households in rural communities are under resourced, translates to limited access to information and different kinds of media. This is not necessarily ignorance; however, knowledge on how to exploit available information is the main reason (Jiyane *Et al.*, 2003). The use of cellphones is merely for communication purposes and is never utilized as a tool to source information. The prevalent kind of media in the community was radio and television sets to a certain degree. As most households are women-headed, they are expected to multi-task with limited time available to exploit other forms of media for information. Key role players from government to private sector need to use this platform to disseminate information about renewable energy to empower households in the rural areas. As rural households are often not involved in energy dialogues held at various levels of the country local radio stations need to be mandated to broadcast issues related to renewable energy and its benefits as part of social responsibility. They need to visit experiential sites to engage with the key informants in the community who are known to the local people.

Table 6, showed that almost all households (97%) indicated that energy sources are replenished monthly. Evidently, this inherent monthly obligation takes a larger portion of income in households this competes with other activities in the household such as education. This is why households prefer to own technology, which translates to paying it off instead of paying an incremental (with use), continuous service fee (Green *Et al.*, 2001). Only 2% replenish their energy sources weekly. Rural households survive on dire financial constraints and it is never possible to finance a weekly premium.

Table 6: Social involvement and current sources of energy among households (n=284)

Variables	Frequency	Percent
Membership or affiliation of group or association that can be used for networking	**Frequency**	**Percent**
Church	233	82.6
Farmers Association/Society	16	5.7
Agricultural Cooperative	11	3.9
Other (Specify)	22	7.8
Use of social media by the household	**Frequency**	**Percent**
None	254	91.4
Internet	7	2.5
Facebook/Tweeter/Instagram	16	5.8
Other (Specify)	1	0.4
Origin of different energy sources	**Frequency**	**Percent**
Electricity	7	2.5
Fuel wood	3	1.1
Brazier	1	0.4
Electricity and Fuel wood	272	96.1
Frequency of replenishing energy resources	**Frequency**	**Percent**
Daily	1	0.4
Weekly	5	1.8
Monthly	272	96.8
Fortnightly	1	0.4
Annually	2	0.7

Source: Field survey data (2014)

4.8 Level of knowledge about renewable energy among households

To determine levels of knowledge about renewable energy respondents were tested on 27 knowledge statements on a two-point scale of True (2) or False (1). Results in Table 7 showed the median score indicated 20 of respondents had above average knowledge regarding renewable energy as alternative energy.

Table 7 also showed that above 70% of the respondents admitted that the current staple energy used in their households is expensive. More than 70% of households have access to enough feedstock that can be used for biogas production. More than 70% households have enough manpower to tend to the potential energy innovation. More than 70% households felt that it is imperative for their households to have access to reliable and relevant energy sources. Lastly, more than 70% of households felt a moral obligation to

use renewable energy instead of the conventional energy. All these factors were salient signs of households' readiness to adopt renewable energy. However, the information gap needed to be closed by widening the scope of discussions across urban and rural poor households. Currently poor households comprise of one-third humanity (Sagar, 2005). On the other hand, only 18% knew about renewable energy as an alternative source while 47% knew that adopting renewable energy would pose risk to their households. Members of the households are more concerned with daily survival and issues directly involved with their current and future livelihoods rather that extreme hazards that external or affluent parties may be worried about (Van Aalst *Et al.*, 2008) and 40% indicated that the decision to adopt renewable energy will be dependent on how the community at large perceives the idea. Oliver *Et al.*, (2011) echo that self-condemnation is often stimulated by the pressure from other household's behavior. There is a general feeling of wanting to identify with the neighbor and a sense of security if someone known tries out a new idea.

Table 7 Level of knowledge about renewable energy among households (n=284)

Statements	True	False
The current staple energy is expensive	96.1	3.9
Knowledge about renewable energy as an alternative source	18.0	82.0
Renewable energy different from other forms of traditional energy	69.3	30.7
Renewable energy is compatible with the lifestyle of the household	64.1	35.9
Renewable energy can improve the household's lifestyle	62.0	38.0
Household has got enough feedstock to use for biogas production	70.4	29.6
Household has got enough manpower to tend to the bio-digester	75.9	24.1
Ease of switching to (completing) the staple energy with renewable energy	54.1	45.9
Choosing renewable energy to other forms of energy	56.4	43.6
Risky to adopt renewable energy	47.5	52.5
Perception of community can influence the decision to adopt renewable energy	40.1	59.9
Training attended on global warming effects such as deforestation	68.0	32.0
Persuasion to use other forms of energy besides the conventional energy	69.0	31.0
Knowledge of generating renewable energy	69.4	30.6
Access to reliable and relevant energy sources	95.4	4.6
Availability of technical support for renewable energy innovations	66.1	33.9
Concern for the future regarding natural resources	66.7	33.3
Availability of finance to enable adoption of renewable energy	67.5	32.5
Perception on durability of renewable energy innovations	67.8	32.2
Moral obligation to use renewable energy instead of the conventional energy	70.2	29.8
Responsibility to deforestation in the neighborhood	66.9	33.1
Adoption of renewable energy despite the lack of awareness	56.2	43.8
Adoption of renewable energy depends on its ability to meet energy needs	65.8	34.2
Need practical alternative source of energy	67.4	32.6
Awareness on energy efficiency motivate the adoption of renewable energy	66.7	33.3
Display of utilizing renewable energy can change perception	66.7	33.3
Adoption of renewable when it is provided free of charge	66.9	33.1
Overall Median [Range]	20 [3;27]	

Source: Field survey data (2014)

4.9 Willingness to adopt renewable energy among households

The results in Table 8 below show that more than two-thirds 68% of the participants were willing to adopt renewable energy for their daily energy needs and amongst them 72% wanted to use renewable energy immediately. Because electricity and consequently appliances remain more expensive compared to other known forms of energy sources

(Williams and Shackelton, 2002; Howells *Et al.*, 2006). This is evident through the continued use of fuelwood despite the strides achieved by the mass electrification policy (Madubansi, 2005; Madubansi and Shackleton, 2006). When asked how much they willing to pay for renewable energy, about three-quarter of the participants 72% did not want to spend any money on adoption of renewable energy. Energy related issues are socio-political in the country therefore any service from government is expected to free of charge. If renewable energy is to substitute then conventional energy then, the expectation is that government must provide them free of charge or least subsidizes a certain portion of it. Bonnet *Et al.,* (2002) and Oliver *Et al.*, (2012) argue that rural households only view themselves as beneficiaries of all service delivery. This also can cause confusion around willingness to pay for services provided by government. Rather developing a shared understanding among stakeholders for a common purpose will ensure sustainable infrastructure development and usage. Indeed, the capital outlay for renewable energy projects is high (Prasad *Et al.*, 2005).

Table 8 Willingness to adopt renewable energy among households (n=284)

Variable	Frequency	Percent
Willing to adopt to renewable energy for your daily energy needs		
Yes	189	67.5
No	91	32.5
Total	280	100.0
When would you start utilizing renewable energy		
Immediately	170	72.3
After a while	15	6.4
Later	50	21.3
How much are you willing to spend monthly on adoption of renewable energy		
None	167	71.7
Less than R1000	64	27.5
R1001 - R3000	2	.9

Source: Field survey data (2014)

4.10 Extent to which renewable energy would be adopted

More than two-thirds (72%) of the respondents showed in Table 9, mentioned that renewable energy would be used for all daily energy needs. Of importance in energy consumption matter is how households view electricity versus any other sources e.g. paraffin and other common energy source. That is normal good versus inferior good

(Louw *Et al.*, 2008). Another dimension is that of price elasticity to conventional energy (Inglesi-Lotz, 2011). The conventional energy remains expensive for an average rural household hence the inclusion of a complementary energy source. The inclusion of modern, reliable renewable energy version into the rural development paradigm is of utmost importance for the sustainability agenda (Brent *Et al.*, 2009). Renewable energy transforms a costly challenge into a profitable solution since it has benefits for everyone in the society. This includes removing drudgery for women, reforestation, improves crop production, job creation etc. (Walekhwa, 2009). About 93% would use renewable energy for cooking. Cooking consumes a lot of energy. Between the range of 90 to 100% of households asserted that cooking consumed most of the energy. Bonnet and Andrew (2003) mention that most households still prefer using fuelwood for high-energy demand activities such as cooking. While only 3% would like to try is first before making the decision. As the renewable energy innovations require a huge capital outlay, it is a big decision for household to make. That can be very costly to undo. It is only apt for households to assess what they can afford against what is available in the market and still be able to meet all their daily needs. Households also believe act in solidarity, they often feel at ease if their neighbours are pro-environmental (Oliver, 2011). It is also a question of trust in various stakeholders from neighbours to authorities bringing the renewable energy innovation as a service (Haddad and Maluccio, 2003).

Table 9: Extent to which renewable energy would be adopted (n=284)

Variables	Frequency	Percent
Amount of energy needs met		
All	159	71.6
Some	28	12.6
Few	7	3.2
None	28	12.6
Reason for the choice		
Cooking consumes a lot of energy	175	93.1
Will never use it	7	3.7
Will have to try to test it first	6	3.2

Source: Field survey data (2014)

4.11 Sources of information regarding renewable energy

Less than half of the participants (47%) mentioned that they heard about renewable energy from radio. Households in rural areas have the challenges in accessing and exploiting information from print media. Also there are restrictions since most household heads are illiterate. Therefore, friends, neighborhoods and relatives are priority sources of information. Oral sources of information in the form of radio are readily available (Jiyane and Ocholla, 2003). Followed by television 26%, the acquisition of these appliances by household is of interest since they remain underutilised due to the fact that electricity is expensive. There is a notion that ownership is linked to prestige (Thom, 2000). Also women are involved in various tasks in the households that is time-consuming so this leaves them with no free time (Jiyane *Et al.*, 2003). Sustainable development prescribes that renewable energy needs to be promoted (Brent and Kruger, 2009). As households make adoption decision based on the process of collecting and decoding the information from different communication channels (Oliver *Et al.*, 2011). Technological ignorance could be the most significance hindrance to the renewable energy activation projects (Brent *Et al.*, 2009). Also lack of awareness in general form of media on renewable energy resource base, both economic and environmental benefits is also a challenge (Amigun *Et al.*, 2008).

Table 10: Sources of information regarding renewable energy (n=284)

Source	Frequency	Percentage
Cell phone	1	0.4
Television	75	26.4
Radio	133	46.8
Neighbors	4	1.4
Social club	3	1.1
Awareness program	4	1.4
Eskom	1	0.4
Government agency	8	2.8
Sales representative	1	0.4

Source: Field survey data (2014)

4.12 Frequency of using renewable energy

More than two-thirds 71% reported that they would use the renewable energy regularly. Although renewable energy has been lamented a fallacy that is already harming a number of households in impoverished areas in certain parts of the continent (Terry, 2009), it is gaining traction in other parts of the continent as mentioned in the literature. On the other hand, Bailis, Ezzati and Kammen (2005), argue that the use of conventional energy is associated with improved health especially in women and children. However, Amigun *Et al.* (2008) cite affordability for individual households as the major motivation to choose a specific energy. Renewable energy is associated with being relatively affordable and readily available. So practicality (renewable energy) outweighs the fantasy (electricity). About 10% will rarely use renewable energy. Consumption of goods by rural households is dependent on how well needs are met by a new technology. The fact that renewable energy can only be used with equipment of choice by the households. The nature of technology ordinarily requires large capital outlay (Green *Et al.*, 2001). Households need continuous capacity building so as to build confidence around using renewable energy. Availability of technical support after installation is also essential. Propensity not to pay for services is quite high. So if the new technology requires household to invest in it, given that there are not expenses incurred when conventional energy.

Table 11: Frequency of using renewable energy (n=284)

Variable	Frequency	Percent
Frequency of use of renewable energy		
Regularly	123	70.7
Occasionally	33	19.0
Rarely	18	10.3
Total	**174**	**100.0**

Source: Field survey data (2014)

4.13 Constraints hindering adopting of renewable energy

About 75% of respondents considered normative belief systems to affect their willingness to adopt renewable energy. Wilk (2002) asserted that one of the social theories suggested consumption a group phenomenon, viewed as another form of collective behavior that assisted households to appease "a sense of belonging" and status that results from social competition and emulation. Although these are embedded in the manner in which one meets their needs, it traces back to personality formation, early family interactions through to actualization of adulthood. On the lower end, 31% does not regard compatibility with the household in adopting renewable energy. Rural households are forced by their demand to meet domestic energy needs to use expensive and inconvenient sources of energy (Green and Dube, 2001). Attitude and subjective behavior form the basis of a particular behavior towards renewable energy (Oliver *Et al.,* 2011). Affordability plays an important in households favoring particular source energy. Therefore, rural households do not have reliable, modern energy options. Financial assistance in the form of grants and subsidies from government and private sector can somewhat stimulate the adoption. Another 31% attributes for lack/access to renewable energy awareness as a constraint of adoption. A healthy appetite for renewable energy can only be developed when households understand what it entails. A comprehensive capacity-building programme that will instill a sense of ownership of the technology can go a long way

Table 12: Constraints hindering adopting of renewable energy (n=284)

Statements	True	False
Normative belief systems affect your willingness to adopt to renewable energy	75.4	24.6
Personal feeling/intuitive appeal about renewable energy	37.3	62.7
Perception of renewable energy based on own understanding	31.7	68.3
Ease to use renewable energy relative to staple energy	31.3	68.7
Compatibility of renewable energy with current household's lifestyle in terms of energy production	31.0	69.0
The amount of work required to manage/maintain renewable energy daily	31.3	68.7
The credibility of the source of information about renewable energy plays a particular role in decision to adopt to it	31.6	68.4
Lack/access to energy efficiency education/training/awareness has direct effect on the final decision to adopt renewable energy	31.0	69.0
Affordability of renewable energy to existing energy source	31.1	68.9
Availability of necessary technical support	31.3	68.7
Sturdiness of renewable energy compared to existing energy source	31.8	68.2
Existing similar cheaper and reliable alternative energy source	32.0	68.0
Little chance of succeeding	31.7	68.3
Availability of technical support	32.0	68.0
Availability of enough feedstock	32.0	68.0

Source: Field survey data (2014)

4.14 Awareness of renewable energy among households

Table 13 shows only 13% of the respondents were aware of alternative energy; in the true sense of renewable energy. If knowledge is, inadequate households remain uncertain about adopting renewable energy (Oliver *Et al.,* 2011). Since fuelwood is the oldest energy source. Therefore, its use is not regarded alternative at all; since there is nothing sustainable regarding current fuelwood use (Prasad and Visagie, 2005). The proportion that seems to be aware of renewable energy does not know it in experiential sense (Green *Et al.*, 2001). Due to lack of educational programmes on energy issues households had sketchy ideas of what renewable energy entail. Although this may be the case; there seems to be a general affinity towards renewable energy if it is to improve the lives of the

households in the sense that no drudgery is involved as the current demands (Shackleton *Et al.*, 2001). This is the reason 79% indicated that alternative energy could be used for both cooking and heating. Most of energy in households is consumed by cooking, and then lighting that is mostly required by school going children. Only 4% responded positively on the use of renewable energy for agricultural purposes. Even though a large population consider themselves as agriculturalists, agricultural activities are for sustenance and prestige. They often depend on members of the household for tending to (Mtshali, 2002; Ngobese and Msweli, 2013). When something better comes along, such as better employment, agriculture is often abandoned; therefore, agriculture is not prioritized neither is energy generation at household level, rather basic energy need take precedence e.g. cooking and lighting. Sustainable issues are interdependent; energy crisis is an overarching matter underlying poverty alleviation strategies. Entrepreneurship education as means to finding sustainable livelihoods in the context of renewable energy by households can stimulate the affinity for renewable energy. It is important that it is addressed in this light if it to change people's lives at household level.

Table 13: Awareness of renewable energy among households (n=284)

Variables	Frequency	Percent
Awareness of alternative energy		
Yes	38	13.4
No	246	86.6
Probable use of alternative energy	**Frequency**	**Percent**
Cooking	58	20.4
Agricultural purposes	1	0.4
Both Cooking and Heating	225	79.2

Source: Field survey data (2014)

4.15 Socio-economic factors influencing the "willingness to adopt the renewable energy"- the dependent variable

The Probit regression model was used to analyze factors that influence the decision to adopt renewable energy as alternative energy source in Mathebethi. Willingness to adopt is the dependent variable; that is dichotomous in nature with a number of underlying factors. This model is ideal for isolating latent variables, as it can resolve the heteroscedasticity that exist in related variables. The willingness to adopt renewable energy using dichotomous dependent variable where by it assumes values 1 in case respondents are willingness to adopt $(y1 = 1)$ or unwillingness to adopt renewable energy$(y1 = 0)$.

Twenty-three socioeconomic explanatory variables that were believed to have influence on the willingness to adopt were included in the analysis. Those explanatory variables include; knowledge, attitude, information sources, age, gender, marital status, Education level, size of household, Rate of employment per household, work designation, farming activities, livestock owned, Place where livestock is kept overnight, current use of manure, arable farming, land ownership, farm size, current use of crop residue, monthly spending on energy, cost of lighting, monthly income, membership affiliation, use of social media. The results of the of Probit regression shows that out fifteen of these variables only knowledge, attitude, information sources, gender, employment status, land ownership, farm size, current use of crop residue, monthly spending on energy and membership affiliation had coefficients that were statistically significant.

4.15.1 The P-value of the intercept

The P values of the intercept are used to interpret the results in the Probit table. The lower these P-values of the explanatory or independent the stronger the statistical significance to the nearest significance level. In the results P value of the intercept is 0,000. This can be interpreted as a high statistical significance 0,001. Since the "willingness to adopt renewable energy" is not an isolate phenomenon as a result of 23 independent variables included in the test. Then each explanatory variable included in the

test will be viewed with respect to the influence it has on the "the willingness to adopt" as a dependent variable, by looking at the respective P-values. Table 14 shows the results.

4.15.2 Knowledge of renewable energy

A positive yet highly statistically significant relationship (Z=16,650: P<0.01) was found between knowledge and willingness to adopt renewable energy at Mathebethi. Oliver *Et al.,* (2011) and Mtshali (2002) agree on knowledge as a basis for household to make well-informed decision with respect to receiving new technologies. Without knowledge, households are more likely to be uncertain, indifferent and indecisive. Therefore, they are likely not to act in favour of the new technology. As it is, knowledge about renewable energy is somewhat limited; as a result, there are many misconceptions of its risks, potential and benefits (Karekezi, 2002).

4.15.3 Attitude of households

Another positive yet highly statistically significant relationship exists (Z=9,828: P<0, 01) between attitude and willingness to adopt renewable energy as alternative source. Attitude forms the basis on which values annihilate. In this case, pro-environmental behavior is the direct results of these values (Oliver *Et al.*, 2011). As behavior is a manifestation of household's belief system and values. The interpretation of the results is that when there is a positive attitude about renewable energy, households most likely to adopt renewable energy as alternative source.

4.15.4 Sources of information for renewable energy

The results showed another negative but highly statistically significant relationship (Z=-4,738: P0, 01) Whilst knowledge is at the forefront for individual households, it is quite a complex variable since it is informed by a strong intuition brought about by a certain level of maturity for discernment as well as some level of education (Hlahla *Et al.*, 2015).

4.12.5 Gender of the household heads

A positive and statistically significant relationship (Z=2,768: P>0. 05) was shown by the gender of the household. Being married might grant the spouse access to meaningful resources. However, the majority of households are women-headed. On the other hand,

the married do not live with their spouses, as many males do not live with their families due to employment reasons and some widowed (Hlahla *Et al.*, 2015).

4.15.6 Employment status of the household head

The findings in table 13 show a positive relationship and statistically significant (Z=1,863: P>0, 10) between employment status and willingness to adopt renewable energy. This implies that when household heads are employed, they are most likely to adopt renewable energy as an alternative source. This affinity comes with households' affordability the resources required for the renewable energy. However, at Mathebethi, the majority of household heads are above the age of 50 and unemployed. A compliment of old age pension and dependence on 'a social grants is the main source of income for the households.

4.15.7 Land ownership by the households

A positive relation and statistically significant relationship (Z=1,920: P>0, 05). Access to resources remains central to women-headed households. The complexity of women-headed household is strafed by the fact that women as household heads and homemaker; they are unable to attend any kind of training and experimentation for market-oriented economic activities (Hayetezu *Et al.*, 2015). Due to domestic responsibilities (Mtshali, 2002). Women generally tasks literally range from managing the household to wood gathering to cooking to tending to the young ones coupled with copious amount of decision making expected from them. Cultural and social issues around land ownership for women remain a challenge. Even though land is distributed locally, the ownership belongs to government. Allocation is often indirectly proportional to household size (Reid *Et al.*, 2006; Hayetezu *Et al.*, 2015).

4.15.8 Farm size of the households

The results show a negative relation yet positive statistical significance (Z=-2,143: P<0, 032). This implies that the more land the household acquire the less likely they are to adopt the renewable energy as alternative source. In line with fact that although land is owned by individual households, however, decision on how to employ this useful resource depends on factors outside the household regardless of the sophistication level

of the decision that needs to be made such as converting current use of the land owned by households or simply acquiring more land. These factors are largely prevailing agro-ecological conditions and trends (Hateyezu *Et al.*, 2015).

4.15.9 Current use of crop residue by the households

The results show a positive and statistically significant relation (Z=3,323: P=0, 01) between the current use of crop residue and willingness to adopt renewable energy as an alternative source. Already a fair number of households use the aftermath of their crops to generate open fire. The assumption is that any recycling behaviour that exists in households automatically shows the willingness to explore different resourceful uses of waste material. This implies that the if households could find more options that the crop residue can be useful for, the more households are likely to adopt the new technology that utilizes these residue as feedstock. Oliver *Et al.,* (2011) affirm that this indicates a pro-environmental behavior by households.

4.15.10 Monthly spending on energy (conventional) by households

A positive statistical significant relation (Z=3,664: P<0, 01) existed with monthly spending on energy with the dependent variable. The interpretation of these results are that the more money the households spend on the current energy the bigger the chance for them to adopt renewable energy as alternative source of energy. Already the notion that affordable but reliable alternative source of energy is needed exists. Hence the community find other alternative source, which are not currently sustainable and reliable in some instances. In fact, other households have been left worse since the installation of electricity, now that there is premium due every month. It does not help that the electricity remains expensive and it increases with the household demand.

4.15.11 Monthly cost of lighting for households

The results show affinity between cost of lighting and willingness to adopt renewable energy (Z=1,940: P>0, 52). This implies that that the increase in cost of lighting can force the households to find alternative sources of energy. Energy needs already consumes a large portion of the household's monthly income, competing with other basic needs of the household such as food and education. If the cost of keeping the lights every night means

compromising other important needs of the household in the process gets higher, households will have no option but to adopt the renewable energy to ease this burden.

4.15.12 Membership affiliation or social belonging

The results show another positive relationship between membership to a social club and willingness to adopt renewable energy exist; (Z=6,145: P<0, 01). Haddad *Et al.*, (2003) and Hitayezu *Et al.*, (2015) highlight that trust is generally lower among women. However, it increases when they are individualized and affiliating in different groups outside their households. Even if participation in a social club is naturally non-economic such as a church, the benefits thereof are interestingly often economical. Naturally, when individuals belong to a particular group, they share similar values, practices and aspirations that increase the level of trust among the members of the same social group. Therefore, adoption decisions to be made can easily enter the discussions and later implemented in the respective households.

Table 14: Probit regression analysis of socio-economic factors influencing the "willingness to adopt the renewable energy" (n=284)

Parameter	Estimate	Std. Error	Z	Sig.
Knowledge of renewable energy	-0.249	.015	-16.650	**0.000*** **
Attitude of households	-0.095	0.010	-9.828	**0.000*** **
Sources of information for renewable energy	-0.304	0.064	-4.738	**0.000*** **
Age	-0.006	0.051	-0.118	0.906
Gender	0.289	0.104	2.768	**0.006***
Marital status	-0.001	0.021	-0.065	0.948
Education	-0.005	0.038	-0.135	0.892
Size of household	0.033	0.045	0.721	0.471
Employment status of the household head	0.125	0.066	1.893	**0.058***
Work designation	-0.025	0.028	-0.905	0.366
Farming activities	-0.042	0.062	-0.678	0.498
Livestock owned	-0.049	0.041	-1.196	0.232
Livestock kept overnight	0.092	0.119	0.772	0.440
Current use of manure	-0.059	0.088	-0.668	0.504
Arable farming	0.022	0.089	0.245	0.807
Land ownership	0.220	0.115	1.920	**0.055***
Farm size	-0.239	0.112	-2.143	**0.032****
Current use of crop residues	0.160	0.048	3.323	**0.001*** **
Monthly spending on energy	0.693	0.189	3.664	**0.000*** **
Cost of lighting	0.403	0.208	1.940	0.052
Monthly income	0.030	0.033	0.907	0.364
Membership affiliation	0.244	0.040	6.145	**0.000*** **
Use of social media	0.049	0.078	0.628	0.530
Intercept	3.564	0.672	5.306	**0.000*** **
Chi Square	93456			
df	256			
p	0.000			

Hint: significance levels; *= significance level 10%, ** = significance at level 5% and *** = significance level 1%

Source: Field survey data (2014)

4.16 Chapter summary

Different variables were analysed under eight themes developed from the objectives of the study. These variables were isolated using the Probit regression analysis to determine the extent of influence on the final adoption decision. Among the twenty three variables that were believed to exert some kind of influence, only twelve were found to have the influence on the final decision that households would make regarding adopting renewable energy as alternative source of energy. Although not all the explanatory variables that were statistically significant had a positive relation with the dependant variable, they all linearly related but varied individually. Psychographic factors such as knowledge and attitude were highly significant for individual households. Other socioeconomic independent variables were significant at different levels of significance. The null hypothesis was therefore rejected.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary, conclusion and recommendations of the study. Salient issues from the findings are discussed in the summary. Conclusions about the findings of the study are made as underlined by the objectives of the study. Finally recommendations based on the findings of the study are presented as guided by the objectives of the study.

5.2 Summary

Relative energy poverty is still rife in the African continent. The Sub-Saharan region had been trading with conventional energy until the enormous jolt of power outages in South Africa, the net energy exporter in the region. The "load shedding" brought the production in the mining industry to a sudden halt. The country lost billions of Rands which were later followed by recession. In 1994 one of the policies adopted was "universal electrification" which saw the number of un-electrified houses doubling in a very short space of time. During this time the energy margins were receding gradually and there were no mitigation strategies implemented to circumvent the eventuality. Alternative energy source became a topical issue at conferences, with natural gases produced from biogas and biomass getting popular. These combinations of organic form of gases are largely known as renewable energy.

Renewable energy can use various feed stocks are used in these projects; including cow dung, pig manure, different waste materials, algae and faecal matter. Although these talks became rife and specific policies crafted to support this motion, these discussions did not really transcend to grassroots level, the households for experimentation. Households form part of the residential energy which presents a rare opportunity to experiment various alternative energy sources without huge economic implications. The promotion of biogas by the eight Development Millennium Goals suggest a need to collaborate different experts to come together and find modern sustainable solutions through participatory approach that embrace social capital important in rural areas. However, despite the

promise presented by renewable energy these discussions never seem to include and be held by households.

This study was undertaken to investigate if households were aware of renewable energy and if they were willing to adopt it as an alternative energy source. The hypothesis was developed stating that socioeconomic factors have no influence in the final decision to adopt renewable energy. The Probit model regression was estimated isolating 23 variables underlined by the objectives of the study outlined as: (a) identification of personal characteristics of household heads (b) Elicitation and ascertaining knowledge of renewable energy by household heads as alternative energy source (c) Determine the willingness to use renewable energy as alternative energy source, (d) Identification of sources of information on renewable energy as alternative energy source, (e) Determination of attitude towards renewable energy as alternative energy source, and lastly, (e) Identification of constraints to the use of renewable energy as alternative energy source. The Probit output showed that 12 of the 23 original variables had an influence in the final decision. Therefore the hypothesis of the study was rejected.

5.3 Conclusion

The aim of the study was to explore and investigate household's willingness to adopt renewable energy as alternative energy source at Mathebethi in KwaNyuswa – eThekwini Municipality in order to share with relevant stakeholders as far as creation and development of renewable energy. The hypothesis was formulated and variables identified based on the literature. The hypothesis was stated in the null, basically it suggested that socioeconomic variables have no influence on the decision to adopt renewable energy by the households. The extrapolation of the Probit model found that the adoption decision can be informed by variables such as knowledge, attitude, information source, age gender, marital status, education, arable farming, land ownership, current use of farm residue, monthly spending on energy, membership or affiliation to social club and use of media. It has already been pointed out that local economy was pivotal when experimenting with renewable energy to find a reliable and compatible the alternative source. Along with the statistically significant variables already mentioned.

Evidently access to reliable energy or the lack thereof is directly linked to economic and social development. As literature suggests that traditional global experience depicts other forms of renewable energy such as biogas technology as energy source that does not require complicated systems to construct and manage. The African continent has already embraced this technology to some extent. Since this kind of energy presents an ideal market to match the sparsely populated nature of most peri-urban/rural households, consummate Mathebethi's mountainous profile. The nature of energy consumption needs is focused more on cooking as it consumes between ninety to hundred percent of the household energy of choice. That is why the community of Mathebethi has continually relied on fuelwood for cooking energy needs and left everything else plugged into conventional energy. Introducing renewable energy in the energy mix can provide households with clean options as opposed to fuelwood that leaves soot and can cause health problems. Households maintain that electricity remains expensive as it consumed a large portion of income. The reality is that in other instances households are left worse off after electrification due to the inherent monthly electricity obligation. There is a dire need for the proliferation of scientific data on which sound progressive innovation strategies must be developed. A participatory technique that will allow key role players, from researchers to innovators to practitioners need to be employed in order to get a head start.

5.4 Recommendations

Recommendation 1 – the first objective of the study was to elicit information on personal characteristics. Age, gender and level of education were the variables in this theme that were statistically significant. Since the majority of households were female-headed by 50 years of age, there is a need to empower them to make decision at the community level. Education can include the awareness pogrammes that the authorities can organize since it builds a strong intuition that women can draw from when making the adoption decision. A comprehensive two-way participatory technique is ideal among all stakeholders involved. Considering that women are left to perform different tasks in the households, which often leave them out of economic training. Organizing roadshows and training programmes during the time when the young ones are at school can guarantee women

participating outside their comfort zones. The benefits for women might not be purely monetary but gains from the opportunity cost presented by a better reliable, clean, new renewable energy. In cases where males are present as custodians of social laws and policies; there is a need for them to relinquish some of the decision making power both at household level as well as community level. Pertinent to healthy, rounded discussions about renewable energy centred on the people involved in energy generation.

Recommendation 2 – the second objective consisted 25 statements that tested the level of knowledge of renewable energy as alternative energy to which respondents answered by stating whether the statement was True or False. Knowledge was highly significant. Literature shows that without knowledge households are left uncertain about the decision to adopt. Availability of relevant information and the source thereof provides confidence to households to justify the decision made. A reasonable level of knowledge also provides a springboard for new innovation/technology. The assumption is that if household heads know about the benefits of utilizing renewable energy as an alternative source they are likely to aspire to adopt it for their daily energy needs. Bridging the information gap is of paramount importance using available avenue such as strategic municipal offices e.g. Community Participation department, technology transfer efforts by research institutions and awareness/training workshops. A trusted source needs to be identified in terms of key informants. However, there was a general trust for the Community Mobiliser from EThekwini Municipality and the Councillor of Mathebethi. Another strategy could be to use them as gatekeepers and key informants about the renewable energy. Also the use of institutions, such as the church, as an entry point into Mathebethi to "preach the gospel" of renewable energy could be effective.

Recommendation 3 – the third objective measured the willingness to adopt renewable energy. Household heads indicated by answering Yes or No to the willingness to adopt renewable energy. Knowledge as a variable was closely linked to this objective. When households do not have sound knowledge about renewable energy, "willingness to adopt" cannot be expected. The notion that "no data, no visibility, no interest" becomes true. There needs to be vigorous awareness programs regarding renewable energy. The ability

to experiment with different types of renewable energy can allow the households to develop an insight into what works for their local environment. Since renewable energy, thrive on the local economy. These spinoffs from the energy could inevitable be a coveted impetus to creating sustainable livelihoods. In that way, creating interdependent enterprises to stimulate local economy. Using public places such municipal offices, clinics or school as testing sites; and to serve as a reference point for the community. This might be the impetus proliferation of experimenting with different forms of renewable energy. A means test needs to be conducted though to contextualize the developmental needs for respective communities.

Recommendation 4 – the fourth objective measured the credibility of different sources of information of renewable energy. The list included media such as audio, print, persons and organizations that households could choose from. Radio was the common medium used as a source of information by households. More awareness programs by government, service providers and research institutions need to be broadcast via this preferred medium of choice. Radio seems to have a wide coverage in terms of its indiscriminate broadcasting ability. It augurs with the nature of multi-tasking by household heads. Other forms of media such as television require one to take time off the different tasks; therefore, it is somewhat not ideal. However; if the timing of the awareness program is strategic such as shortly after the news it might work. Meanwhile radio is still accessible even in areas that are not yet electrified. Key role players need to use local and national media to ensure the dissemination of information. Inanda FM is within the vicinity of Mathebethi. To involve local credible platforms like the local radio station, personalities or local heroes; to drive awareness campaigns, sponsoring local events and enforcement of social responsibility will go a long way in educating the community about alternative renewable energy. Government plays a key role of both an enabler and commentator by rewarding and motivating the role players. In the South African context, stakeholders need to collaborate to find a sustainable competitive edge that would facilitate the proliferation of renewable energy.

Recommendation 5- the fifth objective examined the respondents' attitude to renewable energy. This was measured by using a 5-point Likert scale of Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree. The attitude scale consisted of 25 statements as a minimum score as well and a maximum score of 125. Neoclassical theory suggests that the primary economic factor in determining the demand for any product or service are household's tastes and demands; prices of these products and service underpinned by the buying power of the individual household. The fact that households' view electricity as a normal good whereas other sources of energy that were used before electrification are merely as inferior goods. So there is unfairness in comparing the two products since they are not similar to begin with. For poor household externalities for electrification are obscured since there is an intervention from government in the form of subsidy. A similar strategy needs to be employed for the renewable energy so as to generate interest among the households. Households that proactively adopt renewable energy must be incentivized. A hybrid system must be adopted for places that are still un-electrified; a more diverse approach to electrification will ensure that a "new" household inherently adopts renewable energy. In absolute terms poor households use less energy than wealthier households. If the focus could be generating alternative sources for cooking initially then when this gains traction the project is slowly rolled out to other energy-consuming activities.

Recommendation 6 – the sixth objective consisted of a list of 10 constraints that households could choose the one applicable to the respective scenario. These constraints were believed to hinder the uptake of renewable energy from a list of 10 constraints provided. Among the ten constraints pointed out normative beliefs or trends took the precedence over the intuition. Participation of households at community level is of imperative to diffuse the level of mistrust within households. The nature of affiliation might not be economic. However, economic benefits are a by-product since households are individualized. Discussions on aspirations and desire might inspire others to shift and influence their way of thinking. Clearly reliable access to social capital could facilitate this process. The interaction between societies in schools, churches, social clubs and everywhere else about renewable energy has to ignited and carefully monitored. More

renewable energy search needs to be done from all fields from social science, natural science to engineering to create conducive environment for innovation. For the sake of progress rural energy interventions should not be based on lessons learned from the failures of previous rural energy projects. It must include the current theories found within rural development thinking. There is need to find a methodology that is more embracing that addresses women's needs directly. This methodology should be comprehensive and bottom-up so as to embrace the local context.

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