Thesis:

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Opportunities and Challenges for Renewable Energy Adoption in Malawi. A case study of poultry farms

Diana Theresa Trindade

Supervisors

Prof Dr Joy Clancy

Dr Nthabi Mohlakona

Table of Contents

Table of Figures and Tables:

List of Appendices:

List of Abbreviations

GDP	: Gross Domestic product
NSSD	: National Strategy for Sustainable Development
SDG	: Sustainable Development Goal
FAO	: Food and Agriculture Organisation of the United Nations
RET	: Renewable Energy Technology
MAREP	: Malawi Renewable Energy Programme
PV	: Photovoltaic
IRENA	: International Renewable Energy Agency
CEM	: Community Energy Malawi
PUE	: Productive Uses of Energy

ABSTRACT

Electricity availability and access are some of the biggest energy challenges in Malawi. The use of renewable energy has the potential to increase access to electricity especially in the rural areas. There are several regulatory instruments that are being used to increase access to renewable energy and to influence the adoption of renewable energy technologies in the country. Renewable energy use in the country makes up a small portion of the total primary energy mix. Adoption of renewable energy technologies by the private sector could add to the renewable energy component of the country's energy mix. The research conducted used a case study strategy where data was collected from small and medium poultry farms that are similar in operation. The study looked into issues of awareness and learning as well as application of renewable energy technology in the industry and how they relate to adoption and diffusion of the technology. The study was an in depth study of the factors that can drive adoption and diffusion of solar energy technology in this sector. Results show that there are opportunities to use existing platforms for knowledge sharing on renewable energy technology through associations, media and demonstration projects where renewable energy technology is applied to different agricultural practices. On the other hand, the cost of renewable energy technology such as solar equipment is costly especially for poultry businesses that are growing.

Key words: Renewable Energy Technology, Adoption and Diffusion, Knowledge and Awareness.

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1.0 Introduction

1.1 Background

Malawi is a landlocked country bordered at the north by Tanzania, at the south and west by Mozambique and at the east by Zambia. Its population in 2016 was estimated at 18 million (World Bank, 2017). Poverty as well as inequality are high, attributed to limited opportunities in sectors that are not agriculture based, population growth as well as a volatile growth in the economy (World Bank, 2017). The country's Gross Domestic Product (GDP) is composed of Agriculture (28.6%), Industry (15.6%) and services at 55.9% (CIA, 2018).

1.2 Electricity Access and Energy Use

According to 2014 data by the World Bank, the country has one of the lowest access to electricity at 11.9% of total population. Approximately 30 % of the urban population and 1% of the rural population has access to public electricity supply (Kachaje, Chisanu, & Liangjun, 2017). The country's electricity is mainly from Hydroelectric power at 93.3% (CIA, 2018). Because of challenges in the energy sector and incapacity to generate electricity, frequent blackouts and brownouts are experienced. This consequently has a negative impact on the development of the country because there is low economic activity, low quality of life and investments are deterred (Government of Malawi, 2012). Power outages cost Malawi approximately 2-3% of the GDP (Taulo, Gondwe, & Sebitosi, 2015).

Following the world summit on sustainable development in 2002, Malawi developed the National Strategy for Sustainable Development (NSSD). The strategy sets out an agenda of actions to be implemented in the next 10-15 years in order to attain sustainable development. In this strategy, energy is one of the five thematic areas of focus. Under this theme, a target was set to decrease the biomass component in the energy mix from 93% to 50% by 2020. A target to increase access to electricity from 2.3% to 30% by 2020 was also set (Government of Malawi, 2004). In 2015 , biomass accounted for approximately 80% of total primary energy supply, followed by liquid fuels and biofuels at 10%, renewable energy sources including hydroelectricity at 7% and coal at 2% (Government of Malawi, 2016b). The use of Biomass is a priority area in the draft Malawi Energy Policy of 2016 and recognises the environmental impacts as well as the health impacts that result from its use for cooking because of the particulate matter from firewood and toxic carbon monoxide from charcoal (Government of Malawi, 2016b). In a study conducted by MARGE in 2009 on biomass energy in Malawi, it was estimated that 304, 690 tons of charcoal was consumed in the country with 72% of it be used by urban households (Government of Malawi, 2017a).

1.3 Renewable energy

A 2017 report by the renewable energy policy network (REN 21), identifies five main drivers for renewable energy (RE) deployment as follows: Mitigation of climate change, reducing local air pollution, energy security, costs, local value and jobs (IRENA, 2017a). Malawi is one of the 164 countries to have adopted at least one type of renewable target in the areas of total primary energy supply and electricity (IRENA, 2015b). For Malawi, energy mix targets, including renewable energy source targets are set out in the National Energy Policy (Gamula, Hui, & Peng, 2013). The Malawi Renewable Energy Strategy (MRES), estimates that 23% of the population has access to some kind of electricity, of which 10% is connected to the grid and 13% to an off grid solar device (Government of Malawi, 2017b).

Sustainable development goal (SDG) number seven states that, universal access to clean and affordable electricity by 2030 requires, amongst a range of options, investments in renewable energy sources such as solar, wind and thermal, and can result in economic growth and environmental protection (UNDP, 2018). Further to this, the UN 2030 Agenda for Sustainable development identifies the private business community as drivers of economic growth, job creation and can also drive sustainable development goals by being creative and innovative in the way they solve sustainable development challenges (United Nations, n.db). The integrated nature of all the 17 SDGs are important in ensuring that the purpose of the 2030 agenda for sustainable development is achieved (United Nations, n.db). This means that to achieve access to clean, affordable electricity, other cross cutting issues such as education, economic growth, gender equality, and partnerships for the goals are of importance. The Government of Malawi developed the Malawi Renewable Energy Strategy that focuses on different aspects of renewable electricity, sustainable bioenergy and various cross cutting areas such as Education, capacity building and Research (Government of Malawi, 2017b). Furthermore, the strategy also recognizes the need for cooperation with key stakeholders such as government agencies, Industry, donors, Non-Governmental Organisations (NGOs) and civil society groups.

African Energy Outlook Report (2014) by the International Energy Agency (IEA) estimates 2% of renewable energy in the energy mix for Sub Saharan Africa. This estimate includes solar, wind, hydro, geothermal and bioenergy, with the exception of traditional use of Biomass. The Malawi National energy policy aimed at diversifying the energy mix by focusing on other renewables such as solar and wind, with the expectation of raising the renewable energy target to 7% by 2020 from 2.5% in 2010 (Gamula et al., 2013). It is suggested by Taulo et al. (2015) that increasing both coal and electricity consumption is needed to increase the energy mix of the country. However, with the technological advances and innovations in the development of other renewable sources such as solar, wind and biofuel, the private sector could avoid or minimise the use of fossil fuels through self-generation of energy using cleaner renewable energy sources. For Small Medium Enterprises (SME), solar thermal systems can reduce operating costs by minimising the SMEs dependence on fossil fuels (IRENA, 2014). The Malawi Renewable Energy Strategy suggests that mini grids could serve industry and businesses by generating their own secure energy from renewable energy (Government of Malawi, 2017b). It is further noted in the strategy document that lessons could be learnt from existing businesses that use their own renewable energy systems. Examples of such businesses in the country include Illovo sugar, Lujeri tea estate and Lilongwe International Airport (Government of Malawi, 2017b).

There are several legal instruments that support the drive for renewable energy in Malawi. These instruments include the National Energy Policy, the Malawi Rural electrification act and Programme, and the National Sustainable and Renewable Energy Programme (IRENA, 2018a). In order to build local capacity and skill, the Malawi Testing Centre in Renewable Energy Technologies was established in 2004 (SEforAll, 2012). This institution provides short and long term courses in renewable energy technology, in addition to testing of equipment to check compliance with national standards (IRENA, 2018a). Organizations with a focus on renewable energy in the country include The Renewable Energy Industries Association of Malawi (REIAMA) which facilitates discussions between the renewable energy industry sector, mainly focusing on the commercial businesses. In the Malawi Renewable Energy Strategy, it was

recommended that REIAMA[1] be re-developed to include NGOs and other organisations that may be interested in renewable energy issues (Government of Malawi, 2017b). NGOs with a focus on renewable energy in the country include Renew'N'Able Malawi (RENAMA)[2] and Community Energy Malawi .The Corporation Network for Renewable Energy in Malawi (CONREMA) is an online information sharing platform for RET in Malawi. The private sector could use these existing platforms in pursuing self-generation of electricity from renewable sources.

2.0 Literature review

2.1 Renewable Energy and Agriculture

The Agriculture sector plays a key role in the economies of least developed countries, with a GDP share of 30-60% and employment of 80% of the national workforce (United Nations, n.da). Despite its importance in the economy of the region, this sector makes minimal use of modern energy (IEA, 2014).
A study by Davis et al., (2011) on community energy projects in Malawi, found that through government and NGO's, placement of renewable energy technologies has been done in the health and educational sectors but few projects address the agricultural sector. Furthermore, in a FAO (2011a) report, it was pointed out that despite the existence of various international and national policies that encourage businesses and household on energy efficiency and renewable energy projects, a few energy policies are connected with other policies to strengthen the food sector and ensure food security. To help mitigate effects of climate change, climate smart agriculture is being promoted by FAO in various countries, including Malawi (FAO, 2018b). The FAO defines climate smart agriculture as agriculture that focuses on minimising greenhouse gasses while increasing productivity and generation of income as well as building resilience to climate change (FAO, 2018a)

For the commercial poultry industry, a reliable supply of electricity is important for lighting, heating, and operation of other mechanised equipment such as feeders. In the case that frequent power cuts are experienced, the farms are forced to use other sources of energy such as diesel generators. In addition to increase in fuel prices, improvements in alternative energy technology and the need for cleaner energy sources will be drivers for the adoption of renewable energy technology (Akyuz, Oktay, & Dincer, 2011). It is also suggested by FAO, (2011a), that the modification of agricultural equipment and introduction and adoption of improved energy efficient technology is needed in order to reduce energy intensity in farming. The frequent power cuts and its consequent implication on businesses could be an additional driving factor for adopting renewable energy systems in Malawi. Furthermore, renewable energy can be a source of employment for the local population through installation and maintenance of related equipment (IRENA, 2016).

Increasing population will consequently lead to an increased demand for food supply. For livestock, this will have an effect on the energy cost and its share emission of greenhouse gasses which is currently at 18% (Fawaz, Abiad, Ghaddar, & Ghali, 2014). It is estimated by the Food and Agriculture Organisation

[1] Renewable Energy Industries association of Malawi (association mainly focussing on the commercial side of RET: production, supply, installation, servicing, import and export of RET)
[2] Renew 'N' Able Malawi (NGO that focuses of RET and reduction of energy poverty)

(FAO) that by 2030, the total demand for animal products will more than double in developing countries (FAO, n.d.).

In the past, energy costs made up a small part of total production costs in the food sector, and reduction of energy intensity was not emphasised but this has changed because of increased energy costs, the growing food sector and the need for businesses to reduce the carbon footprint(FAO, 2011a).

2.2 Renewable Energy Technologies

2.2.1 Wind

The use of wind technology is on the rise worldwide partly due to declining costs and electricity generation from it doubled between 2009 and 2013 (IRENA, 2018b). In areas where the wind resource is good in Sub Saharan Africa, wind energy can be competitive in terms of cost (IEA, 2014). Furthermore, Golusin, Dodic, & Popov, (2013 p.361) suggests that the cost is competitive with conventional sources if environmental impacts are factored into the cost of electricity production. However, development of wind farms is more complex and production of energy is variable and unpredictable (Golusin et al., 2013p. 361). In Malawi, wind speeds are moderate to low in the range of 2-7m/s but could be sufficient for generation of electricity for milling of grains, pumping of water and lighting (Taulo et al., 2015).

A pre-feasibility study by Malawi Renewable Energy Programme (MAREP), funded by the Scottish government, found an area suitable for a wind farm with the capacity of 50MW and this has the potential to increase the country's electricity generation by 14% (Government of Malawi, 2017b).

2.2.2 Biogas

Apart from forest residue and products, agricultural residues are a potential source for biogas production in sub Saharan Africa(IEA, 2014). For domestic use, small biogas digesters can be efficiently used with animal manure (IEA, 2014). The use of chicken manure for biogas production could help to alleviate chicken waste disposal problems and reduce smell. On the other hand, use of chicken manure alone for Biogas production is difficult to handle because of the high nitrogen levels and other inorganic compounds like chalk and sand (Fischer et al., 2010). High levels of nitrogen compounds inhibit biogas production and the accumulation of sand in the digester reduces volume capacity of the tank, increasing operational costs (Fischer et al., 2010). Furthermore, chicken manure is mostly used as a component of other substrates, (approximately 30%), otherwise using it on its own requires dilution with water to a solids content of about 5-10% (Fischer et al., 2010). If the manure is used as organic fertiliser by the surrounding community, using it for biogas may make it unavailable for its use as a fertiliser. In the draft Malawi energy policy of 2016, it was pointed out that there is insufficient data with regards to the use of biogas in the country (Government of Malawi, 2016b)

2.2.3 PV

Because of the growing need to achieve energy security as well as the fight on climate change and Global warming, studies are necessary to identify suitable solar applications that can be adopted by other industrial sectors (GIZ, n.d). Although industries that require high grade heat ranging above 800^{o}C cannot benefit from solar technology in a cost effective manner, industries with lower heat requirements may find solar as a sustainable source of energy (GIZ, n.d). Smaller businesses and industries that have low heat and electricity requirements but have high growth rates have high potential of adopting solar technologies for productive uses and can serve as examples that can be easily copied (GIZ, n.d).

With an average of 320 days of sunshine and 2000kWh per m^2 of irradiation annually in a year, the African continent has much potential for solar energy, but its technology in the power sector has been limited (IEA, 2014). For Malawi, the country has approximately 2133kWh/m^2/year of irradiation (Taulo et al., 2015). Compared to wind energy, solar energy is a preferred because it can be used anywhere in the country(Yaron, Environmental Affairs Department, & Ministry of Finance and Development Planning, 2012). Another advantage of solar energy is its simplicity in terms of technology that makes technical skills and knowledge of managing the system easily transferable (Barry, Steyn, & Brent, 2011).

Solar energy technology has its disadvantages in that, although the operation of the technology does not produce greenhouse gas emissions, the manufacture of nanomaterials for the panels has a high energy demand that leads to high CO^2 emissions (Pallas, Peijnenburg, Guinée, Heijungs, & Vijver, 2018). Ground mounted , large scale PV solar farms may present negative impacts on ecology, land use and carbon sequestration (Moore-O'Leary et al., 2017). It is suggested by Moore-O'Leary et al. (2017) that these impacts can be avoided by using roof top installations. However, barriers to building integration systems are low efficiency and capital investments (Mekhilef, Saidur, & Safari, 2011).

For this proposed research, PV technology would be suited based on its applicability to the poultry farms, the abundant resource of solar radiation and its simple technology that makes it easily transferrable.

2.3 Learning as a tool for advancement of PV systems

IRENA (2017b) identified the following as some of the limitations to renewable energy systems deployment: pricing mechanisms that are in favour of competing energy sources, inappropriate or lack of related infrastructure, lack of capital for build-up of industrial capacity and minimal efforts targeting demonstration and learning of technology that enables growth in terms of scale.

Results from a case study by (Huenteler, Niebuhr, & Schmidt, 2016) suggests that local learning has the greatest potential for reducing the cost of renewable energy deployment in developing countries. The effect of knowledge and capacity building is demonstrated in Kenya where demand in PV systems resulted from efforts by the donor community through workshops, training, and demonstration projects but a private market eventually grew as PV system prices declined and donor support was reduced (Nygaard, Hansen, Mackenzie, & Pedersen, 2017). Demonstration projects are a source of knowledge where experimental and pilot projects could bring lessons and the sharing of such lessons could be beneficial in rolling out of other RET projects. Studies on on-farm trial projects of new technology shows that the demonstration projects play an important role in the adoption process (Marra, Pannell, & Abadi Ghadim, 2003)

According to IRENA (2014), 75% of SMEs are in developing countries with large renewable energy sources and this can lead to development of equipment associated with renewable energy and encourage learning by doing. Learning by doing is when experience with a new type of technology increases efficiency in its use (Warner 1974) as cited by (Marra et al., 2003).

Networking in the society may play a role in the adoption process of RET. Jacobsson & Johnson (1998), describes networks as means through which knowledge is transferred and is helpful in identifying problems and developing technical solutions for them. Furthermore, the technological system is made up of actors and their capabilities, as well as institutions and networks whereby their failure may hinder the advancement of new technology (Jacobsson & Johnson, 1998). An important factor in predicting adoption

of an innovation is an individual's network (Rogers, 2010). It is also suggested by Rogers (2010), that the pace at which an innovation is adopted is affected by the extent to which networks are interconnected in the society.

2.4 Theoretical Framework

It is suggested by Straub (2009) that the ability of an individual to learn by observing others rather than personal experiences are one of the foundational concepts of the **Social Cognitive Theory** which was developed by Bandura (1987). Social learning plays an important role in adoption and diffusion of innovation, whereby individuals may consider adopting a particular innovation by observing others (Straub, 2009). In addition to learning through observation, Straub (2009) also suggests that technological developments and access to information through media has increased the possibilities of social learning. It is also suggested by Straub (2009) that individuals have the capacity to learn from experiences of those around them and not just their own experiences.

Rogers Theory of Diffusion (2010) defines diffusion of innovation as a process where various channels are used over a period of time to communicate the innovation in a society (Rogers, 2010). According to Rogers (2010), characteristics of innovation are said to have an effect on the adoption of innovation in a society. In General, it is suggested by Rogers (2010) that innovations are adopted quicker if they have a greater advantage over preceding ones and can be easily incorporated within existing norms and values in the society. Furthermore, those that are simpler to understand and can be tried and tested would also be adopted quicker than those that are more complex. Finally, the degree to which the outcomes of an innovation to which an innovation can be seen by others has an effect on the rate of adoption in that those that are not easily observed are adopted slowly. The communication element in the process of diffusion is important in that circulation of the innovation within a population can be achieved if it is passed on from one person to another.

The Theory of Reasoned Action by Azjen and Fishbein, 1980, suggests that intent to perform a certain behavior determines the persons behavior, and that intent is dependent on attitude and external pressure that may influence certain behavior (University of Twente, 2017). **The Theory of Planned Behavior** is an extension to the Theory of Reasoned Action by addition of the perceived behavioral action control to the theory (Azjan, 1991). Perceived behavioral control is described by (Azjan, 1991) as people's perception of how easy or difficult it is to perform a certain behavior.

In a study by Lynne et al. (1995) on conservation technology adoption decisions and the Theory on Planned Behavior, it was found that financial capability was of importance for farmers adopting water saving irrigation. Furthermore, the study by Lynne et al. (1995) also suggested that a combination of persuasion and incentives with modest control may be needed in technology policy for farmers to adopt and invest in conservation technology.

Kuiken (2015), cites the definition of strategic decisions by Salvato and Corbetta (2014) as decisions that are made by the decision maker in order to reach an organizations goal or set of goals. Based on this definition, Kuiken (2015) suggests that the Theory of Planned Behavior can be used to predict strategic decisions by considering individual and organizational beliefs. Because interactions among individuals

result in common intentions for the organization, it is argued by Kuiken (2015) that Theory of Planned Behavior can be applied at the organizational level.

In view of the theories discussed above, this paper will look into knowledge and awareness of renewable energy (in terms of advantages and disadvantages), the regulatory framework and policies that have an effect on such technologies and experiences with the technology. The paper will also investigate possible channels of communication through which information on renewable energy can be communicated.

2.5 Problem Statement

Availability and access to electricity in Malawi is one of the biggest challenges with regards to energy use in Malawi. One way of increasing access could be through the use of renewable energy technology. However, renewable energy still makes up a very small percentage of the energy mix of the country. Furthermore, the frequent blackouts have had cost implications on businesses, with some companies resorting to the use of diesel generators for energy supply. In addition to cost implications, the use of diesel generators results in greenhouse gas emissions and have an impact on the air quality and noise pollution in surrounding areas. The poultry industry is one sector that has potential to use renewable energy technology, especially by the use of roof top PV technology. This is mainly because farm houses provide the required roof space for the installation of panels. This thesis will investigate how the poultry industry can contribute to the renewable energy mix and how the use of renewable energy technology by the farms can create opportunities for learning by employees and communities.

Overall, sustainable development in Malawi is hindered by technological barriers; green technology is minimal and not easily adopted (UNDP, 2012).

2.6 Aim and Objectives

To assess how the poultry industry can adopt renewable energy technology and consequently add to the countries renewable energy mix by using sources of energy from rooftop solar systems in farm houses. The thesis also aims to assess whether use of renewable energy by poultry farms has an effect on adoption of renewable energy technology by employees, surrounding communities and other similar industries.

2.6.1 Research Questions

Q1. How can the Poultry Farms contribute to the renewable energy mix by using PV systems?

Sub questions:

- How can solar equipment be used by the poultry farms in their activities and what are the advantages and disadvantages?
- What role does information sharing and awareness play in the adoption of RET by poultry farmers

Q2. How can self-generation of electricity by poultry farms influence employees and surrounding communities to use PV systems?

Sub questions:

- To what extent is PV used by employees in their homes and communities. What are their motivations and barriers?
- Has exposure to PV as a renewable energy source influenced employees and surrounding communities to adopt other systems?

3.0 Methodology

3.1 Research Framework

The research framework for the study has been developed according to (Verschuren, Doorewaard, & Mellion, 2010), as follows:

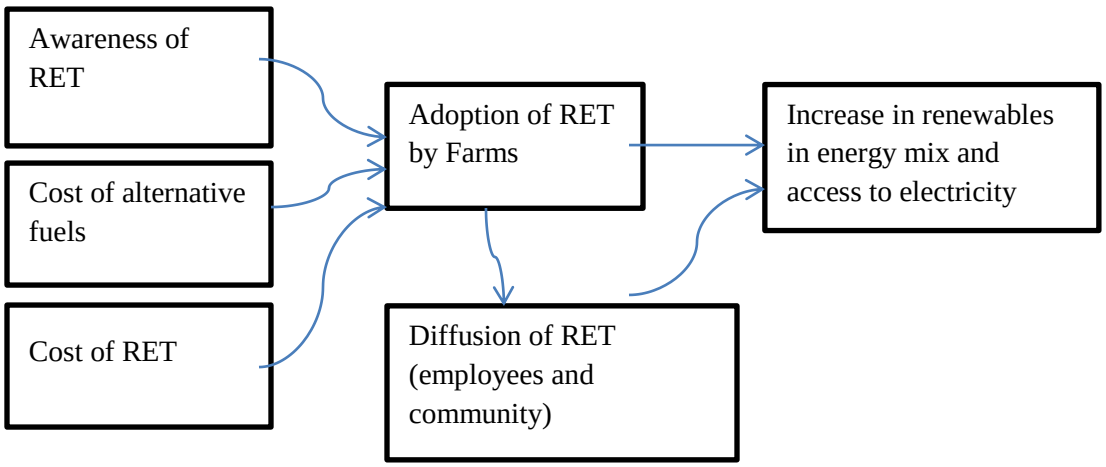
3.1.1 Defining the Research Objective

To assess how the commercial poultry industry can add to the renewable energy mix of the country by adopting renewable energy technology and diffusion of the technology to its employees, surrounding communities and similar industries.

3.1.2 Establishing the nature of the Research Perspective

A conceptual model was developed after a study of relevant literature and theories. A conceptual model helps to show the relationships between the main concepts of the research as well as create boundaries for the research subject (Verschuren et al., 2010). The use of renewable energy by the businesses in the country is a challenge. The poultry industry is an important economic sector and for this research is used as a case study to identify challenges and opportunities that may help to reach government policy objectives. According to (Verschuren et al., 2010), the practice oriented research has a practical problem in its context. Electricity availability and access is the main problem that the paper aims to address. This research was therefore practice oriented.

Figure 3.1: Conceptual model



3.1.3 Defining Key Concepts

Networks: Means through which knowledge is transferred

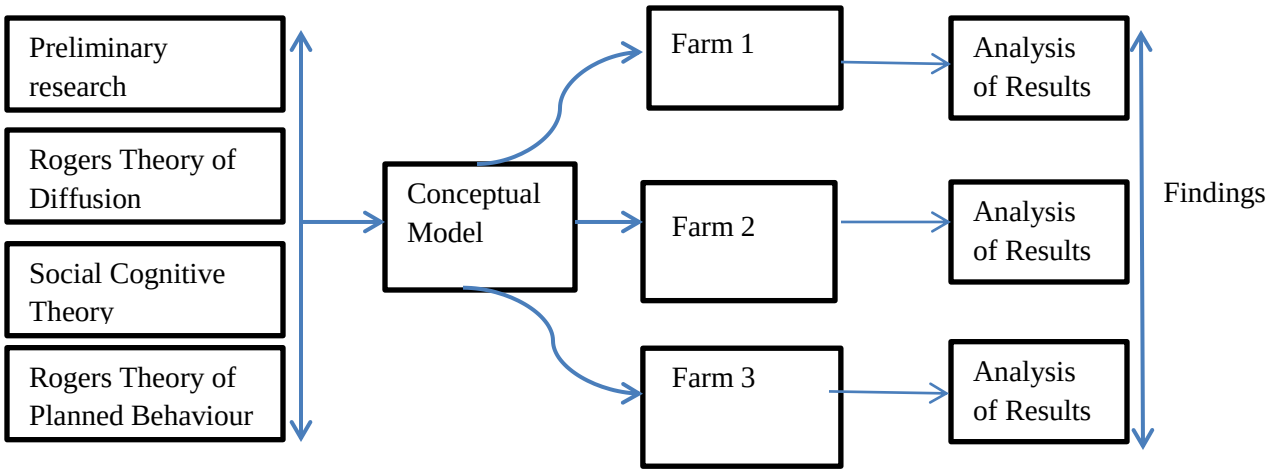
Innovation Adoption: A decision to integrate a particular innovation (Straub, 2009)

Innovation Diffusion: Process where various channels are used over a period of time to communicate an innovation in a society (Rogers, 2010)

Solar PV technology: All solar technology including roof top solar panels, potable solar lamps, solar radios and phone chargers.

3.1.4 Schematic representation of the research Framework

Figure 3.2: Research Framework



3.1.5 Sources for deriving the research perspective

Literature that has been used to study the key concepts has been summarised in the table below:

Figure 3.3: Table indicating sources for deriving research perspective

Key Concept	**Source**
Knowledge/Awareness	Theory of Planned Behaviour
Adoption and Diffusion of Innovation	Rogers Theory of Diffusion/ Social Cognitive Theory

3.2 Research Strategy

Yin (2014), defines a case study as an empirical inquiry through which the researcher can investigate a case in a real world context. Furthermore, it is more focused on making in depth inquiries by using

intensive and a mix of data collection methods (Verschuren et al., 2010). The research focused on mainly SME poultry farms and these farms were selected according to criteria mentioned in section 3.2.1 below:

3.2.1 Selection of Research units

The research units were small and medium enterprises. Key informants were managers or supervisors and employees at the farms. The farms chosen were located within the Northern region of Malawi. Because the farms are located within the same area, they are likely to experience the same power outages, load shedding and similar levels of solar irradiation. They may also have access to the same shops that sell renewable energy technologies. Networking, participation in training programmes and sharing of resources is more beneficial and cost effective if the farms are in the same general location. One on one interviews were conducted with the owners, manager or supervisor while the focus groups were done with the employees of the farms. The focus group discussions were conducted at the work place. This is because the employees are assumed to learn from technology that is available in their areas of work through observation. Each focus group consisted of an equal number of men and women.

As a way of collecting collaborative data, an interview was conducted with a representative of Renewnable Malawi (RENAMA). The organisation is located in Blantyre and a one on one interview was conducted there.

3.2.2 Boundaries

The Farms selected for the research were all located within 100 km of Mzuzu city, in the Northern region of Malawi. Workers selected for focus group discussions were those working within the farm premises.

3.3 Data Collection and Analysis

3.3.1 Data Collection

The methods used to collect data included interviews that were open ended in nature and focus group discussions.

Introductory letters explaining the research and requests for interviews were sent to the commercial poultry farms before data collection, but due to unavailability of the proposed farms for the interview, requests were sent to smaller scale farms, of which two farms responded and agreed to both interview and focus group discussions. At the time that the report was being finalised, there was no response from the third farm to participate in the research. As such data was collected from two farms only and not three as proposed initially. Due to time limitations, only the data from two farms and one NGO has been analysed.

During the data collection, it was found that organisations and associations could play a role in the adoption and diffusion of RET. As such, sub questions initially proposed for RQ1 were changed as follows:

Proposed Sub Question	New Sub Question
What government policies and strategies are available to promote self-generation of electricity by use of PV? What is the level of knowledge in terms of opportunities and advantages of self-generation of electricity by use of PV?	What role information sharing and awareness play in the adoption of RET by poultry farmers

Also, it was found that apart from rooftop solar applications, there are other activities on the poultry farms that could use solar applications. Therefore sub research question for RQ 1 was also changed as follows:

Proposed Sub Question	New Sub Question
What financial mechanisms can be used by the commercial farms to finance PV system installation?	How can solar equipment be used by the poultry farms in their activities and what are the advantages and disadvantages?

Introductory letters were sent and given to the owners when requesting for the interview and they are included in appendix 3 of this report. The guiding questions for the interviews and focus group discussions were also sent to the farmers prior to the interviews. The guiding questions have been included in Appendix 2. This was also done for interviews conducted with the NGO representative.

Interview Questions

One on one Interview

One on one interviews were conducted with farm managers and a representatives from an NGO that focuses on RET. Questions for the interview with the farm owners or Managers were standardised and open ended in order to get the managers views on the impact of power outages or lack of access to the grid, the use of renewable energy technology at the farms and to determine the advantages and disadvantages of its use. The standardised interview questions are worded and structured in such a way that participants are asked the same questions but in a way that the responses are more open ended (Turner, 2010). More in-depth information can be acquired from one on one interviews compared to other methods of qualitative data collection methods such as focus groups because the participant has more time to be engaged in the topic of discussion (Greenbaum, 1998). For the association representative, the interview may not be broadly open ended as with the farm managers because they may serve the purpose of collaborating some of the information gathered from focus group discussions and interviews with Farm managers or owners. In this case, the questions will need to be worded in such a way that they allow the interviewee to give new insights on the topic and to avoid asking leading questions (Yin, 2014. p 111).

Although interviews are a source of rich and in depth data, they may present a problem where coding of the data from transcripts is difficult because of much detailed information resulting from the open ended

nature of the responses (Turner, 2010). To overcome this, only information within the themes that were relevant to answering the research question was used in the analysis of the data.

Focus group discussions

Interviews with farm employees were done through focus group discussions. Focus groups are conducted with a group of people on concepts related to the study in such a way that the moderator of the discussions tries to deliberately get views of all participants in the group (Yin, 2014. p 112). The focus groups for this thesis were mini-groups. These are group discussions consisting of 4 to 6 people (Greenbaum, 1998). Mini group discussions potentially provide more in-depth information as each person has more time to participate in the discussion (Greenbaum, 1998) and data validation is possible because group members moderate each other. During one of the focus group meetings, the discussion was starting to go off topic and this was resolved by restating the question and bringing back the group to focus on the original topic.

Care should be taken not to focus on only one or two participants when conducting focus group discussions, but to engage all participants in order to get an overall understanding of the topics of discussion (Greenbaum, 1998). One of the disadvantages of using focus group discussions according to Breen, (2006) is the possibility of some participants being influenced to agree or disagree with those that are more dominant or vocal. Another disadvantage of the focus group discussion is that time may be lost discussing irrelevant issues as the interviewer may not have much control over a group of people as compared to a one on one interview (Marshall & Rossman, 1999). To minimise this risk, time was allocated for the interview and participants briefed on the issues to be discussed prior to the start of the interview.

Preparing for the interviews

Before an interview started, several principles were followed using guidelines by McNamara, (n.d) and Turner (2010). The principles include: conducting the interview in a place with minimal distraction, explaining issues of confidentiality, format and time required for the interview, provision of the researchers contact details and addressing any questions the interviewees may have before starting the interview. For this thesis, the issues that were addressed before the interviews and group discussions started have been provided in table 3.4 below.

Figure 3.4: Preparation for Interviews

1	Ask Interviewee for a room with minimal disturbance
2	Explain purpose of the Interview, its format and duration
3	Explain ethical requirements and details of the consent form
4	Obtain consent by providing the form and asking for a signature (English or Chichewa)
5	Ask Interviewee for consent to record the interview
6	Provide researchers contact details
7	Address any questions that the interviewee may have before the interview starts

A paper by Castillo-Montoya (2016) summarises steps through which a protocol for interviews can be developed. Aligning the interview questions with the research questions by the use of a matrix ensures that research questions and purpose of study are answered and to identify gaps where more questions may be needed. The paper also suggests constructing an inquiry based conversation. According to Castillo-Montoya, (2016), this includes the formulation of interview questions that are different from the research questions so that they are easily understood and without technical words. Rubin and Rubin (2012) indicates that on the part of the interviewer, gestures such as nodding and thanking the participant show understanding (as cited by Castillo-Montoya, 2016). It is also suggested by Castillo-Montoya (2016) that testing the interview with another person apart from the selected interviewee could help to check if the questions are understandable and if the time allocated for the interview is sufficient. The interview format and questions for this thesis were developed using these guidelines.

A dummy focus group discussion was carried out with some women that previously worked for a poultry farm in order to check interview questions address the research question, as well as to estimate the time required for the focus group discussions. The test focus group discussion took approximately 40 minutes. This showed that the one-hour time allocated for the focus group discussions was sufficient.

The questions for the Interviews and focus group discussions have been included in appendix 3

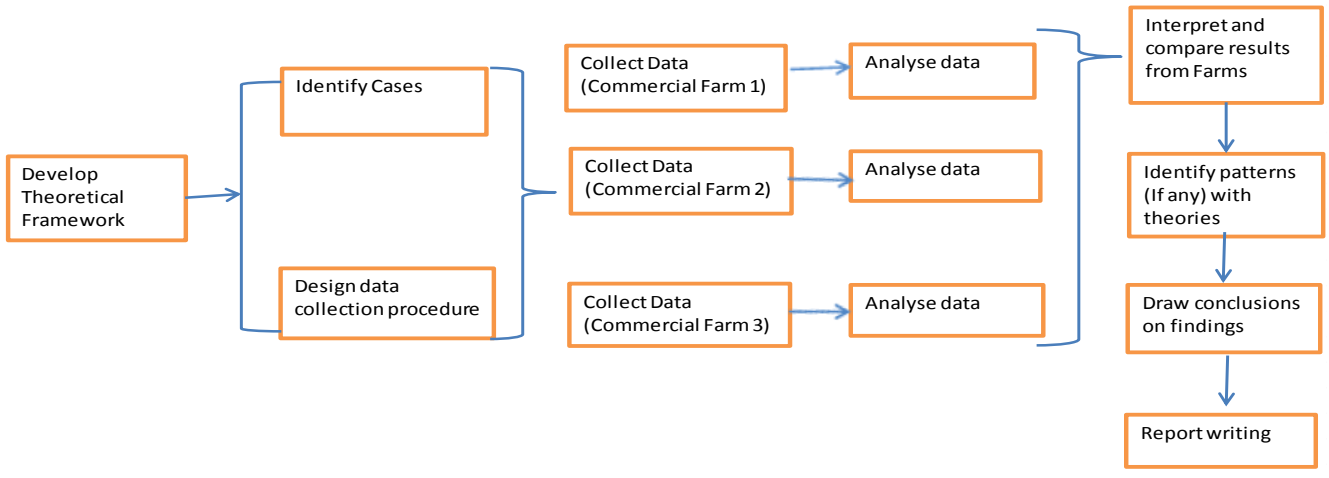
Literature

In addition to the interviews and focus group discussions, data was sourced from the various research papers, online databases and Government policy documents

3.3.2 Data analysis

The data from each case study was analysed separately and results compared to identify patterns with theory. The analysis procedure is illustrated in the figure below:

Figure 3.5: Case study procedure adopted from (Yin, 2014)



Thematic analysis

The analysis of the data collected from interviews and focus groups followed a thematic analysis method, adopted from Clarke & Braun, (2014) as summarised below:

- Familiarisation of data from interviews and focus groups by re reading textual data and making notes to highlight areas of interest according to the research questions
- Identification of themes from text that draw on the research questions or theoretical framework. These will be presented in a table format
- Identification of relationships and patterns between themes and review of themes to check coherence
- Definition of themes by summarising the themes to check if they address the research question
- Include quantitative data from questionnaires and interviews
- Send summary of findings to representative of Poultry Company for review and feedback.
- Include secondary data from desk research
- Include findings in Final report

3.3.3 Research Question1

In order to answer the proposed research questions and sub questions, data required, their sources and methods of analysis are summarised in the table below:

Table3.6: Data types, sources and methods of collection and analysis for question 1 (What are the opportunities for the Poultry Industry to contribute to the renewable energy mix by using PV systems?)

Research sub question	**Data/Information required**	**Source**	**Collection method**	**Analysis method**
What are the impacts of power outages on poultry farming	Financial: Cost of backup power Equipment damage Labour costs Loss of product Non-Financial Noise pollution	Farm Manager	Interview/ Desk Research	Qualitative and Quantitative
What are the advantages and disadvantages of using solar power in the poultry farms	Advantages Reduction of backup fuel costs Continuous power supply Reduced noise pollution Disadvantages Initial investment cost Maintenance costs Availability of equipment and expertise Substandard equipment	Farm Manager Representative of RENAMA	Interview/Desk Research	Qualitative
How can public incentives be used by the poultry farms to promote self-generation of electricity by using PV?	Tax reductions on PV equipment Funding Provision of expertise	Farm Manager Representative of RENAMA	Interview/ Desk Research	Qualitative

3.3.4 Research Question 2

Table3.7: Data types, sources and methods of collection and analysis for proposed research question 2 (How can self-generation of electricity by poultry farms influence employees and surrounding communities to use PV systems)

Research sub question	**Data/Information required**	**Source**	**Collection method**	**Analysis method**
To what extent is PV used by employees in their homes	Number of households using PV compared to other energy sources For what purpose is the PV used (Lighting, other electrical equipment)	Farm employees	Semi structured Questionnaire	Quantitative
		Farm employees	Focus group	
Has exposure to PV as a renewable energy source influenced employees to adopt other systems?	<u>Advantages</u> of using PV Constant availability of electricity Operation does not produce fumes/pollution <u>Disadvantages</u> of PV Cost of purchase Cost of batteries Durability	Farm Employees	Focus group	Qualitative

3.4 Data Validation

Construct validity is defined by (Yin, 2014) as the extent to which concepts being studied are accurately reflected in the case study design. One way of ensuring validity during data collection is through the use of multiple sources of evidence (Yin, 2014). For this study, the sources of evidence included interviews, focus groups, government policy documents and previous research papers.

Internal validity during analysis is checked by using a pattern matching logic as recommended by (Yin, 2014)

To ensure validity during the composition of the report, (Yin, 2014) recommends review of the draft report by key informants. For this study, the findings from each farm were sent to the owners for comment before finalising the report. The findings from the NGO interview were also sent to the interviewee for verification

3.5 Ethical Requirements

Prior to interviews being conducted, consent was sought from the participants in order to ensure privacy and confidentiality of participants. Participants were provided with the consent forms and the researcher explaining the ethical requirements of the research. Where required, the form was translated into the local language and explained in the local language. Interviews only commenced after the signed forms were obtained from the participants. The consent form that was used is included in appendix 1.

A password protected excel file has been used to store all data gathered from participants in order to protect their names and information gathered. Only the researcher and supervisors had access to such information. The names of participants have been anonymised where it has been necessary to use names.

Permission was sought and granted from the BMS ethics committee at the University of Twente before conducting the interviews and focus group discussions.

4.0 Results

Access to electricity as well as its availability are challenges with regards to energy use in Malawi. This also has an impact on businesses and the economy of the country. The use of Renewable Energy Technology such as PV systems could contribute to the increase in access and availability of electricity as well as help to achieve government policy objectives on energy access.

The main objective of this research was to assess how the poultry industry could contribute to the use of RET systems as well as RET adoption and diffusion.

It should be pointed out that the results below are only indicative due to the small sample size and cannot be generalised. There is a possibility that data from commercial farms could produce different results.

4.1 Case 1: Findings from Interview and Focus group from Farm 1

The first interviews were conducted with two farm supervisors (one male and one female). Following the interview, a focus group discussion was conducted with a total of six workers consisting of equal number of men and women. Both Interview and focus discussion happened at the work place and were conducted between the researcher and the participants in the local language. Transcriptions were done in English.

After transcription of the interviews and focus group discussions, the data was grouped according to common codes that address the research question. The codes were further categorised into two main themes of challenges and opportunities. This was done for both research questions. The data extracts and assigned codes or labels have been included in appendix 4.

4.1.1 Opportunities

An opportunity for adoption can be a motivation to own or use renewable energy technology. Opportunities for use of renewable energy can be through the use of RET by the farm and through the creation of awareness for their employees.

Participants of the focus group that had solar equipment use it for lighting purposes. Firewood and charcoal are used for cooking and for warmth .The opportunities for adoption of renewable energy technology have been categorised and ranked according to the following:

Usability/Convenience: Issues related to usability and convenience of PV technology were brought up the most during the focus group discussion. A motivation to use PV systems could be its ease of use, compared to other technologies. An example is when Supervisor A mentioned that they use solar equipment in different area because of its mobility. The use of PV systems does not require refueling as compared to diesel generators that require constant refueling. Amongst the focus group participants, it was found that the use of PV technology was more convenient than other sources of lighting such as candles and dry cell batteries. Solar technology also provides options for other household uses such as charging of telephones. This was noted by Mr Chikondi in the group, "Some of them have adaptors that you can use for charging telephones". This could also be an opportunity for businesses that provide cell phone charging services in areas with no access to the grid.

Awareness/Knowledge/Learning: There are several sources of knowledge in the use of solar technology amongst employees. One opportunity for the adoption and diffusion of RET is through the use of media such as radio. Mrs Madalo noted out "We heard about the solar torches from the radio, then we went to town to find out, and after explaining it to us and we decided to buy and take it home". It was found that some people were motivated to use solar after observing neighbors using solar and through word of mouth. One motivation for using solar was the experiences that the respondents have had with other energy sources such as candles because using candles required daily purchases where PV panels require once off purchase.

Cost implications of alternative energy: The use of alternative fuels for back up electricity presents cost and time implications. In addition to this, the power outages also affect other operational activities such as water pumping. As mentioned by the supervisor A "this means that when the power goes off, the water pump doesn't work". In some cases the generator inefficiency does not meet the needs of all facilities on the farm. This may have consequent impacts on profits as inefficient lighting has impacts on the feeding habits of chickens. The use of diesel for running the generator is an added cost to the business. As mentioned by supervisor A that "On the part of the business or our work, it means that we are adding costs. The use of PV panels for lighting could complement other energy sources and reduce pressure on sources such as the generator.

Cost of RET: Opportunities for financing RET such as solar equipment could motivate the adoption of RET where there are groups such as village banks where members can borrow money and repay in

installments. It was found that in some cases members of a certain village bank were able to buy solar panels through such a group where members pay for the panels over a certain period of time.

Application in businesses/Poultry farming: These are areas or activities on the farms where RET, in particular PV systems can be used. Apart from the use of solar panels for the use of lighting, there are other operational activities that can use RET. According to the supervisor, the water on the farm is pumped from underground using electricity from the grid as well as a diesel generator. The supervisor pointed out "We also used the generator for making feed". These are some activities on the farms that can use solar systems for their operation.

Safety: The use of PV systems has the advantage of being a safer alternative for lighting compared to generator that requires the storage of flammable materials and has moving parts. The use of simple solar torches could be used during the blackout period and safely used when switching on the generator from the time that the power goes off.

4.1.2 Challenges

A challenge could be a barrier that prevents or reduces the use of RET in the poultry farms. The challenges to adoption of RET in poultry farming have been categorised as follows:

Usability/convenience: Theft has been identified as one of the barriers to the use of solar panels on poultry farms. It was noted by Supervisor A that "It happens. We have had one panel stolen". This was also pointed out in the focus group discussion that it is better to place solar panels on the ground where it can be seen by the owner to minimise the risk of theft. The quality of the RET equipment can be a disadvantage when they are not robust enough for areas where there are environmental factors such as strong winds. Another challenge with the equipment is when the sun is not sufficient on cloudy days to charge the battery fully. For some appliances, there is an option of recharging them with electricity.

Cost of RET: The cost of solar systems is also a challenge to the adoption of the technology especially for businesses as they require more permanent and secure supply of electricity for businesses to be viable. According to Supervisor A, he considers solar systems to be expensive as he pointed out, "But besides that the solar systems are expensive. It was also found that once off purchasing costs are high although beneficial in the long term.

Availability of alternative energy sources: The reliability of other cleaner sources of energy and RET could be a barrier in that although they work, their supply is unreliable. Supervisor B pointed out when comparing the use of Liquefied Petroleum Gas (LPG) and charcoal for heating, "The gas used to run out and the place to buy more of it is far. With Charcoal it's easier because it's close to the farm and we just go and buy it when needed.

Case 2: Interview and Focus Group Findings

4.2 Case 2: Findings from Interviews and Focus groups from Farm 2

The Interview with the owner of Farm 2 and the focus group discussion with employees also took place at the farm. Data extracts are included in appendix 5. The findings from the one on one interview has been summarised according to the following:

4.2.1 Opportunities

Awareness/Knowledge/Learning: For case 2, issues related to awareness and knowledge were more common. From the interview with the owner it was found that there is a knowledge gap in heating using Renewable Energy Technology (RET), as the owner indicated interest to use RET for heating in the chicken houses. There was also knowledge on the use of briquettes and intent to use them for heating. An entry point for dissemination of information, networking and knowledge sharing through organisations such as the Malawi Chamber of Commerce and Industry (MCCI), where energy issues are discussed. Networking could play and important role in adoption of RET in terms of sharing knowledge on suppliers and experiences with use of RET such as solar equipment. With regards to procurement of solar equipment, the owner mentioned "I think now it would be a lot more easier for me to go out and source and I know more people now than I did then". Amongst the focus group participants, there was some knowledge acquired from school on other RET such as Biogas. Opportunities for the adoption of RET could be through educational institutions. There was also knowledge on other community hydro projects in an area within 60km of the farm location. Other motivations to use RET were through observations of relatives and neighbours that were using PV technology.

Cost of RET: Secondly, cost of PV technology, in some cases was perceived as cheap in the sense that it is charged with the sun and there is no need for refueling as in other technologies such as diesel generators. Although this was pointed out during the focus group discussion and in reference to household use, for the farmers, solar technology was found to be expensive for installation on the farm houses.

Cost implications of alternative energy: The use of generators for power backup could have financial impacts on the businesses and could slow down expansion and growth of the businesses, as the owner pointed out "Its money you want to use on other things and build up. So with that you find that where you would have improved, you are actually going backwards". Compared to the farm in case 1, where the use of gas was tried out for heating, this farm tried the use of electric brooders. There is a need of more knowledge on other alternatives for heating of chicken houses in place of energy sources like charcoal that is currently being used. An opportunity to reduce heating costs could be through the use of briquettes. The owner of the farm indicated the intent to make briquettes from waste organic material and sell off the excess. Use of solar equipment in small businesses such as barber shops could be another motivation for its use, as it may be a cheaper option for electricity compared to the use of generators in areas with no access to the grid or as a backup power for those with access to the grid.

Usability/Convenience: As in case 1, the mobility of the solar panels was found to be an advantage of PV technology as it was mentioned by Mr Chifundo during the focus group discussion "it's easy compared to electricity because you just remove it from the house and put it out to recharge in the sun". In addition to this, another advantage of the use of PV could be that it does not cause pollution during its

operation. Mrs Madalo pointed out during the group discussion that the generator "produces smoke" and that it "also makes noise in the ears".

4.2.2 Challenges

Usability/convenience: One barrier to the use of PV could be its reduced efficiency during rainy days or on cloudy days. This is also similar to case 1 where this was also pointed out as a disadvantage of using solar panels.

Cost of RET: As in case 1 another barrier to RET adoption is it's once off purchase cost and the cost of batteries for the solar panels. The owner of farm indicated that a quote for installation of solar equipment for use on the farm turned out to be expensive for a farm that is still trying to expand and grow. The owner noted "somebody came through to give us a quotation of trying to do solar on the chicken houses and it worked out so expensive and we thought,, you know if we've got to do this why is it so expensive?". This could be due to the amount of panels and associated equipment such as batteries that would be needed to be sufficient for the whole farm.

Availability of alternative energy sources: A challenge to the adoption of RET such as solar is its reliability. This is also similar to case 1 where it was noted that other fuels such as charcoal are more readily available. During focus group discussions in case 2, it was also pointed out that charcoal is more readily available for use. The availability and reliability of such fuels is a hindrance for RET adoption.

4.3 Findings from Interview with Non-Governmental Organisation (NGO)

The following results are from an interview with an NGO representative that focuses on Energy Poverty and RET issues especially in the rural areas. Data extracts from the interview have been included in appendix 6.

Awareness/Knowledge/Learning: There is opportunity for diffusion of the technology mainly through their advocacy programmes and information sharing activities. Although implementation and roll out of pilot projects may be restricted by geographic locations where supervision would be needed, advocacy programmes such as use of radio offer a mode of communication and awareness. As the NGO representative pointed out "we do advocacy work and that is not restricted to geographic location". This could be related to the finding from case 1 where a participant of the focus group discussion was motivated to buy solar equipment after hearing about it on the radio. Another media platform for knowledge sharing and awareness is through CONREMA which is a free internet databases. Registered members have access to the database and members post information about projects they are working on.

Other opportunities for learning are through various pilot projects that are implemented by such organisations. For example there are some lessons learnt from energy kiosk projects rolled out by the NGO, where a kiosk in one location was successful and the other was not due to the differences in location. The successful one was located in an area that was off grid and was more patronised compared to the other that was close to the power grid. Although the NGO is yet to implement agriculture related projects, such lessons could be used when the time comes to implement the projects.

Apart from sharing of information from their experiences only, there are opportunities for knowledge sharing through observations done of other NGO projects during exchange visits. As the NGO representative pointed out “So some time last year we had an exchange visit in the southern region of Malawi where we visited different projects to try to get lessons & best practice and to see what’s working, what’s not working”. From such visits and knowledge sharing projects it was found that projects where equipment is given to the energy kiosk beneficiaries does not ensure sustainability of the projects.

It was found that the NGO also has awareness activities that touch on other social issues as well such as health issues related to the use of unclean sources of energy. This finding indicates there are relationships and interconnections formed with other organisations that are external to the NGO itself in order to achieve the case for RET.

Cost of RET: This is a challenge for the push of RET such as solar because of the availability of substandard equipment in the local market. Although the equipment may seem to be cheap to purchase, they may not be cheap in the long run as they may need to be frequently replaced or repaired if possible. On this, the NGO representative pointed out “Substandard equipment is a known fact in the industry”.

5.0 Discussion and Conclusion

From the results, two main broad themes will be discussed and these were the ones to be found most common in the interviews and focus group discussions. The themes are firstly awareness or knowledge, followed by cost implications of alternative fuels and where RET can be used in Agriculture. The issues of convenience and usability will be discussed briefly as these were not anticipated before the collection of data.

Awareness/ knowledge

In all cases, issues related to knowledge and awareness were common. Opportunities for the increase of awareness and knowledge could be through the use of radio, observations from others as well as from peoples own experiences. A study by Osok (2010), suggested that physical demonstration of RET was required in rural areas in Kenya where there is no access to media. The use of cellular phones with radio applications is an opportunity to overcome this barrier. According to the Malawi National Statistics office (NSO), the penetration rate for mobile phones increased from 11.2% in 2008 to 37.5% in 2015 (Government of Malawi, 2016a). The challenge to this is the poor cellphone coverage in rural areas in the country (Batzilis, Dinkelman, Oster, Thornton, & Zanera, 2010). Despite this, Batzilis et al. (2010) also reported that roll out of mobile phones in Malawi occurred rapidly from the year 2000 to 2010 with more than 50% of the country’s population have access to a mobile network. Therefore, there is an opportunity here to use the increasing use of mobile phones with radio applications for the dissemination of information on RET. This could be through awareness programmes or through advertising by RET businesses. In Malawi, RENAMA and Youth and Network counseling conduct a radio programme together that is especially focused on renewable energy issues.(Mphamvu Now, n.d.). The availability of solar charged radios could be one way through which information is disseminated in rural areas without access to the grid. One non-governmental organisation that has radio programmes and focuses on climate smart agriculture is the Kusamala Institute of agriculture and ecology (Kusamala, 2015). The Contextual

Interaction Theory assumes that motivations, information as well as power play a crucial role in policy processes (Bressers, 2004). Furthermore, the extent to which policy actors perceive how the instruments contribute to their objectives and interests has an effect on the policy instruments applied (Bressers, 2004).

Motivation to adopt RET is also through learning by observation from others. It has been found that some individuals are motivated to use RET by observing neighbours and relatives. Some observations were made in the rural areas. Examples of such observations made were of roof top solar panels as well as community mini hydroelectric power technology. In terms of policy implementation, Bressers (2004) suggests that in addition to the motivations of policy actors, the success of the policy implementation also depends on whether the policy actors have adequate information. For the farmers, results show that networking and knowledge sharing could play an important role in the adoption of RET. An entry point exists with associations such as the MCCI where energy issues are also discussed in addition to other issues of business interest. The MCCI is a partnership between businesses and associations from different sectors of the Malawian economy. The organization carries out research on issues affecting businesses and does lobbying and advocacy on the issues identified so that they are addressed by the government (MCCI Malawi, n.d.). Besides its national influence, it is affiliated with the Association of SADC Chambers of commerce and industry (ASCCI) as well as the Common Market for Eastern and Southern Africa. These associations provide a platform the knowledge sharing of energy issues not only on a national level but also at an international level where lessons can be learnt from other countries. Another form of networking is taking place between NGOs and other civil society organisations. There are NGO's in the country that focus on RET. One area that can be explored for the adoption and diffusion of RET is to use the interrelationships that these organisations have with other sectors that have different societal focus areas. An example is collaboration and interaction between RENAMA and the following civil society groups: Youth and Network Counseling (YONECO), Malawi Equity Health Network (MEHN), National Association of Business Women (NABW) and Community Energy Malawi (CEM). These interactions would be helpful to understand different sectors of society, their understanding and belief towards RET. It is suggested by Bressers & de Boer (2013), that in developing new policies, lessons can be learnt from old and existing policies by understanding how different policy actors are influenced by external stakeholders. The Contextual Interaction Theory states that human interaction processes and the characteristics of those involved has an effect on policy processes (Bressers & de Boer, 2013). As such, these interactions between the different societal groups would be beneficial during development and implementation of RET policies.

Cost implications of alternative energy and where RET can be used on the farm

Results indicate that the using diesel generators for power backup is expensive for poultry farmers, and is a hindrance to businesses that are expanding. Income that could be invested into growing the business is instead used for fuel and purchase of generators. On the farm, apart from lighting purposes, generators are used in some cases for pumping water, as well as the running of other equipment such as mills for chicken feed and heating brooders. These are activities that could utilise RET on the farms as well as reduce energy costs for businesses. In a study by Reddy & Painuly (2004), it was found that people in India were reluctant to adopt RET because of initial costs which were high and this is common in such countries because of a lack of access to loans by low income users. Furthermore, it was noted by Reddy & Painuly (2004), that users would rather reduce initial costs rather than operating costs over time. In a

study by Lynne et al. (1995), it was suggested that in addition to incentives, some persuasion would play a role in adoption of conservation technology. The theory of planned behavior suggests that a person's perception of how easy or difficult it is to perform a certain behavior is one of the factors affecting the intent to perform a certain behavior (Menozzi, Fioravanzi, & Donati, 2015). Therefore, although the initial costs may be covered over the long term during operation, users may be doubtful in investing in RET because of the length of time it would take to cover costs.

The use of solar pumps could be of benefit in areas where there is no connection to the piped water system. This is also applied in other agricultural sectors such as crop irrigation. According to (IRENA, 2015a), a benefit of RET in the food supply chain is that access to modern energy services is improved especially in rural areas. People in rural areas could be motivated to use RET if they can benefit from it by using it in their agricultural activities as well. However, this may not be suitable for crops that require intensive irrigation. In a study on productive uses of PV technology in Bangladesh by Blunck (2008), he suggests that in order for PV pumps to be economically viable, there is need to use cropping techniques that are less water intensive. Furthermore, for RET to be sustainable in irrigation it needs to be in conjunction with improvements in water use efficiency (FAO, 2011b). In Malawi, the Millennium Challenge Corporation (MCC) through the Millennium Challenge Account (MCA), funded a 60 hectare solar powered irrigation scheme in the southern region of the country (MCA-MALAWI, n.d.). Solar powered irrigation pumps are used by some communities where irrigations schemes received solar powered irrigation pumps through the Climate proofing initiative, coordinated by the Ministry of Natural Resources, Energy and Mining with support from the UNDP (UNDP, 2011). In a study by FAO, it was noted that one challenge to the use of solar irrigation systems is the possibility of unsustainable and wasteful use of water because of the low operational energy costs (Hartung & Pluschke, 2018). Therefore if such systems are rolled out, awareness and education of water saving would be necessary as well as the coordination with the Ministry of water and irrigation.

Another area where solar technology can be used in the poultry farms is the use of solar mills for making chicken feed. Although from the results of this study, one farmer is not currently producing feed on site but intent was expressed to do so. In Malawi, solar mills have been used in some districts such as Dedza. It has been reported by (Eales et al., 2017) that a market assessment of productive uses of energy (PUE) done by Community Energy Malawi found that survey respondents from villages felt that for households, maize mills were the most useful PUE followed by potable water and irrigation. However, the study by Eales et al., found that phone charging, irrigation and shop lighting were found to be the most beneficial for businesses. It is suggested by (Eales et al., 2017) that solar maize milling would need funding assistance due to high capital costs and long payback periods of up to 5 years. Although there are opportunities to use solar mills in poultry farming, their initial cost as well as payback period may be a barrier. The use of solar mills may be more suited for SMEs compared to bigger Farms that have relatively larger feed requirements and consequently larger equipment that need more energy. Learning through observation for RET is also taking place between NGOs in the country. Other area where RET is being used is in the rural areas where NGOS are having pilot projects such as energy kiosks. This offers another area of opportunity for learning by observation from an organizational point of view. There are site visitation trips between the NGO's to observe and learn from each other from the projects that have been implemented between them. It has been found that there is a need for knowledge on the use of RET in poultry farming especially for heating purposes. Some technology that could be explored include biogas and briquettes. In a study conducted by MARGE in 2009, it was estimated that 304,690 tonnes of

charcoal was consumed in the country (Government of Malawi, 2017a). Charcoal is used in poultry farming for heating the chicken houses, more especially those used for housing chicks. The lack of RET for heating may influence the use of unsustainable use of charcoal. Therefore, if technologies such as biogas and briquettes are used, they may reduce the demand for charcoal more especially in the poultry industry.

These projects offer learning opportunities for future projects if the experiences of the existing projects are shared with other sectors of agriculture such as in poultry farming. This is supported by the social cognitive theory where apart from learning from own experiences, individuals learn from observing others around them (Bandura 1987) as reported by (Straub, 2009). Social learning may play a role in adoption and diffusion of technology through modeling where individuals are motivated to adopt a technology when they hear or observe the experiences of someone who successfully or unsuccessfully used the technology (Straub, 2009). Although observations may play a role in the adoption and diffusion of RET, the availability of funding for projects may be another factor.

Convenience/ Usability

From the results of the focus group discussions, it was found that the use of solar equipment such as solar torches was found to be more convenient for use compared to candles and dry cell battery operated torches. Besides its advantage of reducing the costs associated with frequent purchase of candles and dry cell batteries, it also reduces the hassles of constant purchase of candles and batteries. This was not anticipated before collection of data. The added advantages of RET such as solar could be help in the adoption and diffusion of the technology. As Rogers theory of diffusion suggests, that if the innovation has greater advantage than those used before, then the innovation can easily be incorporated into society

Conclusion

Access to electricity and availability is a challenge with regards to energy in Malawi and brings with it economic and social impacts in the country. There are efforts by the government to address these challenges through policies that promote the adoption and diffusion of renewable energy technology. Various opportunities exist where knowledge sharing and awareness could help in reaching policy objectives on renewable energy technology. These could be through existing business associations, RET demonstrations where the technology is applied to different agricultural activities and through the use of media. Although use of renewable technology such as solar is used for lighting purposes, there is need for more knowledge on heating using renewable energy technology especially in the poultry sector. With regards to cost of renewable energy technology, although small home use equipment such as solar torches may seem affordable, the once off purchase costs for equipment are high for growing businesses that need to use the technology on a larger scale. For future policies on renewable energy technology, the motivations for the adoption of the technology could be investigated and incorporated into the policy processes and existing platforms of information sharing such as media and associations could be explored for the role they could play in the policy implementation.

This research was initially proposed to focus on commercial poultry farms but due to unavailability of the selected cases, requests were made to small and medium enterprise farms. It should be pointed out that only two out of the three farms that were planned to be interviewed, responded to requests for participation in the research. This is a limitation to this study due to the sample size, therefore the results

could not be generalised and are only indicative. This also brought limitations to the amount of cross referencing that could be done between cases. In addition to this, the data collected was from small and medium enterprise farms and therefore results may not apply to commercial farms operating on a bigger scale. Data from the bigger farms may have different results. Studies on commercial farms could be investigated further. Some information from focus group discussions could not be verified by observations as the focus group discussions were carried out at the work place and observations of RET use in households could not be verified. This may make the study vulnerable to biased responses and inconsistencies in the data.

6.0 References

Akyuz, E., Oktay, Z., & Dincer, I. (2011). Energetic, environmental and economic aspects of a hybrid renewable energy system: a case study. *International Journal of Low-Carbon Technologies*, *6*(1), 44–54. https://doi.org/10.1093/ijlct/ctq041

Azjan. (1991). The Theory of Planned Behavior. ORGANIZATIONAL BEHAVIOR AND HUMAN DECISION PROCESSES 50, 179-211 (1991).

Barry, M.-L., Steyn, H., & Brent, A. (2011). Selection of renewable energy technologies for Africa: Eight case studies in Rwanda, Tanzania and Malawi. *Renewable Energy*, *36*(11), 2845–2852. https://doi.org/10.1016/j.renene.2011.04.016

Batzilis, D., Dinkelman, T., Oster, E., Thornton, R., & Zanera, D. (2010). *New cellular networks in Malawi: Correlates of service rollout and network performance* (No. w16616). Cambridge, MA: National Bureau of Economic Research. https://doi.org/10.3386/w16616

Blunck, M. (2008). Productive Uses of Photovoltaic Technology in Rural Bangladesh-Potentials, Barriers, Recommendations.

Breen, R. L. (2006). A Practical Guide to Focus-Group Research. *Journal of Geography in Higher Education*, *30*(3), 463–475. https://doi.org/10.1080/03098260600927575

Bressers, H. (2004). Implementing sustainable development: How to know what works, where, when and how. Chapter 10 of: Governance for Sustainable Development: The Challenge of Adapting Form to Function, William M. Lafferty (Editor), Edward Elgar publishing: Cheltenham, 2004, pp. 284-318.

Bressers, H., & de Boer, C. (2013). Theory for assessing water governance, policy and knowledge transfer. *(2013) Water Governance, Policy and Knowledge Transfer: International Studies on Contextual Water Management, Pp. 36-54.*, 19.

Castillo-Montoya, M. (2016). Preparing for Interview Research: The Interview Protocol Refinement Framework, *21*, 22.

CIA. (2018). The World Factbook — Central Intelligence Agency. Retrieved March 31, 2018, from https://www.cia.gov/library/publications/the-world-factbook/geos/mi.html

Clarke, V., & Braun, V. (2014). Thematic Analysis. In A. C. Michalos (Ed.), *Encyclopedia of Quality of Life and Well-Being Research* (pp. 6626–6628). Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-007-0753-5_3470

Davis, G., MacKay, R., MacRae, M., Nicolson, L., Currie, C., MacPherson, M., … Picken, S. (2011). Supporting_community_energy_development_in_Malaw.pdf. Retrieved March 30, 2018, from https://strathprints.strath.ac.uk/56104/1/Davis_etal_2011_Supporting_community_energy_development_in_Malaw.pdf

Eales, A., Buckland, H., Frame, D., Unyolo, B., Gondwe, C., & Kaunda, M. (2017). University of Strathclyde and Community Energy Malawi, 58.

FAO. (2011a). ENERGY-SMART FOOD FOR PEOPLE AND CLIMATE Issue Paper. Food and Agriculture Organisation of the United Nations (FAO).

FAO. (2011b). “ENERGY-SMART” FOOD FOR PEOPLE AND CLIMATE ISSUE PAPER. Retrieved from http://www.fao.org/docrep/014/i2454e/i2454e00.pdf

FAO. (2018a). Climate-Smart Agriculture. Retrieved August 16, 2018, from http://www.fao.org/climate-smart-agriculture/en/

FAO. (2018b). FAO - News Article: Farmers struggle to adopt climate-smart methods. Retrieved August 16, 2018, from http://www.fao.org/news/story/en/item/181017/icode/

FAO. (n.d.). World Agriculture: Towards 2015/2030 - An FAO perspective. Retrieved March 30, 2018, from http://www.fao.org/docrep/005/y4252e/y4252e07.htm

Fawaz, H., Abiad, M. G., Ghaddar, N., & Ghali, K. (2014). Solar-assisted localized ventilation system for poultry brooding. *Energy and Buildings*, *71*, 142–154. https://doi.org/10.1016/j.enbuild.2013.12.021

Fischer, E., Schmidt, T., Höra, S., Giersdorf, J., Stinner, W., & Scholwin, F. (2010). Agro-industrial biogas in Kenya -GIZ, 76.

Gamula, G. E., Hui, L., & Peng, W. (2013). Development of renewable energy technologies in Malawi.

GIZ. (n.d). Identification of Industrial sectors promising for commercialization of solar energy. Commercialization of Solar energy in Urban and Industrial areas. Prepared by Pricewaterhouse coopers P Limited, India.

Golusin, M., Dodic, S., & Popov, S. (2013). *Sustainable energy management*. Amsterdam: Elsevier, Academic Press.

Government of Malawi. (2004). Malawi National Strategy for Sustainable Development 2004.pdf.

Government of Malawi. (2012). Malawi: Poverty Reduction Strategy Paper. *IMF Staff Country Reports*, *12*(222), i. https://doi.org/10.5089/9781475506129.002

Government of Malawi. (2016a). 2016 Statistical Yearbook.pdf.

Government of Malawi. (2016b). Draft Malawi Energy Policy submitted 22 Feb 2016-2_0.pdf. Retrieved August 15, 2018, from http://conrema.org/sites/default/files/Draft%20Malawi%20Energy%20Policy%20submitted%2022%20Feb%202016-2_0.pdf

Government of Malawi. (2017a). Malawi National Charcoal Strategy Draft Final (June 17-2017). Retrieved August 9, 2018, from http://conrema.org/sites/default/files/Malawi%20National%20Charcoal%20Strategy%20Draft%20Final%20%28June%2017-2017%29.pdf

Government of Malawi. (2017b). Malawi Renewable Energy Strategy Final(1).pdf. Retrieved from http://conrema.org/downloads

Greenbaum, T. L. (1998). *The Handbook For Focus Group Research* (2nd ed.). SAGE publications, International Educational and Professional Publisher.

Hartung, H., & Pluschke, L. (2018). The Benefits and Risks of Solar Powered Irrigation, 87.

Huenteler, J., Niebuhr, C., & Schmidt, T. S. (2016). The effect of local and global learning on the cost of renewable energy in developing countries. *Journal of Cleaner Production*, *128*, 6–21. https://doi.org/10.1016/j.jclepro.2014.06.056

IEA. (2014). World Energy Outlook, 2014 Africa Energy Outlook.

IRENA. (2014). Renewable Energy in Manufacturing: A technology roadmap for REmap 2030, 36.

IRENA. (2015a). Renewable Energy in the Water, Energy and Food Nexus, 128.

IRENA. (2015b). Renewable Energy Target Setting, 80.

IRENA. (2017a). ADVANCING THE GLOBAL RENEWABLE ENERGY TRANSITION. Highlights of the REN21 Renewables 2017 Global Status Report in perspective. Retrieved from http://www.ren21.net/wp-content/uploads/2017/06/GSR2017_Highlights_FINAL.pdf

IRENA. (2017b). IRENA_Energy_Transition_Innovation_2017.pdf. Retrieved from http://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Jun/IRENA_Energy_Transition_Innovation_2017.pdf

IRENA. (2018a). IRENA REsource Renewable Energy Capacity_CountryProfile. Retrieved March 12, 2018, from https://public.tableau.com/views/IRENAREsourceRenewableEnergyCapacity_CountryProfile/Charts?:embed=y&:showVizHome=no&:size=487,1&:embed=y&:showVizHome=n&:bootstrapWhenNotified=y&:tabs=n&:toolbar=n&allowtransparency=true&Country=Malawi&:apiID=host0

IRENA. (2018b). Wind energy. Retrieved March 30, 2018, from /wind

IRENA, A. (2016). Renewable Energy Benefits: Measuring the Economics, 92.

Jacobsson, S., & Johnson, A. (1998). The diffusion of renewable energy technology: an analytical framework and key issues for research.

Kachaje, O., Chisanu, L., & Liangjun, Y. (2017). Electricity reforms in Malawi; Impacts and Consequences.

Kuiken, A. (2015). Theory of planned behaviour and the family business. In M. Nordqvist, L. Melin, M. Waldkirch, & G. Kumeto, *Theoretical Perspectives on Family Businesses* (pp. 99–118). Edward Elgar Publishing. https://doi.org/10.4337/9781783479665.00013

Kusamala. (2015). Kusamala Institute of Agriculture and Ecology. Retrieved August 16, 2018, from http://www.kusamala.org/about/resources/

Lynne, G. D., Franklin Casey, C., Hodges, A., & Rahmani, M. (1995). Conservation technology adoption decisions and the theory of planned behavior. *Journal of Economic Psychology*, *16*(4), 581–598. https://doi.org/10.1016/0167-4870(95)00031-6

Marra, M., Pannell, D. J., & Abadi Ghadim, A. (2003). The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: where are we on the learning curve? *Agricultural Systems*, *75*(2–3), 215–234. https://doi.org/10.1016/S0308-521X(02)00066-5

Marshall, C., & Rossman, G. B. (1999). *Designing qualitative research* (3rd ed.). SAGE.

MCA-MALAWI. (n.d.). 600 farmers to benefit from MCA-M funded irrigation scheme. Retrieved August 1, 2018, from http://www.mca-m.gov.mw/index.php/82-mca-malawi/269-600-farmers-to-benefit-from-mca-m-funded-irrigation-scheme

MCCI Malawi. (n.d.). MCCI - Malawi - About Us. Retrieved August 9, 2018, from http://www.mccci.org/index.php?option=com_content&view=article&id=40&Itemid=121

McNamara, C. (n.d.). General Guidelines for Conducting Research Interviews. Retrieved May 14, 2018, from https://managementhelp.org/businessresearch/interviews.htm

Mekhilef, S., Saidur, R., & Safari, A. (2011). A review on solar energy use in industries. *Renewable and Sustainable Energy Reviews*, *15*(4), 1777–1790. https://doi.org/10.1016/j.rser.2010.12.018

Menozzi, D., Fioravanzi, M., & Donati, M. (2015). Farmer's motivation to adopt sustainable agricultural practices, 23.

Moore-O'Leary, K. A., Hernandez, R. R., Johnston, D. S., Abella, S. R., Tanner, K. E., Swanson, A. C., … Lovich, J. E. (2017). Sustainability of utility-scale solar energy – critical ecological concepts. *Frontiers in Ecology and the Environment*, *15*(7), 385–394. https://doi.org/10.1002/fee.1517

Mphamvu Now. (n.d.). Radio Session for Green and Inclusive Energy in Malawi. Retrieved August 9, 2018, from http://www.mphamvu-now.info/2017/10/05/rradio-session-for-green-and-inclusive-energy-in-malawi_05-10-2017-2/

Nygaard, I., Hansen, U. E., Mackenzie, G., & Pedersen, M. B. (2017). Measures for diffusion of solar PV in selected African countries. *International Journal of Sustainable Energy*, *36*(7), 707–721. https://doi.org/10.1080/14786451.2015.1086768

Osok, F. O. (2010). Barriers to the development and deployment of Renewable Energy Technologies in Kenya¬¬, 109.

Pallas, G., Peijnenburg, W., Guinée, J., Heijungs, R., & Vijver, M. (2018). Green and Clean: Reviewing the Justification of Claims for Nanomaterials from a Sustainability Point of View. *Sustainability*, *10*(3), 689. https://doi.org/10.3390/su10030689

Reddy, S., & Painuly, J. . (2004). Diffusion of renewable energy technologies—barriers and stakeholders' perspectives. *Renewable Energy*, *29*(9), 1431–1447. https://doi.org/10.1016/j.renene.2003.12.003

Rogers, E. M. (2010). *Diffusion of Innovations, 4th Edition*. Simon and Schuster.

SEforAll. (2012). malawi_report_of_the_national_sustainable_access_to_energy_4all_cmg4_final_draft.pdf.

Retrieved March 27, 2018, from https://www.hivos.org/sites/default/files/malawi_report_of_the_national_sustainable_access_to_energy_4all_cmg4_final_draft.pdf

Straub, E. T. (2009). Understanding Technology Adoption: Theory and Future Directions for Informal Learning. *Review of Educational Research*, *79*(2), 625–649. https://doi.org/10.3102/0034654308325896

Taulo, J. L., Gondwe, K. J., & Sebitosi, A. B. (2015). Energy supply in Malawi: Options and issues. *Journal of Energy in Southern Africa*, *26*(2), 19–32.

Turner, D. W. (2010). Qualitative Interview Design: A Practical Guide for Novice Investigators. The Qualitative Report, 15(3), 754-760, 9.

UNDP. (2011). Discovering Community Solutions in Solar Irrigated Farming. Retrieved August 1, 2018, from http://www.mw.undp.org/content/malawi/en/home/presscenter/articles/2017/12/01/discovering-community-solutions-in-solar-irrigated-farming-.html

UNDP. (2012). UN Conference on Sustainable Development. National Preparatory Process. Progress towards achieving Sustainable Development Goals 20 years since the 1992 Earth Summit in Rio. Synthesis Report - Malawi. Retrieved from https://sustainabledevelopment.un.org/content/documents/1037malawi.pdf

UNDP. (2018). Goal 7: Affordable and clean energy. Retrieved March 10, 2018, from http://www.mw.undp.org/content/malawi/en/home/sustainable-development-goals/goal-7-affordable-and-clean-energy.html

United Nations. (n.da). Role-of-the-private-sector-in-advancing-the-implementation-of-the-IPoA.pdf. Retrieved from http://unohrlls.org/custom-content/uploads/2014/01/Role-of-the-private-sector-in-advancing-the-implementation-of-the-IPoA.pdf

United Nations. (n.db). Transforming our world: the 2030 Agenda for Sustainable Development .:. Sustainable Development Knowledge Platform. Retrieved March 27, 2018, from https://sustainabledevelopment.un.org/post2015/transformingourworld

University of Twente. (2017). Health Communication | Theory of Planned Behavior/ Reasoned Action. Retrieved March 19, 2018, from https://www.utwente.nl/en/bms/communication-theories/sorted-by-cluster/Health%20Communication/theory_planned_behavior/

Verschuren, P., Doorewaard, H., & Mellion, M. J. (2010). *Designing a research project* (2. ed). The Hague: Eleven International Publ.

World Bank. (2017). Overview, Malawi [Text/HTML]. Retrieved March 31, 2018, from http://www.worldbank.org/en/country/malawi/overview

Yaron, G., Environmental Affairs Department, & Ministry of Finance and Development Planning. (2012). *Malawi state of environment and outlook report: environment for sustainable economic growth, 2010*.

Yin, R., K. (2014). *Case Study Research, Design and Methods* (5th ed.). SAGE.

7.0 Appendices

Appendix 1: Interview Consent Form

Title research: _____

Responsible researcher: _____

To be completed by the participant

I declare in a manner obvious to me, to be informed about the nature, method, target and [if present] the risks and load of the investigation.

I know that the data and results of the study will only be published anonymously and confidentially to third parties. My questions have been answered satisfactorily.

[If applicable] I understand that film, photo, and video content or operation thereof will be used only for analysis and / or scientific presentations.

I voluntarily agree to take part in this study. While I reserve the right to terminate my participation in this study without giving a reason at any time.

Name participant _____

Date: _____

Signature participant: _____

To be completed by the executive researcher

I have given a verbal and written explanation of the study. I will answer remaining questions about the investigation.

The participant will not suffer any adverse consequences in case of any early termination of participation in this study.

Name researcher: _____

Date: _____

Signature researcher: _____

Appendix 2: Interview Questions

(Farm Manager/Owner Interview). RQ 1: How can the Poultry Farms contribute to the renewable energy mix by using PV systems?	Background Info	What are the impacts of power outages on poultry farming?	What are the advantages and disadvantages of using solar power in the poultry farms?	How can public incentives be used by the poultry farms to promote self-generation of electricity by using PV?
Could you tell me a bit about the farm ,number of employees (men/women) general activities and your role at the farm	X			
Follow up: what are the activities that require energy use around the farm (they might be mentioned in Q1) and what are the sources of energy	X		X	
What has been your experience with regards to energy sources (grid, biomass, diesel, paraffin, torches, solar) mentioned		X		
Is there a preferred source of energy amongst those mentioned? What are the reasons for preferring this source of energy			X	
Are there any associations that your business is part of	X			X
What is your involvement in the association/institution	X			X
Does the association handle or deal with issues related to energy?				X
what encourages or discourages the farms from using PV equipment			X	X
Any comments and questions on the issues discussed?				

(Farm employees group discussion) RQ 2: How can self-generation of electricity by poultry farms influence employees and surrounding communities to use PV systems?	Background Info	To what extent is PV used by employees in their homes. What are their motivations and barriers?	Has exposure to PV as a renewable energy source influenced employees and surrounding communities to adopt other systems?
Where do you live (proximity to work), what your work involves	X		
What your work involves	X		
What sources of energy are used in your home (Biomass, grid electricity, solar)	X	X	
For what use (cooking, lighting, etc)		X	
What are the advantages and disadvantages of these sources?		X	
What sources of energy are similar to those at work			X
How did you get to know solar equipment			X
What encouraged you or discouraged you to use/not use solar equipment			X
Any comments and questions on the issues discussed?			

NGO INTERVIEW
Could you please tell me abit about the organisation?
What other organisations do you work with whether in the public or private sector?
What has been your experience with the renewable energy projects you have worked on?
Have you worked on projects that are agriculture related?
Does the organisation require membership by other individuals?

Appendix 3: Introductory Letters

UNIVERSITY OF TWENTE.

To whom it may concern

FACULTY OF MANAGEMENT AND GOVERNANCE
DEPARTMENT OF GOVERNANCE AND TECHNOLOGY FOR SUSTAINABILITY (CSTM)

YOUR REF -
OUR REF -
DATE 24 April, 2018

PHONE +31(0)53-4893537
FAX +31(0)53-4892159
EMAIL j.s.clancy@utwente.nl
http://www.utwente.nl/mb/cstm

PAGE 1

SUBJECT: Research support request

Dear Sir or Madam,

This letter serves as an introduction to Diana Theresa Trindade, currently studying, under my supervision, for a Master in Environmental Energy and Management (MEEM) at The University of Twente.

As a requirement for her degree, she is undertaking research for her thesis. Her research is on the opportunities and challenges of adopting renewable energy technology in Malawi. The study will look at commercial poultry farms in Malawi as a case study.

Dianne would like to request your company's participation in her research. She intends to conduct an interview with one person at management level and a focus group discussion with a maximum of 8 employees from your egg production chicken farms. It is expected that the interviews and focus group discussions will not take more than an hour per interview/discussion.

Dianne intends to conduct the interviews and focus group discussions between 5 and 12 June 2018. Prior to the interview, a summary of the topics for discussion will be sent to you and a consent form will be given for you to approve your participation in the interview. Names of participants will not be included in the Thesis report. Any commercial information will be treated in the strictest confidence. Her research proposal, including the storage and use of personal data, has been approved by the appropriate body of the University of Twente and complies with the ethical research standards of our University. You will be given the opportunity to check that the thesis complies with these statements prior to its submission to the University for marking.

I therefore respectfully request that you allowing Dianne to conduct interviews with your employees.

If you require any further information, please do not hesitate to contact me.

Yours faithfully,

Joy S Clancy

Joy S Clancy,
Professor Energy and Gender

UNIVERSITY OF TWENTE.
MB-CSTM

The Netherlands
www.utwente.nl/mb/cstm

UNIVERSITY OF TWENTE.

To whom it may concern

FACULTY OF MANAGEMENT AND GOVERNANCE
DEPARTMENT OF GOVERNANCE AND TECHNOLOGY FOR SUSTAINABILITY (CSTM)

YOUR REF -
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DATE 24 April, 2018

PHONE +31(0)53-4893537
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SUBJECT: Research support request

Dear Sir or Madam,

This letter serves as an introduction to Diana Theresa Trindade, currently studying, under my supervision, for a Master in Environmental Energy and Management (MEEM) at The University of Twente.

As a requirement for her degree, she is undertaking research for her thesis. Her research is on the opportunities and challenges of adopting renewable energy technology in Malawi. The study will look at commercial poultry farms in Malawi as a case study.

Dianne would like to conduct an interview with you regarding her research topic. She has asked permission from your employer and that request has been granted. It is expected that the interview will not take more than an hour each. She intends to conduct the interview within the period of 5 and 12 June 2018.

Prior to the interview, a summary of the topics for discussion will be sent to you and a consent form will be given for you to approve your participation in the interview. Names of interviewees will not be included in the Thesis report. Any commercial information will be treated in the strictest confidence. Her research proposal, including the storage and use of personal data, has been approved by the appropriate body of the University of Twente and complies with the ethical research standards of our University. You will be given the opportunity to check that the thesis complies with these statements prior to its submission to the University for marking.

Your participation in her research is highly appreciated.

Yours faithfully,

Joy S Clancy,
Professor Energy and Gender

UNIVERSITY OF TWENTE.
MB-CSTM

P.O. Box 217,
7500 AE Enschede
The Netherlands
www.utwente.nl/mb/cstm

Appendix 4: Case 1 data extracts and codes

Research Question 1: What are the opportunities for the Poultry Industry to contribute to the renewable energy mix by using PV systems?

Data Extract	Code	Opportunity for RET	Challenge for RET
Two ways, mainly ESCOM (Grid), especially for lighting. But we also use it for pumping water from a borehole. We use that water on the farm.	Application in business/Poultry farming	Opportunity for RET	
The generator is used to supplement for electricity when the power goes off. We also used the generator for making feed.	Application in business/Poultry farming	Opportunity for RET	
Sometimes we have baby chicks and when power cuts happen unexpectedly, sometimes it takes long to connect the generator. At this time it delays feeding of the chicks and affects their weight. And may only be sold after 7 weeks	Cost implications of alternative energy	Opportunity for RET	
It does not take too long. At most 30 minutes. Mostly within 10 to 20 minutes. But for example, last night the power went off and we tried to use the generator for the power but it wouldn't work. So we had no power for the night. There was no other plan because what we rely on was the generator. But most times it take 10 to 20 minutes to work. Maximum of 30 minutes	Cost implications of alternative energy	Opportunity for RET	
On the part of the business or our work, it means that we are adding costs. That is, cost of production. Because we are adding more inputs. Sometimes we run out of fuel for the generator and the generator goes off. It's like we are paying twice for the costs. That also affects us. This means that when the power goes off, the water pump doesn't work.	Cost implications of alternative energy	Opportunity for RET	
The lighting from the generator is dim because it fails to support all facilities (chicken houses, water and proper lighting). This affects us because it affects the eating habits of the chickens.	Cost implications of alternative energy	Opportunity for RET	

Yes we have used them, not that we have tried but we have actually used them. On the farm there are extra chicken houses. These houses are used to keep extra chickens when the main chicken houses are overcrowded. The extra chicken houses do not have electricity. So we use power banks and Solar panels.	Awareness/Knowledge	Opportunity for RET	
I think it's good because it's not difficult to use. We charge it with the sun, and we don't use or spend much. It's not hard to get it working. We just place it. I can say that its user friendly.	Usability/convenience	Opportunity for RET	
No, we remove it because of theft. Leaving it in one place is a risk because of theft	Usability/convenience		Challenge for RET
It happens. We have had one panel stolen. Another reason is that we use it in different areas so it is mobile	Usability/convenience	Opportunity for RET	
We have problems with the sources we use. ESCOM electricity keeps going off. With the solar it won't present problems of unavailability. It will just be available at all times. Kind of being full time. Before I continue with answering, I might not have understood the question. Could you repeat?	unreliability of power from grid	Opportunity for RET	Challenge for RET
For us, if the government could do civil education in the farms. Since we meet some problems with regards to solar, they can be minimised by teaching us about solar, its advantages compared to solar and generators.	Awareness/Knowledge		Challenge for RET
Because solar seems to have more benefits. But besides that the solar systems are expensive. For the solar to be used here you need a lot of panels and a system that is stable so maybe if the government can subsidise	Cost of RET	Challenge for RET	Challenge for RET
I think if the government can subsidise the equipment everyone would have it and use it. Also problems with ESCOM availability it's difficult to use generators because it's very expensive. That's how I see it	Cost of RET	Opportunity for RET	Challenge for RET
Because with the solar also for it to be available, it's a problem but If the government could put a policy to make the technology cheap, so that anybody should be able to buy and be able to access it and be able to use	Cost of RET	Opportunity for RET	Challenge for RET

it. That would help			
The gas used to run out and the place to buy more of it is far. With Charcoal it's easier because it's close to the farm and we just go and buy it when needed.	Availability of alternatives	Challenge for RET	

Research Question 2: How can self-generation of electricity by commercial poultry farms influence employees and surrounding communities to use PV systems?

Data Extract	Code	Opportunity for RET	Challenge for RET
For lighting, we take it where we need to use it	Usability/convenience	Opportunity for RET	
Because we found that to buy batteries every day is not manageable. But with solar once you have bought it that's it. That's what I had seen	Usability/convenience	Opportunity for RET	
The change is that before we were buying candles every day but now we make a budget for a once off purchase of a solar light. Once we buy a solar lamp that's it, we forget about it.	Usability/convenience	Opportunity for RET	
Because the batteries are rechargeable, in the morning you just take it out (the torch) and put it in the sun. The torches mostly have solar piece at the top so we just put it out to charge. At night it's used directly and in the morning we put it on the sun.	Usability/convenience/Cost of RET	Opportunity for RET	
Some of them have adaptors that you can use for charging telephones.	Usability/convenience	Opportunity for RET	
See the same solar batteries some of them are rechargeable you can remove them and charge them with electricity say when there isn't enough sunlight	Usability/convenience		Challenge for RET
But if you want, and because people can steal it, you can look after it but placing it where you can see on the ground.	Usability/convenience		Challenge for RET

At first we were using the normal battery cells, and the batteries finish.. By then you may not have money so you end up sleeping in the dark. So that when I decided buy something that is permanent and you forget rather than the batteries that keep running out and you need to buy more. If you buy a candle at K100 a day and for a month you use K3000. But a torch that you buy for K3000 lasts years	Usability/convenience/Cost of RET		
They work well better than electricity (ESCOM). They have 3 bulbs you can use for lighting in the house because they have adaptors where the bulb is there is a socket where you can join another cable for another bulb. One power bank can light up to 10 bulbs	Usability/convenience		
The sources I was using before made me want to buy Solar	Availability of alternatives	Opportunity for RET	
The sun here is just like this and it doesn't get full (the battery)	Usability/convenience		Challenge for RET
Because on the roof,, with the wind you might find it has fallen and gets broken . But needs to be removed and have someone (wife) to check on it while I'm at work	Usability/convenience		Challenge for RET
Theft is not so much of a problem in this area but then with the wind they break a lot. The roof is high so if it falls from there to the ground then it is finished	Usability/convenience		Challenge for RET
We heard about the solar torches from the radio, then we went to town to find out, and after explaining it to us and we decided to buy and take it home.	Awareness/Knowledge	Opportunity for RET	
For me it was from the neighbour	Awareness/Knowledge	Opportunity for RET	
I was complaining that we slept in the dark and they laughed at me. I asked what they used and they showed me a powerbank and solar panel. I said it looked like they were in town and they said yes they don't see a problem. I asked them how it is and they explained to me and told me the shop they got it from in town. I wished I had what they had and I went to buy mine	Awareness/Knowledge	Opportunity for RET	

For me it was more about the problem of sleeping in the darkness. You see others using solar instead of electricity (ESCOM) because there is no electricity here. A torch helps. The same place I found the torch they have solar as well (panels)	Awareness/Knowledge	Opportunity for RET	
I saw that my neighbours have torches and I decided to go and buy so that we the problem we have is removed	Awareness/Knowledge	Opportunity for RET	
That's when they brought in the power banks to use. They were bigger power banks that were wired to 7 bulbs. And a big solar panel. And 3 bulbs were enough for one chicken house	Awareness/Knowledge	Opportunity for RET	
When there is no sun. But when there is sun I put it to charge with the panel outside and it charges well. But also the good thing is that when you buy it, it stays for long. You lose a lot of money when buying but in future it helps a lot.	cost of RET		Challenge for RET
As for me what I have observed is some people were registering for loans and solar equipment was there on loan so a lot of people use solar equipment	Cost of RET	Opportunity for RET	

Appendix 5: Case 2 data extracts and codes

RQ 1: What are the opportunities for the Poultry Industry to contribute to the renewable energy mix by using PV systems?

Quotation	Code	Opportunity	Challenge
They would come on and probably around midnight, 1 am they go off	Awareness/Knowledge		Challenge for RET
But I'm sure once we are done with all the building because with what we have we still have room for three more houses. Once we are done with that we would probably revisit and see how we can best, conserve on this ESCOM power and solar or whatever it would be. But the other thing that I'm most interested in is how I can do heating	Awareness/Knowledge	Opportunity for RET	

With the problems that Malawi is facing with ESCOM, in fact yesterday we were at MCCI, meeting where we had someone from ESCOM and he was explaining the problems that they are going through..	Awareness/Knowledge	Opportunity for RET	
So that in itself is a motivational thing because you look at the years coming and the developments that we are still having here, we need power. So Yes, I would be interested in going solar.	Awareness/Knowledge	Opportunity for RET	
And we have a lot of sunlight so…but we just need to find the right ones that do not switch off at 1am	Awareness/Knowledge		Challenge for RET
Not really. Mind you the time that we did that were the first few months for me to be in Malawi. I think now it would be a lot more easier for me to go out and source and I know more people now than I did then.	Awareness/Knowledge	Opportunity for RET	
I don't know, but one has to go out and check. Because I am sure there are people who do solar and I also saw that I think it's the UN or some UK organisation that's here teaching people on solar so that has given me confidence	Awareness/Knowledge	Opportunity for RET	
The other thing that we are actually looking at, I've already had meetings with a gentleman who knows about briquettes	Awareness/Knowledge	Opportunity for RET	
Well, just as terrible as everybody.. But luckily we have got a standby generator because that then is also expensive because then you need to have diesel all the time to make sure that you are not caught unawares so in times when there is no power we use a generator for lighting	Cost implications of alternative technology	Opportunity for RET	

that could have gone towards something else. So it means that in the long run it affects other areas of operations yes	Cost implications of alternative technology	Opportunity for RET	
Yes. It does. Because I think it concerns all businesses. When there is no power people can't work especially those with factories. We also need power for brooding and we need power to run things. It means that then the cost of production goes up. Those that can afford generators are going to spend a lot of money on diesel	Cost implications of alternative technology	Opportunity for RET	
And its money you don't want to spend. Its money you want to use on other things and build up. So with that you find that where you would have improved, you are actually going backwards because you are spending money you shouldn't be spending. So if we had power, constant power at least you would be focussing your energy and resources on improving your production or whatever that one is doing	Cost implications of alternative technology	Opportunity for RET	
Yes, and they don't work on a bigger scale so if you were to use that you would need a lot and highly mechanised. So I would like to look at something else.	Cost implications of alternative technology	Opportunity for RET	
Well, its big enough (generator) to run a mill if we were to start producing our own feed but at the moment its underutilised but it is there,, we are using it just for lighting	Where PV systems can be used	Opportunity for RET	
And to power obviously our wifi equipment and other things so at least we would still be able to work with that	Where PV systems can be used	Opportunity for RET	
So I need to go into briquette making so that we would be able to produce that for the farm and sell off some excess	Application of RET/business opportunity	Opportunity for RET	

RQ 2: How can self-generation of electricity by commercial poultry farms influence employees and surrounding communities to use PV systems?

Quotation	Code	Opportunity	Challenge
Yes. Sometimes we use electricity to charge them and sometimes we put them on the sun so that they work with solar	knowledge/awareness	Opportunity for RET	
In Nkhatabay I think, It was a new experience for me, they use energy from the stream. There is a thin wire from the stream.. They are even using that now. All you have to do is make sure you have no weed. That weed in the water. They basically go there after a week, they clean and the electricity is perfect. And now most people they are planning to get to know how to use it. They are saying it's much more beneficial	knowledge/awareness	Opportunity for RET	
Yes, I have learnt about it. I have learnt about it and have knowledge about it but haven't experienced it.	knowledge/awareness	Opportunity for RET	
For me, my uncle was using it	knowledge/awareness	Opportunity for RET	
For me,, I bought it because I have the knowledge about it. I know that once I have the solar, It's the whole day. Solar, battery and inverter. During the day you charge the battery and at night you use the energy from the battery. If it's raining, if the battery is charged you have enough energy.	knowledge/awareness	Opportunity for RET	
Moving around and at school	knowledge/awareness	Opportunity for RET	
At night we use a generator, and there are some tilly lamps as he has explained. We use about 6. For us to have clear lighting at night we use about 6 but still at times they are not enough.	Convenience/Usability		Challenge for RET

At times for about 6 to 7 hours. But when the power goes off the genset is not automatic. It is manually operated. So like this they use solars from the chicken houses. So by the time we get here we use those tilly lamps because when the power goes off chickens are so sensitive. So we use them for few minutes until the genset comes on	Convenience/Usability and Cost implications for alternative fuels	Challenge for RET/ Opportunity for RET	
With solar it's easy compared to electricity because you just remove it from the house and put it out to recharge in the sun. But its disadvantage is that sometimes it's raining and can't charge it	Convenience/Usability	Opportunity for RET	
when it rains its cloudy and the panels cannot be charged because there is no sun	Convenience/Usability		Challenge for RET
Like during a blackout we experience the loss of chickens because without light chickens won't survive	Cost implications of alternative technology	Opportunity for RET	
Yes they come to a bunch just for heat. So if you are not careful this is a loss. I mean we reduce the losses when the temperatures and lighting are all fine and the chickens are warmed up.	Cost implications of alternative technology	Opportunity for RET	
The good thing is that they are easy to find	Availability of other alternatives		Challenge for RET
It also produces smoke. So it spoils the air. But it also makes noise in the ears	Pollution from alternative fuels	Opportunity for RET	
For some people it's expensive to buy ESCOM units every day. Some people can't afford buying that. The one with the token, you have to buy units. For some it's an advantage but for some who are not that (), it's a disadvantage because you can't be paying all the time. Some people can afford, some can't. So I would say it's not all that. It doesn't balance because it's not equal in the economy, how people get their income	Cost implications of alternative technology	Opportunity for RET	

three times in a month at least	Cost implications of alternative technology	Opportunity for RET	
There are some people that have barber shops. Some have video show rooms	business opportunity	Opportunity for RET	
With solar, the costs are the reason why most people do not have them. But when we go to disadvantages, solar doesn't have pollution	Cost of RET		challenge for RET
Disadvantage but it can be an advantage. But the disadvantage is the cost of purchasing the solar panels. And you also need the battery cells and inverters. But it's a good form of energy in that there is no form of pollution.	Cost of RET		challenge for RET
As far as I've heard although I haven't used it, it's cheap. It is charged naturally with the sun. So you don't need to say that no, there is no power and I can't charge it. It's naturally charged. So it means it's an advantage to most people	Cost of RET	Opportunity for RET	
I saw that ESCOM electricity is more expensive than solar	Cost of RET	Opportunity for RET	
I have the experience of how it works. Until the point where you have installed in at the top and its working. That's why I'm saying it doesn't have pollution	knowledge/awareness	Opportunity for RET	

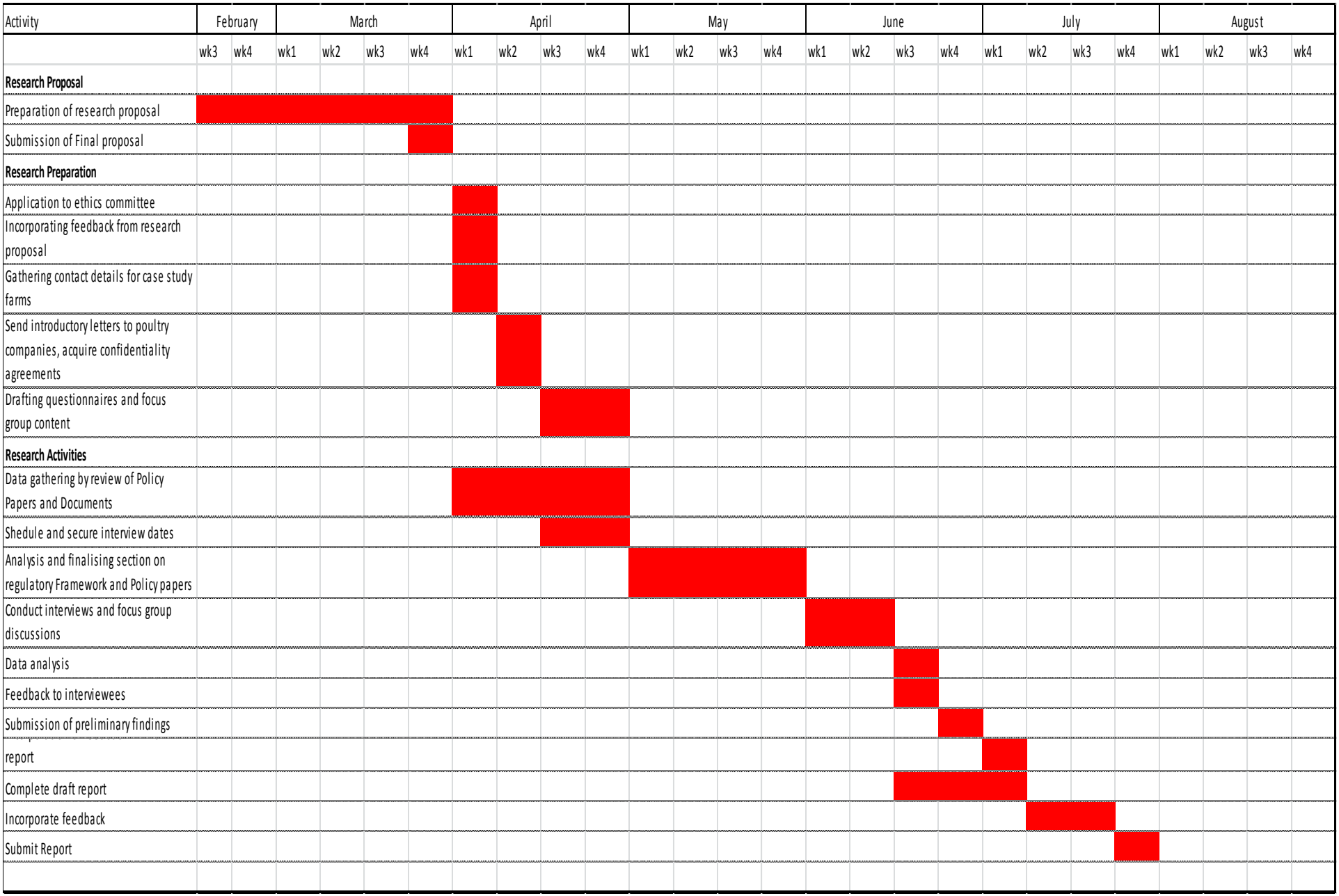
Appendix 6: Data extracts from interview with NGO

Quotation	Code	Opportunity	Challenge
And Sunny Money as well, I'm not sure if you have heard of sunny money. They've got these small pico solar lamps which they are selling. It's also a social enterprise so we get those pico lights from them and sell them out in the rural areas. We have got a revolving fund. We have some people selling them so we have a revolving fund, some people get them from us and sell them on pay as you go model. Those	Cost of RET/ Business opportunity	Opportunity	

are some of the people we are working with			
It's in the pipeline. We want to set up solar irrigation	Where PV can be used	Opportunity	
We do some advocacy work and that is not restricted to geographic location	Knowledge/Awareness	Opportunity	
Experiences maybe on the technical side, one of the projects we had in Bvumbwe, rural solar kiosk. So a challenge was with the technology after three years after the project was implemented, the technology needed to be replaced to get new batteries, and since we had handed over the project to the community, they did not have enough money to replace the technology because the model was that they needed to generate their own income from that kiosk and that income would in time be used to replace the batteries and broken down equipment but sadly that did not occur and came another phase, the donor brought some more funding, it's just phasing out now, the second phase of the project but there are still some challenges.	Cost of RET		Challenge
Yes.. One of our biggest success stories is from our projects in Phalombe. Because this project we set it up with a kiosk at school. So the school also connected some lines so that kids can also study at night resulting in the school becoming the top primary school on Phalombe district in terms of pass rate and selection rate for secondary school admission	Knowledge/Awareness	Opportunity	
one of the key lessons is giving things to people for free doesn't necessarily motivate them to do their best to make sure it continues on a sustainable path. We compare this with another project that was similar, that was implemented in Lilongwe, different model was used. People have to pay, they don't receive it for free. They pay something, a token and its working. Because they know that they've invested some money in it so they so they take	Knowledge/Awareness	Opportunity/Challenge	

that thing seriously as opposed to something they get for free			
Maybe the location that maybe because this one is at a school, the one in phalombe and phalombe was totally off grid. The one in Bvumbwe was next to the ESCOM power line.	Knowledge/Awareness	Opportunity	
They are the ones who implemented that. So some time last year we had an exchange visit in the southern region of Malawi where we were visited different projects to try to get lessons & best practice and to see what's working, what's not working, so from the findings of that trip, the one in Lilongwe is sustainable partly because of the model they chose to use. They didn't give it out all for free	Knowledge/Awareness	Opportunity	
Energy Poverty. You know, most people are affected, they don't have access. You know over 90% are not connected to the power grid so these are issues that we advocate on, creating awareness of these alternative solutions, solar products, cleaner cook stoves. And just educating the masses, health effects that come with the use of unclean technology and things like that	Knowledge/Awareness	Opportunity	
Yes, CONREMA, yes, If you can just subscribe to be a member of CONREMA so that you are part of the network, because it's a database and online database, if you want to log in and check what other people are doing and if you want to post what you are doing then you need to be a member. But it's a free membership.	Knowledge/Awareness	Opportunity	
Substandard equipment is still there. I think the article was just from a newspaper. Not necessarily that we wrote that. Because we just share pieces of information. Substandard equipment is a known fact in the industry.	Cost of RET		Challenge

Appendix 7: Planned Timeline For Thesis


Activity
February
March
April
May
June
July
August
wk3 wk4 wk1 wk2 wk3 wk4 wk1 wk2 wk3 wk4 wk1 wk2 wk3 wk4 wk1 wk2 wk3 wk4 wk1 wk2 wk3 wk4 wk1 wk2 wk3 wk4
Research Proposal
Preparation of research proposal
Submission of Final proposal
Research Preparation
Application to ethics committee
Incorporating feedback from research proposal
Gathering contact details for case study farms
Send introductory letters to poultry companies, acquire confidentiality agreements
Drafting questionnaires and focus group content
Research Activities
Data gathering by review of Policy Papers and Documents
Shedule and secure interview dates
Analysis and finalising section on regulatory Framework and Policy papers
Conduct interviews and focus group discussions
Data analysis
Feedback to interviewees
Submission of preliminary findings
report
Complete draft report
Incorporate feedback
Submit Report