Eindhoven University of Technology

MASTER

Buying into the Kenyan solar market
exploring user perspectives on investing in solar electricity

Hoefsloot, E.M.

Award date:
2017

Link to publication

Disclaimer
This document contains a student thesis (bachelor's or master's), as authored by a student at Eindhoven University of Technology. Student theses are made available in the TU/e repository upon obtaining the required degree. The grade received is not published on the document as presented in the repository. The required complexity or quality of research of student theses may vary by program, and the required minimum study period may vary in duration.

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain

Eindhoven, 8 March 2017

Buying into the Kenyan solar market

Exploring user perspectives on investing in solar electricity

By Ellen Hoefsloot

identity number 0752721

In partial fulfilment of the requirements for the degree of

Master of Science
in Innovation Sciences

Department of Industrial Engineering and Innovation Sciences
Eindhoven University of Technology

Supervisors

dr. J.I. Höffken	Department of Industrial Engineering and Innovation Sciences
dr. H.A. Romijn	Department of Industrial Engineering and Innovation Sciences
dr. F. Schipper	Department of Industrial Engineering and Innovation Sciences

Eindhoven University of Technology
Department of Industrial Engineering and Innovation Sciences

Series Master Theses Innovation Sciences

0EM06: MSc thesis Innovation Sciences

Summary

By conducting an inductive exploratory research based on literature reviews and ethnographic fieldwork I will answer the following research question:

Which perspectives do people living in rural households in western Kenya have on investing in access to electricity, and how do these perspectives compare to the prominent perspectives held by scholars and practitioners in the field of rural electrification?

The answers to this question provide insight into the experience of unelectrified households and electricity users in western Kenya, and the current ability of actors involved in the development of rural electrification in Kenya to address the perspectives of users. The resulting conclusions of this research can inform the efforts of other actors in the field rural electrification.

For my fieldwork, I contacted a company called SolarNow. SolarNow is a "*for-profit social business*" (SolarNow 2017) which aims to increase rural electrification through the provision of solar home systems. In preparation of their planned expansion to one of the countries neighbouring Uganda, SolarNow asked me to travel to Kenya to study the market for solar home systems. This gave me the opportunity to gather empirical data about the user views on investing in electricity.

Energy poverty, rural electrification, and access to electricity in Kenya

Energy poverty, or "*the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development*" (A. Reddy 2000, p. 44), is a problematic issue which strongly impacts the quality of life of the rural poor. Many of my respondents have to deal with the consequences of energy poverty on a daily basis, and energy poverty is the issue which SolarNow is ultimately trying to solve by increasing rural electrification rates. Electricity is a versatile, cheap, and safe energy carrier which offers a wide range of energy services. Access to electricity can resolve many of the issues associated with energy poverty, and opens up new avenues for household productivity.

There are two broad ways in which rural electrification can be pursued; through grid expansion and through off-grid electrification. Both these options have their own merits and drawbacks. Because of the precedent set by rich countries, the Kenyan government focuses mainly on grid expansion to increase rural electrification. Grid expansion requires large

capital investments and is associated with high marginal costs. In return it provides access to a wide range of electricity services because, within household context, there are no technical limitations to the amount of appliances that can be connected to the electricity grid. Recently, the Kenyan government has focused on promoting 'last mile connectivity'. The last mile connectivity project has proven popular among my respondents, but in the past government policies to increase electricity access were largely ineffective. This led to the development of a solar photovoltaic market, to serve as an alternative to grid expansion. However, despite the existence of a competitive market, prices of solar home systems long remained prohibitively high for many of the poorest households. In reaction to this issue, new businesses emerged which sell solar home systems on credit in hopes of improving the affordability of solar home systems. An example of such a business is SolarNow. The efforts of these companies make purchasing solar home systems an attractive and attainable alternative to grid connection.

Perspectives on user investments in electricity

Through my analysis of literature and data about the perspectives of rural electrification practitioners, I have found that practitioners in the field of rural electrification seem to operate under two powerful assumptions pertaining to the ability and willingness of users to invest in household access to electricity. The first assumption is that access to household electricity has the power to *transform* daily life in rural areas of poor countries. The second assumption, which follows in part from the first assumption, is that the main deterrent of households investing in electricity access is *affordability*. Consequently, the prevalent idea about improving access to electricity revolves around the idea that when all issues with affordability are addressed, rural electrification will follow. However, I have found that the perspectives about affordability of practitioners and users do not always align, and the highly stylized transformational narrative about household access to electricity provides an inaccurate representation of the outcomes of electrification.

In general terms, user perspectives on investing in access to electricity align with the perspectives of scholars and practitioners of rural electrification; users are also concerned with affordability and the benefits provided by electricity. However, there are significant differences between the way these subjects are perceived by scholars, practitioners, and users. Scholars and practitioners of rural electrification focus on reducing the burden of prohibitively high *upfront costs*, and this is indeed an issue which is also mentioned by representatives of rural households. Interestingly, while scholar and practitioners of rural electrification recommend addressing high upfront costs by improving access to financial

services, users have developed their own tactics to reduce the burden of high upfront costs. I observed clusters of households which shared grid connections, and households which built their electricity system over time through modular cash purchases. Furthermore, I found that users held diverging views on purchasing expensive items such as solar home systems on credit, mainly due to the uncertain nature of their incomes. For these reasons, providing access to financial services may not increase rural electrification rates, and specifically the uptake of solar home systems, as much as expected.

In addition to the issue of upfront costs, I found that users mentioned having problems with the *costs of use* of electricity. In the case of grid electricity, respondents had issues with the fact that they were unable to control their energy expenditures because of the way electricity is billed. With solar home systems, I found that users were unaware of the fact that system components often require maintenance or replacement during the lifetime of a solar home system, which led to unexpected costs. Also, both households with access to grid electricity and households with solar home systems were unable to completely cut their spending on traditional fuels because of grid unreliability or solar home system limitations. In contrast, rural electrification literature emphasizes the fact that electricity provides a much higher level of service than traditional energy sources, making it the more economical alternative. This benefit was often not perceived by the respondents in this study.

Furthermore, I found that users thought solar home systems provided electricity of lesser quality than the electricity grid. This links back to the concept of energy services. The average solar home system cannot accommodate the same amount of electrical appliances as grid electricity, and therefore provides fewer electricity services. The unhappiness users expressed about this fact could indicate that solar home systems do not provide sufficient electricity services to make people feel as though their household has been electrified. This influences user perceptions about the overall desirability of solar home systems, and as a consequence their willingness to invest in them.

Finally, in terms of benefits I found that users described electricity as a convenient, useful, and fun addition to their daily lives. What people most enjoyed about having household access to electricity was having bright, electric lights and television. However, the lack of productive uses, the unreliability of the electricity grid, and the technical limitations of solar home systems meant that, at the time of this study, I observed little development of essential practices or routines around the use of electricity. The lack of productive use of electricity

might be the reason that people do not think of electricity as an investment with the potential for financial returns, but more as something which provides convenience and entertainment. Ultimately, people who lived in electrified households did not feel that electricity had *transformed* their lives.

In conclusion, I found that the views expressed in academic literature were mostly reflected in the information I gathered at SolarNow offices, and often did not correspond to the views held by the representatives of rural households I spoke to. This indicates that, while rural electrification literature in general and affordability literature specifically does focus on how to make electricity more accessible for rural users, the prominent perspective taken in literature is the perspective of rural electrification practitioners, which does not always align with the perspective of users.

These findings have the following implications for rural electrification practice. First, practitioners in the field of rural electrification should be mindful of the effects of the language they use to convey the benefits of electricity to their customers. On the one hand, promising to transform the lives of electricity users can lead to unrealistic expectations and subsequent disappointment. On the other hand, the promise of transforming the lives of users can help companies to attract investors and motivate staff. Second, practitioners in the field of rural electrification can increase the transformational potential of electricity by providing information about how electricity can be used to increase productivity and household income. By improving the transfer of knowledge about these topics, users might come to see electricity as an investment in their futures.

Contents

1 Introduction

The past few decades have seen a growing interest, from policy makers and academics alike, in the role private sector actors play in development efforts. Businesses are called on not only to facilitate economic development, but also to contribute to poverty alleviation, sustainability transitions, and social goals in general (Kolk and van den Buuse 2012). The transfer of social responsibilities from governments and development organizations to businesses has been caused in part by the global wave of privatisation in the second half of the 20th century, and by the failure of the governments of developing countries to increase the standard of living for the majority of their citizens (Mukherjee-Reed and Reed 2009).

A case in which private sector actors have come to play a significant role in the process of poverty alleviation and sustainability transitions is the case of rural electrification in developing countries. Rural electrification programmes in sub-Saharan Africa have been widely promoted since the early 1980s due to the role rural electrification plays in the socio-economic development of communities (Bernard 2010). Rural electrification can improve access to good healthcare and education, as well as increasing economic activity and connectivity between rural and urban areas (International Energy Agency 2014). While national electrification programmes typically focus on extending the existing electricity grid to unserved areas, the high marginal costs along with the slow progress of grid expansion to the most remote areas has created a market for off-grid electrification options (Deichmann, et al. 2011) (Bazilian, et al. 2012).

One of the most common ways of providing off-grid renewable electricity is through the installation of stand-alone solar home systems, which make households self-sufficient electricity producers. A good example of a country in sub-Saharan Africa with a well-developed solar home system market is Kenya. The initial uptake of solar power as an electricity source in Kenya in the late 1980s was driven by large subsidized projects aimed at providing social institutions such as health centres and schools with reliable electricity, but the demand for residential solar systems had already surpassed the institutional demand by the early 1990s (Hansen, Pedersen and Nygaard 2015). This demand was driven by the falling prices and smaller sizes of solar systems, as well as the spread of TV and radio signals to rural Kenya. As of 2008 Kenya has the second-largest solar home system market in the world; only China has a larger market share (Ondraczek 2013).

Despite the existence of a competitive market in Kenya, solar home systems are purchased mainly by middle- and higher income households, and the poorest households still lack access to electricity. One of the explanations for this is that they lack access to capital, and that the upfront cost of purchasing a solar home system is too high for the lowest-income households. This problem is exacerbated by the fact that these households are often not eligible for traditional forms of credit provision, which require a steady income or some form of collateral (Pode 2013). However, unelectrified households do seem to have the capacity to save money and purchase expensive items, as is evidenced by the fact that a small proportion of these households own televisions and other relatively expensive electric appliances (Lee, Miguel and Wolfram 2016).

This suggests that, aside from the cost of acquiring access to electricity, there are other factors that play an important role in the decision of households to spend their money on some form of electricity. If the private sector actors involved in the process of rural electrification in Kenya focus mostly on solving the 'lack-of-money' issue, they could well be missing out on interesting opportunities to engage customers and expedite the process of rural electrification. Goméz Garcia and Montero Bartolomé (2010) state that, in spite of extensive interest in understanding western users of technology, a similar level of interest in understanding the wishes, issues, and motivations of non-western technology users does not exist. This leads to assumptions about users that are based on extensive research conducted in the United States and in Europe, which may not hold true for non-western users (Gómez Garcia and Montero Bartolomé 2010). By conducting an inductive exploratory research based on literature reviews and ethnographic fieldwork I will answer the following research question:

Which perspectives do people living in rural households in western Kenya have on investing in access to electricity, and how do these perspectives compare to the prominent perspectives held by scholars and practitioners in the field of rural electrification?

The answers to this question provide insight into the experience of electricity users in western Kenya, and the current ability of actors involved in the development of rural electrification in Kenya to address the experiences of users. The resulting conclusions of this research can inform current and future rural electrification research and practice.

For my fieldwork, I contacted a company called SolarNow. SolarNow is a Ugandan "*for-profit social business*" (SolarNow 2017) which aims to increase rural electrification through the provision of solar home systems. In preparation of their planned expansion to one of the

countries neighbouring Uganda, SolarNow asked me to travel to Kenya to study the market for solar home systems there. This gave me the opportunity to gather empirical data about the user views on investing in electricity. An account of my research methodology is given below, and a more elaborate description of SolarNow and the area I visited for my fieldwork can be found in chapter 2.

1.1 Methodology

The aim of this exploratory research is to uncover the perceptions of electricity users about investing in electricity in Kenya, and to compare and contrast these views to the views held by scholars and practitioners of in the field of rural electrification. I conducted this research in an iterative manner, which means that every part of this research has remained open to evaluation and change throughout the entire process. The benefit of such an iterative approach to research is that it provides the freedom to reconsider earlier decisions, and it has allowed me to hone and refine my research (Verschuren and Doorewaard 2010). A consequence is that every part of this research, including the research design, has changed along the way. In this section I will provide an overview of the methodology I ended up using to gather and analyse my data.

1.1.1 Gathering empirical data

Verschuuren and Doorewaard (2010) indicate that research focused on exploring the views held by specific groups of people is best conducted using a qualitative approach to gathering empirical data. In brief, my specific approach combined semi-structured interviews with participant observation, and textual material such as grey literature, news articles, and web sites, to obtain an extensive set of empirical data.

I selected the people I interviewed through strategic sampling (Verschuren and Doorewaard 2010). This means I assessed whether or not people might be interesting to interview based on criteria I formulated, such as visible signs of household electrification, and indications of income-level such as the building materials used and the size of the homes. The interviews were recorded and transcribed for analysis. The decision about when to stop interviewing was based on whether or not I felt I had reached a point of saturation – so whether or not subsequent interviews provided little to no new information or insights (Corbin and Strauss 2008).

Due to the language barrier between me and several of my interviewees, a colleague from SolarNow named Rachael, who is a native Kiswahili speaker and fluent in English, helped me

translate when necessary. The interviews I was able to conduct in English generally yielded richer and more in-depth stories than the ones which required translation, because speaking to people directly improved my ability to connect with them, which resulted in conversations instead of interrogations. However, the translated interviews provided valuable complementary information about living conditions, household energy expenses and access to electricity. Also, being accompanied by someone who was well-versed in local customs and manners helped greatly in making initial contact with people, especially since we mostly showed up to houses unannounced.

In addition to conducting interviews, I spent three days as a guest in a rural household which did happen to be connected to the electricity grid. This household consisted of a mother, her two adult daughters, the baby of the eldest daughter, and a girl who took care of the baby and the household when the other women went to work during the day. During my stay, I took on the role of participant-as-observer, which means that my role as observer was secondary to being a participant (Creswell 2014). Spending a few days as an observer in this household allowed me to observe closely how electricity was used, and provided a more informal setting for conversations about what is means to have electricity in rural Kenya. In addition, and perhaps more valuable, the role of participant allowed me to gain first-hand experience with daily life in rural Kenya, which proved to be helpful during my subsequent interviews and analysis. The observations I made and the conversations I had about electricity during this time were not recorded as audio files, in order to not disturb daily life more than necessary, and to keep with the informal setting of the conversations. Instead, I recorded the interesting remarks and observations in the form of researchers notes, as suggested by Creswell (2014).

In order to gather empirical data from the supply-side views on user investments in rural electrification, I spent one month at SolarNow offices. First I spent a week going through the mandatory SolarNow employee training, which teaches new employees what the company does, how they hope to sell their product, and finally how to install a solar home system. After that, I spent a week at the SolarNow field office in Kabale, western Uganda, to experience how SolarNow employees and customers interacted in different situations. Finally, I spent three weeks preparing my field trip at SolarNow headquarters in Kampala, where I was able to observe how the company was really run (as opposed to how it is told during the employee training). To supplement the information gathered through observations and informal chats, I interviewed the de-facto manager of SolarNow, Ronald Schuurhuizen. Additionally, I gathered information about companies which are similar to SolarNow, but which operate in

Kenya, through their websites, news articles, grey literature, and informal conversations at their field offices.

1.1.2 Analysis

As I stated, I conducted this research in a largely inductive manner in order to develop new lines of thought that may be helpful to understand the perspectives of electricity users in rural western Kenya, as well as aid the process of rural electrification in general. This means that I analysed the gathered empirical data without predetermined codes based on existing theory, and instead attempted to formulate my own theories based on my empirical data, before going back to the literature to verify or further develop my findings (Corbin and Strauss 2008).

In order to achieve this, I carried out an iterative analysis in three rounds. In the first round of analysis I took my empirical data as a point of departure, and through open, axial, and selective coding I made a first attempt at distinguishing relevant categories of thought as expressed by (prospective) users of electricity (Verschuren and Doorewaard 2010). In a second round of analysis, I compared my findings to existing literature in the field of rural electrification, as well as to the information I gathered on the views of providers of electricity. The literature was sought through a systematic literature review, focusing on the topics I identified in the first round of analysis. The objective of this second round of analysis was to verify and further develop the categories derived from the empirical data. For the third and final round of analysis, I returned to my empirical data to check whether in my first round of analysis I had overlooked any of the new categories I found through the literature review. This iterative process brought me to my final analysis, which integrates the three aforementioned rounds of analysis, and which can be found in chapter 5 of this report.

1.2 Thesis outline

The remainder of this thesis is structured as follows. Chapter 2 provides background information about my case. This information consists of a description of the mission, vision and strategies of SolarNow, the company I conducted my research with. In addition, this chapter provides information about the geography and demography of the areas I visited for my interviews, and about the people I spoke to during my field work.

Chapter 3 provides the academic context for this research. I will first introduce the concept of energy poverty, and the issues associated with it. The issues described here are issues which many of my respondents have to deal with on a daily basis, and they are the issues which SolarNow is ultimately trying to solve. I will go on to discuss current ideas about rural

electrification. The ideas about energy poverty and rural electrification presented in chapter 3 are necessary to understand the analysis provided in chapter 5 of this thesis.

Chapter 4 provides the socio-economic context for this research. I will give a brief overview of government- and market based rural electrification developments in Kenya. Furthermore, I will discuss the most common ways in which I found households can get access to electricity in western Kenya. The contextual information presented here is helpful to understand the analysis of household perspectives on investing in electricity provided in chapter 5 of this thesis.

Chapter 5 examines how user perspectives on investing in electricity compare to the insights of existing scientific literature and rural electrification practitioners. The interviews I conducted with representatives of rural households showed me that there is a difference in the way major issues such as affordability of electricity and the benefits experienced from access to electricity, and more specifically access to solar electricity, are understood by users and practitioners. I will provide evidence to support this argument throughout chapter 5.

In chapter 6 of my thesis I will answer my research question: *Which perspectives do people living in rural households in western Kenya have on investing in access to electricity, and how do these perspectives compare to the prominent perspectives held by scholars and practitioners in the field of rural electrification?* After answering this question, I will discuss which implications this answer has for rural electrification research and practice.

Finally, in chapter 7 I will include some of my personal reflections on doing research in East Africa and writing a thesis. The reason for this is that I feel that most of what I have learned during this project pertains to the process of doing research, and not necessarily to the content of my report.

2 Case description

This chapter provides background information about my case. This information consists of a description of the mission, vision and strategies of SolarNow, the company I conducted my research with. In addition, this chapter provides information about the geography and demography of the areas I visited for my interviews, and about the people I spoke to during my field work.

2.1 SolarNow

As I mentioned in my introduction, I conducted my fieldwork with the help of a company called SolarNow, which sells solar home systems in Uganda and was planning to expand to Kenya in 2016. SolarNow is a "*for-profit social business*" (SolarNow 2017) which aims to increase rural electrification through the provision of solar home systems. The fact that they are a for-profit social business means that their social goal – improving access to electricity – is pursued in a commercial way, and without relying on aid. A dual goal such as this can create tension in a business, because often the intended social outcomes of a business depend on reaching customers who cannot pay for products or services (Seelos and Mair 2005). It is important to address this duality, for example by making social value creation a precondition which shapes the way economic value is created and captured, or by pursuing economically valuable activities which have been shown to create social value (Doherty, Haugh and Lyon 2014). SolarNow attempts to balance the pursuit of these two goals by focussing on offering quality products at affordable prices, in order to expedite the process of rural electrification.

The emphasis on affordability and quality is reflected in the SolarNow mission statement; their mission is to "*transform the lives of East Africans*" by making "*quality solar accessible through affordable finance*" (SolarNow 2016a). They pursue this mission by offering electrification solutions to the rural poor through a novel business model which integrates product, financing, installation, user training, and after-sales services such as maintenance and warranties. This makes it easier for the customer to find the information and help necessary to arrange their own access to electricity, because it is all in one place. Literature suggests that such a business model is an effective method of increasing the affordability of solar home systems for the rural poor (Pode 2013).

The two main ways through which SolarNow tries to make their systems affordable are appropriate system sizing and provision of credit. In order to make their products both

affordable for low-income households and interesting to higher-income households, SolarNow offers a wide array of different system sizes, with different application possibilities (SolarNow 2016b). In addition, SolarNow provides the option of buying solar home systems on credit, even to people without a traceable financial history. Creditworthiness is assessed by conferring with the social network of a customer, as well as by assessing capital in the form of land and livestock. Guarantees are built into the credit system by using the solar home system itself as collateral (Pode 2013). SolarNow requires monthly repayments, but repayment plans can be adjusted to converge with harvest season, since many rural households rely on farming for their income (SolarNow 2016c). M-KOPA, Mobisol, and Azuri, companies which are very similar to SolarNow, but which operate mainly in Kenya and Tanzania, have similar business models, though they employ a pay-as-you-go payment system instead of set monthly payments. Through this, they give customers an additional incentive to repay their solar home systems, because the system is switched off when payments are not made (Rollfs, Byrne and Ockwell 2014).

2.2 Western Kenya and the people who live there

In preparation of their planned expansion to one of the countries neighbouring Uganda, SolarNow asked me to travel to Kenya to study the local market for solar home systems. This gave me the opportunity to gather empirical data about the user views on investing in electricity. Based on the practical consideration that any new SolarNow location should be relatively easy to reach by road from Uganda, we mutually decided that I would focus my field work in western Kenya. Because of the commercial interest of SolarNow in my project, I agreed to more specifically focus my field work in rural areas around the six commercial centres with the highest population densities and levels of employment in the greater area. We also took official electrification rates into account. The final selection of field work locations, along with the corresponding population density and employment rate, can be seen in Table 1. The electrification rates of the municipalities I visited, which consist of rural and urban areas, is shown in Table 2. The area I visited is shown in Figure 1.

Western Kenya in general benefits from a good climate for farming, leading to high agricultural yield. The climate is especially well-suited to the farming of tea, a lucrative cash crop. However, western Kenya is relatively densely populated and geographically far removed from urban markets, which means the agricultural potential of the area has not led to higher-than-average household incomes (Waithaka, et al. 2006).

TABLE 1: LOCATIONS CONSIDERED FOR FIELD WORK (WITH LOCATIONS VISITED IN GREY) (KNBS 2010)

	Kisumu	Bungoma	Kitale	Eldoret	Kericho	Migori	Kisii	Yala	Oyugis	Kakamega
Population density (p/km^2)	465	454	328	267	306	353	875	333	367	544
Employment rate	44%	54%	43%	39%	53%	46%	55%	49%	41%	48%

TABLE 2: ELECTRIFICATION RATES IN RESEARCH LOCATIONS (KNBS, 2010)

	Kisumu	Bungoma	Kitale	Eldoret	Kericho	Kisii
Electricity access	**26%**	**7%**	**12%**	**29%**	**17%**	**14%**
Grid electricity	25%	6%	12%	28%	16%	13%
Solar electricity	0.6%	0.5%	1.0%	1.2%	1.4%	0.9%

To gather empirical data about the consumer-side views on investing in electricity, I conducted 36 semi-structured interviews with people living in rural areas around western Kenya. Many of the people I spoke to relied in part or entirely on farming for their livelihood. These farming activities ranged from the small-scale subsistence farming of maize, beans, and sukuma wiki[1], to larger maize or tea farms with high enough yields to earn a living and have some disposable income. There were several households which had an additional means of income through the employment of one of the household members as teachers, security guards, electricians, or shop employees. Furthermore, many women managed small businesses, such as running a clothes or vegetable stall on the local market, as an additional source of income.

2.3 Traditional energy use in Kenya

Energy use in Kenya is largely similar to the energy use patterns in developing countries in general. While the group of households I interviewed is not homogeneous, and included both electrified and unelectrified households, their energy consumption patterns roughly correspond to global Kenyan energy use.

[1] Sukuma wiki is a leafy vegetable similar to kale.

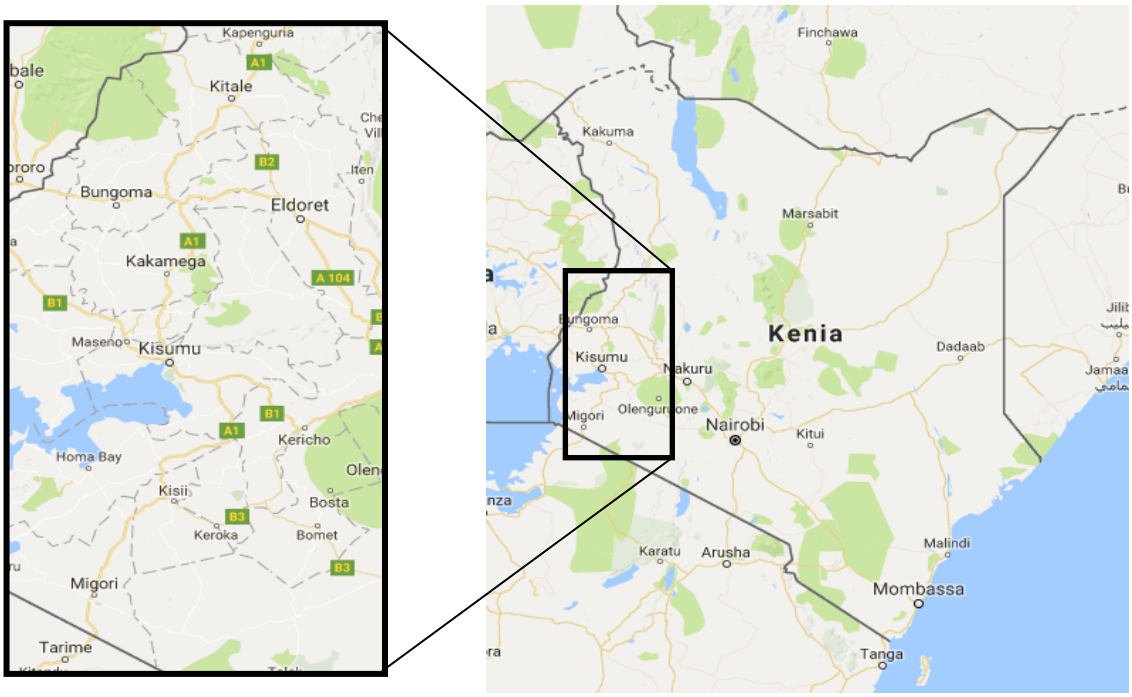

FIGURE 1: WESTERN-KENYA

Unelectrified households make up the majority of households in rural Kenya. The 2009 Kenya Population and Housing Census reported that 23% of the nearly nine million households in Kenya used electricity as their main source of light (KNBS 2010). However, this figure includes urban and rural households; based on the census data the amount of rural households with an electricity connection in Kenya was around 3% in 2009. More recent studies estimate similar or slightly higher percentages of rural electrification for Kenya, ranging from 3% (Deichmann, et al. 2011) to 5% (Lee, Brewer, et al. 2014) (Abdullah and Markandya 2012), and even a very optimistic 26% (REA 2013).

The majority of unelectrified households in rural areas rely heavily on firewood, charcoal, and to a lesser extent agricultural residue for cooking, and paraffin lamps for lighting (Abdullah and Markandya 2012). In addition, around 40% of households own battery powered appliances such as mobile phones, torches, and radios. Just over 15% of unelectrified rural households even own a television with no evident means of powering it (Lee, Miguel and Wolfram 2016).

A full overview of my respondents, their household size, their main sources of income, and the primary energy sources used in their households can be found in Appendix A.

3 Energy poverty and rural electrification

This chapter provides the academic context for this research. I will first introduce the concept of energy poverty, and the issues associated with it. The issues described here are issues many of my respondents have to deal with on a daily basis, and they are the issues which SolarNow is ultimately trying to solve. I will go on to discuss current ideas about rural electrification, which is one of the ways through which energy poverty can be addressed. The ideas about energy poverty and rural electrification presented here are necessary to understand the analysis provided in chapter 5 of this thesis.

3.1 Energy poverty

Energy poverty has become an almost mandatory topic in development policy, both on a national and on an international level. While the United Nations' Millennium Development Goals (MDGs) – a set of eight goals formulated in 2000 with the purpose of improving the lives of the poorest communities in the world – did not explicitly state the reduction of energy poverty as a goal, there was a widespread notion among scholars and policy makers that the goals were not attainable without tackling the issue of energy poverty (Sovacool 2012) (Gonzáles-Eguino 2015). After the expiration of the MDG deadline in 2015 the UN instated a new set of goals, the Sustainable Development Goals (SDGs), to serve as a guideline for development until 2030 (UNDP 2016a). Of this set of seventeen goals there is one that directly addresses energy poverty; SDG 7 is to "*ensure access to affordable, reliable, sustainable and modern energy for all*" (UNDP 2016b). In addition many of the other goals, such as ensuring good health and well-being, providing quality education, and promoting sustainable cities and communities can be achieved more easily when modern energy services are available.

Energy poverty does not have one universal definition, though most definitions contain many of the same elements found in the seventh SDG: *lack of access* to *affordable, reliable, sustainable* and *modern energy*. 'Modern' energy refers to energy carriers such as electricity and refined fossil fuels, which typically have a high efficiency and energy density. This is opposed to inefficient and low-energy density 'traditional' energy, which includes energy sources and carriers such as human or animal power, firewood, charcoal, candles, and paraffin (Sovacool 2012). A more extensive definition of energy poverty is formulated by Reddy (2000, p. 44): Energy poverty is "*the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support*

economic and human development". This definition includes several notions which are not explicitly mentioned (though perhaps implied) in SDG 7, two of which are interesting to elaborate upon in light of this research: *energy services* and *absence of choice*.

The distinction between access to energy and access to energy services is an important one. While people who do not have access to electricity may say that what they want is electricity, what they actually want are the services that electricity provides (A. Reddy 2000). In other words, they want to be able to flip a switch to turn on the lights, to charge their mobile phones, to watch TV, to use a refrigerator, and so on. This implies that the energy sources and carriers used to provide a certain energy service should be of little consequence to consumers, as long as the result is the same. It is important to note that not all energy carriers provide the same level of service for the same price, and unfortunately people do not always have the opportunity to choose the energy carrier with the best value for money. In poor countries there are only a limited number of energy carriers that a household can choose to use, which are typically traditional ones such as firewood and paraffin (Gonzáles-Eguino 2015).

A consequence of the absence of alternatives is that households are forced to rely on energy carriers which have a narrower range of uses (e.g. paraffin can only be used for lighting and cooking, while electricity can be used for lighting, cooking, space heating, and powering appliances such as TVs and mobile phones), provide a lower level of service (e.g. a paraffin lamp is not nearly as bright as an electric light bulb), and on top of that are more expensive per unit of energy than modern energy carriers (A. Reddy 2000). Sovacool (2012) estimates that unelectrified households spend between 20% and 30% of their income directly on traditional energy sources. Additionally, household spending power is impacted negatively by the indirect costs associated with the use of traditional energy sources. These costs include, but are not limited to, the loss of productive time which is spent on gathering traditional fuel sources (Sovacool 2012), and the cost of healthcare required as a consequence of indoor air pollution (Barron and Torero 2016). The fact that many of the world's poorest people are paying more but receiving less in terms of energy exacerbates their inability to fulfil their basic needs; needs that are required for human development (Sovacool 2012). The other side of that same coin is that many households in developing countries could significantly improve their indoor environment and their purchasing power, and thus their access to better food, shelter, education, and healthcare, by switching from traditional to modern energy (A. Reddy 2000). As we will see in the analysis in chapter 5, the level of service provided by an energy carrier plays an important role in the considerations of users about investing in energy access.

Because energy poverty is a broad problem, projects to enhance access to modern energy services typically focus on one of three key areas: (1) energy sources for cooking, (2) electricity for lighting, communication technologies, household appliances, and to support social services such as education and healthcare, and (3) mechanical power to transport people and goods, and to assist in agricultural and other productive activities (Modi, et al. 2006). While this research focuses on the issue of lacking access to electricity in rural households, this should not be taken to mean that this area of interest are more important than the others; reducing energy poverty requires effort and improvement in all three areas.

3.2 Rural electrification

Lacking access to electricity is a predominantly rural problem (Bhattacharyya 2013). Of all the people without access to electricity, almost 80% live in rural areas (International Energy Agency 2014). For this reason, much of scientific and policy literature on electrification tends to focus on *rural* electrification. In this chapter I will give an account of academic insights about the benefits of access to electricity. I will then elaborate on the two broad ways in which rural electrification can be achieved; through grid expansion and through off-grid technologies. Finally, I will discuss an important point of contention within rural electrification literature, namely what constitutes 'electrification'.

3.2.1 The benefits of rural electrification

The consequences of lack of electricity are roughly the same as the consequences of energy poverty. Without electricity, people are forced to rely on traditional energy sources such as paraffin and candles for lighting in their homes, and are required to find external electricity sources to charge appliances such as mobile phones and radios. These traditional energy sources are expensive, cost time to access, and provide low levels of service compared to electricity (A. Reddy 2000). In addition, lighting sources such as paraffin and candles cause fire hazards and indoor air pollution, which can lead to pulmonary diseases (Barron and Torero 2016).

Aside from replacing expensive, inefficient, and harmful traditional energy sources, electricity opens up a range of new options and opportunities for households and businesses. First, electric light is brighter than paraffin lamps or candles, and therefore more comfortable to work by in the evening. The use of electric light lengthens working hours for both students and adults, which in turn improves the prospect of succeeding in school or at work (Azimoh, et al. 2015). Second, electricity enables easy access to connective devices such as TV, radio,

and mobile telephones. These electric appliances have the potential to decrease the distance between urban and rural life, and contribute to female empowerment (Matinga and Annegarn 2013). Third, electricity opens up access to household appliances such as refrigerators and flat irons. These appliances can contribute to better hygiene and increased comfort. Also, the use of these appliances can lead to time savings, especially among women, because household chores can be done more efficiently. This in turn can lead to an increase in female employment rates (Salmon and Tanguy 2016). Finally, access to electricity broadens the options which rural households have for production. Electricity can be used to optimize agricultural production, for example through powering small irrigation systems, cow feed mills, or hatcheries. Additionally, in the context of rural life in developing countries, access to electricity can lead to novel income generating activities (Peters and Sievert 2015). The positive impact of rural electrification on productivity is one of the main justifications for many policy makers and rural electrification practitioners, among them SolarNow, to pursue this cause (Matinga and Annegarn 2013). In the analysis in chapter 5 we will see that the aforementioned benefits of rural electrification play a significant role in investment decisions made by rural households.

Rural electrification is used as a catch-all term for a wide variety of ways in which access to electricity is improved in rural areas, each with its own benefits, drawbacks and advocates. Broadly speaking, there are two options for providing access to electricity in rural areas; grid expansion and off-grid electrification.

3.2.2 Rural electrification through grid expansion

Lacking access to electricity in rural areas in poor countries is caused by the absence of electricity infrastructure in these areas. Grid expansion projects aim to resolve this by extending the reach of existing electricity infrastructure to un- or underserved areas. Rural electrification through grid expansion is often pursued by governments and national electricity companies, because it has proven successful in both developed and developing countries (Levin and Thomas 2016).

The main benefit of electrification through grid expansion is that there are no technical limitations to the amount of electricity available to a household and all electric appliances can be connected with relative ease (Lee, Miguel and Wolfram 2016). However, in reality, issues with grid quality and electricity supply in developing countries lead to frequent planned and unplanned power outages, making grid electricity an unreliable source of energy. Problems

with the reliability of electricity grids in developing countries are often exacerbated by an uptake in rural electricity connections (Kiplagat, Wang and Li 2011). This is caused in part by the fact that the already limited resources have to be shared among more households, and in part by the electricity consumption of rural households, which, more so than that of urban households, is concentrated in the evenings (Zerriffi 2011). This leads to relatively large demand fluctuations between off-peak and peak demand times. The reason for this is that electrified rural households often do not have appliances which require a steady supply of electricity throughout the day, such as refrigerators, to provide a base demand (Zerriffi 2011). Another factor limiting the success of rural electrification through grid expansion is the uncertain assumption that people will take the initiative to connect their households to the electricity grid as soon as it is within reach. Electrification rates among 'under grid' households, households which are located within 200 meters from the electricity grid, remain very low in Kenya (Lee, Brewer, et al. 2014).

To resolve issues with reliability and low connectivity rates, rural electrification through grid expansion requires large investments in centralized electricity generation and distribution facilities (Levin and Thomas 2016). In the case of grid expansion to remote and sparsely populated areas, the large required investments lead to high marginal costs (the additional cost of connecting one more household or village to the grid), making it difficult to recover these investments through customer fees (Deichmann, et al. 2011). This means government-led grid expansion projects often depend on foreign investments or loans. Organizations such as the International Development Association (part of the World Bank) and the African Development Fund have extended funding to grid expansion projects in Kenya in the past years (KPLC 2016).

It is important to note that, contrary to prevalent preconceptions, rural electrification through grid expansion is not necessarily non-renewable. In Kenya, over 90% of the country's electricity is generated in large hydro-power plants or geothermal energy plants (Energy Regulatory Commission 2014), and much of the renewable energy potential is still unexploited (Kiplagat, Wang and Li 2011). This means that it is feasible to increase electricity generation in Kenya significantly without resorting to the use of fossil fuels.

Despite the issues associated with grid expansion, rural electrification goals set by the Kenyan government focus mainly on strengthening and expanding the existing electricity infrastructure to achieve better coverage and quality of the electricity grid (Energy Regulatory

Commission 2014). Kenyan electrification policies, which are described in more detail in chapter 4, have led to considerable successes in the past few years, and have shaped the context in which other rural electrification practitioners such as SolarNow operate. This has in turn influenced the perspectives of users when it comes to investing in electrification options, as we will see in the analysis in chapter 5.

3.2.3 Off-grid rural electrification

Although the Kenyan government has invested in grid expansion to promote rural electrification, the high marginal cost associated with grid expansion to remote areas, in combination with the low reliability of the electricity grid in Kenya, has created a demand for alternative electrification solutions which operate independently from the existing electricity grid (Deichmann, et al. 2011). While for a long time off-grid solutions were only economically interesting alternatives to grid expansions in very remote areas, thanks to the ever decreasing costs of these off-grid technologies, they have become viable alternatives in a wider range of scenarios (Levin and Thomas 2016). Off-grid electrification projects are typically relatively small in size and inevitably geographically localized, since they are not connected to a large distribution grid.

Most commonly, off-grid systems for household electrification are stand-alone systems which serve one household (Pedersen 2016). These household electricity systems can range in size from 5 watts – enough to charge a phone or a lantern – to several kilowatts – enough to power several larger appliances such as televisions, refrigerators, and flat irons – depending on the wishes and the financial solvency of the specific household (Bond, Aye and Fuller 2010). The smallest solar systems, known as solar lanterns, consist of a lantern with an integrated solar panel, and sometimes have an integrated USB port which can be used to charge small appliances such as telephones and radios. Solar lanterns provide better-quality light than traditional light sources such as candles and paraffin lamps, and the replacement of candles and paraffin lamps with solar lanterns leads to significant improvements in indoor air quality (Barron and Torero 2016).

Solar home systems are generally larger than solar lanterns, and are made up of several components, making it easier to adapt them to specific needs. The typical solar home system consists of a solar panel, a battery, a charge controller, wiring, loads (lights, phone charger, TV, etc.), and possibly an inverter – which transforms direct current into alternating current – for grid connection. Because of their modularity, solar home systems are available in wide

variety of sizes, ranging from powering a few lights and providing the option of phone charging, to grid-connected systems capable of accommodating many appliances. In terms of the developmental benefits afforded by electricity, small systems are shown to provide nearly as much improvement as larger solar home systems. Because the small systems provide high-quality light and improved indoor air quality just as well as the larger systems, the benefits of increasing systems size are not proportional to the required extra investments (Bond, Fuller and Aye 2012). However, if given the choice, people prefer a larger system because it provides more points of light and connection options for other appliances, and the perceived quality of the light is higher (Bond, Aye and Fuller 2010).

Household stand-alone systems are either donated through aid projects, or purchased by the prospective users. Both non-governmental organizations and governments have supported off-grid electrification through efforts which provide solar lanterns or solar home systems. These projects require extensive planning and collaboration with multiple parties in order to organize funding, hardware, installation, and maintenance (Van der Vleuten, Stam and Van der Plas 2007). Van der Vleuten, Stam, and Van der Plas (2007) find that, while these projects are often successful at arranging funding, hardware and installation, most have difficulties when it comes to arranging durable and effective maintenance programmes, which has led to failures to achieve project goals in the long run. As previously stated, the beginning of the twenty-first century has seen growing involvement of private sector actors in the rural electrification field. These companies, of which SolarNow is an example, have a holistic approach to selling solar home systems which includes novel financial constructions and after-sales services such as maintenance (Kolk and van den Buuse 2012).

Since 2012 there has been growing interest in the development of mini-grids, through which multiple households in close proximity to each other are connected to a central source of electricity (Pedersen 2016). Mini-grids in Kenya are usually owned by private sector actors who operate as a utility company; people pay per kWh, just as they would when connected to main electricity grid. The main benefits of mini-grids are that they can reach distant communities more easily than the central electricity grid can, and that they can benefit from economies of scale, in contrast to household systems. While promising, mini-grids for rural electrification in Kenya are still few and far between. Most mini-grid projects in Kenya are being implemented as a way to increase the reliability of electricity provision in cities and large towns (Pedersen 2016).

3.2.4 When is electrification achieved – a contested issue

While literature on rural electrification studies the issues associated with lack of access to electricity, and while there are many papers that examine the different paths practitioners have taken to achieve wider access to electricity, there are few academics who seem concerned with defining what constitutes electrification. In other words, there is no consensus about which conditions have to be met in order to say that electrification has been achieved. In practice, access to electricity is not binary, and can mean very many different things. For example, there are many people who do not have household access to electricity, but who none the less have access to electricity services – such as phone charging – through acquaintances or local businesses (Krause and Nordström 2004). Also, there are many electrification projects and private sector actors who focus specifically on the provision of solar lanterns, which provide quality lighting and require only a small investment, making them interesting for users and aid projects alike, but which are also very limited in terms of the quantity of light and of the range of services they provide (Bond, Fuller and Aye 2012).

Solar home systems suffer from similar issues. As Azimoh, Klintenberg, Walling and Karlsson (2015) put it, solar systems lead households to become "*illuminated but not electrified"* (p. 354), because solar systems offer such a limited range of electricity services. On the other hand, rural electrification through grid expansion provides access to large amounts of electricity, but in practice electricity grids in developing countries suffer from frequent power outages and voltage drops, which means that access to the electricity grid may not always equal access to electricity (Zerriffi 2011). In general terms, electrification through grid expansion and electrification through off-grid technologies do not necessarily provide the same access to electricity in terms of quality or quantity (Zerriffi 2011). This consequently affects the way in which electricity is used to power appliances (Lee, Miguel and Wolfram 2016).

The evaluation of solar home systems as suitable alternatives to grid electricity in the long run often stands or falls with implicit assumptions about this issue. One of the main arguments against 'leapfrogging' – bypassing the installation of an electricity grid altogether by generating sufficient electricity though sustainable and decentralized alternatives – with solar home systems, is that solar home systems cannot accommodate levels of electricity consumption as seen in rich countries (Murphy 2001). This seems to imply that anything below a certain level of consumption does not really constitute 'access to electricity', or at least not the level of access we should ultimately strive for. This issue remains unresolved in

academia, though there are policy papers which have put forward practical suggestions to help evaluate whether electrification has been achieved. For example, the Energy Sector Management Assistance Program (ESMAP), part of the World Bank Group, has developed a framework for assessing household access to electricity by focussing on the types of services a household has access to as a result of their electricity consumption (ESMAP 2015). In chapter 5 we will see that user perspectives on the issue of whether or not access to electricity has been achieved, especially when it comes to electrification through solar home systems and solar lanterns, strongly influences the way electricity access is evaluated.

3.3 In summary

Energy poverty, or "*the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development*" (A. Reddy 2000, p. 44), is a problematic issue which strongly impacts the quality of life of the rural poor. One solution to energy poverty is to increase rural electrification rates. Electricity is a versatile, cheap, and safe energy carrier which offers a wide range of energy services. Access to electricity can resolve many of the issues associated with energy poverty, and opens up new avenues for household productivity.

Broadly speaking, there are two ways in which rural electrification can be pursued; through grid expansion and through off-grid electrification. Both these options have their own merits and drawbacks. Because of the precedent set by rich countries, the Kenyan government focuses mainly on grid expansion to increase rural electrification. Grid expansion requires large capital investments and is associated with high marginal costs. In return it provides access to a wide range of electricity services because, within household context, there are no technical limitations to the amount of appliances that can be connected to the electricity grid. Despite public investments in grid expansion in Kenya there is a market for off-grid electricity technologies. The prices of off-grid technologies have continuously decreased, making them economically competitive alternatives to grid-expansion in a wide range of scenarios. The main drawback of off-grid electrification technologies is that they provide a limited range of electricity services compared to grid electricity.

An important issue within the field of rural electrification studies is the lack of understanding about when electrification is achieved. This issue is something which affects the evaluation of rural electrification alternatives by rural households, as my analysis in chapter 5 will show.

4 Access to electricity in Kenya

This chapter provides the social-economic context for this research. I will give a brief overview of government- and market based rural electrification developments in Kenya. Furthermore, I will discuss the most common ways in which I found households can get access to electricity in western Kenya. The contextual information presented here is helpful to understand the analysis of household perspectives on investing in electricity provided in chapter 5 of this thesis.

4.1 Government-led rural electrification

In an effort to increase electrification rates in rural areas, the Kenyan Ministry of Energy established the rural electrification programme in 1973, under which the government planned to subsidize rural electricity generation and distribution. The implementation was to be done by the Kenya Power and Lighting Company (KPLC) (Lee, Brewer, et al. 2014). However, rural electrification never took off under the rural electrification programme, as is evidenced by the low electrification rates nearly four decades after its conception. In 2006, the Kenyan government released the KPLC from its role in the implementation of the rural electrification programme by transferring its responsibilities to the newly formed Rural Electrification Authority (REA) (Lee, Brewer, et al. 2014). The REA has been tasked with accelerating the pace of rural electrification, which is done mainly through the electrification of public facilities such as schools, health clinics and markets (REA 2016).

The grid connection of public facilities, 90% of which had been connected by the end of 2013, has led to a significant increase in grid coverage in rural Kenya (REA 2013). With the electricity grid reaching most rural communities in Kenya, the expectation was that household connections would follow without much extra incentive. However, an extensive study into the connectivity rates of ‘under-grid’ households shows that the electrification in households in close proximity to the electricity grid remains low (Lee, Brewer, et al. 2014). To increase what the Kenyan government calls ‘last mile connectivity’, the Ministry of Energy, together with the International Development Association and the African Development Fund, has subsidized grid connections for households within 600 meters of selected transformers, reducing the connection fee from roughly USD 350 to 150. In addition, new customers are offered the option of paying the connection fee in instalments over a period of up to 36 months (KPLC 2016). These policies to increase last mile connectivity have proven popular among rural households in western Kenya, as my analysis in chapter 5 will show.

4.2 Development of the solar home system market

While the last mile connectivity programme has the potential to be successful, previous government policies to increase electricity access were largely ineffective. This led to the development of a market for solar systems, to serve as an alternative to grid expansion. The initial uptake of solar systems as power sources in Kenya in the late 1980s was driven by large subsidized projects aimed at providing public institutions such as health centres and schools with reliable electricity, but the demand for residential solar systems surpassed the demand generated by public institutions by the early 1990s (Hansen, Pedersen and Nygaard 2015). Residential demand was driven largely by the falling prices and smaller available sizes of solar systems, as well as the spread of TV and radio signals to rural Kenya (Ondraczek 2013).

Despite the established solar home system market in Kenya, solar systems have long remained accessible only to middle- and higher income households. The poorest households have not been able to gain access to electricity mainly because they lack access to capital. The upfront costs of electricity access are prohibitively high for low-income households. This problem is exacerbated by the fact that these households are often not eligible for traditional forms of credit provision, which require a steady income or some form of collateral (Pode 2013). With the introduction of the business models such as the ones used by SolarNow in Uganda and M-KOPA in Kenya, solar home systems have become more accessible for low-income households. Because of the possibility of reaching the poorest people, which represent a previously untapped market segment, this business model is taking off on the Kenyan solar home system market (Lee, Miguel and Wolfram 2016).

4.3 Getting household access to electricity

With the efforts of the REA and the last mile connectivity project headed by the Kenyan Ministry of Energy, electrification through grid connection has become easier to achieve for rural households in Kenya. However, for many households getting connected to the electricity grid remains a difficult and costly process. The application process for electricity can be tedious and untransparent because, despite high awareness of the last mile connectivity project thanks to radio and TV advertisements, many people do not know whether they qualify for the reduced fee; the reduction only applies to connections with selected areas. There is also typically a long waiting period between application and connection, ranging from a few months to up to a year, depending on how congested the local KPLC office is.

Despite the problems households encounter when applying for a grid connection, grid connection remained the most sought-after electrification option among my interviewees.

The most common alternative to household electrification through grid connection is electrification using solar power. The smallest solar systems for household use are solar lanterns, which typically consist of one integrated unit containing a small solar panel, an LED light, and sometimes a USB port which can be used to charge mobile phones or small radios. On average solar lamps cost around USD 54 per lamp, and can be bought at local hardware stores, super markets, and petrol stations (Lee, Miguel and Wolfram 2016). Solar lamps are a direct replacement of paraffin lamps; the way in which the appliance is used does not change much, though a solar lamp offers the benefit of not having to spend time or money to purchase paraffin as well as providing high-quality light. Solar lamps are therefore easily integrated into traditional energy use patterns. During my fieldwork, I often found solar lanterns in homes which were connected to the electricity grid, where they served as back-up lighting in case of power outages.

A step up from solar lamps are solar home systems. The basic components of a solar home system are the solar panel, a battery, a charge controller, the wiring required to connect the system and the appliances. The price of a solar home system is difficult to estimate, because it depends on the size of the system, which can vary greatly. The average solar panel size of a solar home system in Kenya is 25W (Jacobson 2006), which costs around USD 300. This is enough to power three LED lightbulbs for five hours and charge two mobile phones each day. This means that the average solar home system in Kenya provides roughly three times the power of a solar lamp. Nonetheless, the average solar home system in Kenya is limited in terms of the amount of appliances it can accommodate. The advantage of solar home systems over solar lamps is that they are easier to expand. It is possible to expand a solar home system by adding a few components, such as an extra solar panel and perhaps an extra battery, in order to accommodate larger appliances such as televisions. Expensive components such as the charge controller do not need expansion in this case. In spite of the possibility of expanding a solar home system fairly easily, other technical limitations to the loading possibilities of solar home systems remain. First of all, solar home systems require the use of direct current (DC) appliances, as opposed to the alternating current (AC) appliances which connect to an electricity grid. It is possible to install an inverter, which converts direct current to alternating current, but inverters are very costly. Second, the limited wattage of the battery used to store electricity means that high wattage appliances such as kettles and flat irons

cannot easily be used with a solar home system. Correct sizing of the solar home system is necessary for trouble-free use of all appliances, and if the possibility of using high wattage appliances is requested, the system will have to be oversized significantly.

Components of solar home systems are sold in most hardware shops, supermarkets and even in market stalls and on street corners. I observed that the people selling solar home system components had varying degrees of knowledge about how a solar home system works, and of how it should be sized. In the larger hardware stores people were generally knowledgeable, and also able to recommend a local electrician to help with the installation. In supermarkets and market stalls people were less knowledgeable, and could provide little service other than the outright sale of hardware.

As stated earlier, solar home systems are also sold by dedicated companies, such as SolarNow, which do not sell individual system components, but instead sell entire systems. In response to the difficulties experienced by households when applying for a grid connection, these businesses attempt to relieve their clients of all unnecessary burdens, including high upfront costs, during the sales process.

Besides these one-stop-shop solar system providers, there are other institutions through which rural households can get access to credit for electricity. Local financial institutions such as the Kenya Women's Finance Trust (KWFT) and most Savings and Credit Cooperative Organizations (SACCOs) offer solar loans, specifically for the purchase of solar home systems (KWFT 2016) (Rollfs, Byrne and Ockwell 2014). KWFT has partnered with a provider of solar home systems to make the process of purchasing a solar home system easier. This partnership mimics one-stop-shop companies, though after-sales services are less well-organized. KWFT and SACCOs also offer loans for grid connections (KWFT 2016) (Rollfs, Byrne and Ockwell 2014).

4.4 In summary

To increase household electrification rates, the Kenyan government focuses mainly on grid expansion projects, with an emphasis on promoting 'last mile connectivity'. The last mile connectivity project has proven popular among my respondents, but in the past government policies to increase electricity access were largely ineffective. This led to the development of a solar photovoltaic market, to serve as an alternative to grid expansion. However, despite the existence of a competitive market for solar home systems, prices long remained prohibitively high for many of the poorest households. In reaction to this issue, new businesses have

emerged which sell solar home systems on credit in hopes of improving the affordability of solar home systems.

Because of government-led efforts to increase grid coverage and the existence of a competitive solar home system market, the most common ways in which households can get access to electricity in Kenya are by connecting to the electricity grid, or by purchasing a solar home system. Despite the efforts of companies such as SolarNow to make purchasing solar home systems as attractive and easy as possible, grid connection remained the most popular electrification option among my respondents. In my analysis in the next chapter I will discuss why this is the case.

5 Perspectives on user investments in electricity

This chapter examines how user perspectives on investing in electricity, which I gathered during my field work, compare to the insights of existing scientific literature and rural electrification practitioners. Through my analysis of literature and data about the perspectives of rural electrification practitioners, I have found that practitioners in the field of rural electrification seem to operate under two powerful assumptions pertaining to the ability and willingness of users to invest in household access to electricity. The first assumption is that access to household electricity will lead to significant benefits which will transform daily life in rural areas of poor countries. The second assumption, which follows in part from the first assumption, is that the main deterrent of households investing in electricity access is affordability. These assumptions are not necessarily wrong, but the interviews I conducted with representatives of rural households showed me that there is a difference in the way major issues, such as affordability of electricity and the benefits experienced from access to electricity, and more specifically access to solar electricity, are understood by users and practitioners. Throughout this chapter I will provide evidence to support this argument. I will do this by analysing user perspectives on affordability, on the desirability of solar home systems, and on the transformational power of electricity.

5.1 Affordability

Literature about affordability in the context of rural electrification is user-centric, and attempts to determine which factors make electricity more or less affordable for rural households (Schillebeeckx, et al. 2012). Much of this literature focuses on one of three topics. The first is the role of lacking access to financial infrastructures and credit on the dissemination of rural electrification (Glemarec 2012) (Pode 2013) (Rollfs, Byrne and Ockwell 2014). The second topic is the ability or willingness of rural households to pay for electricity. This is often done by performing cost-benefit analyses of electricity compared to traditional forms of energy, supplemented with survey data about users' own indications of how much they would be willing to pay for different types of electrification (Abdullah and Jeanty 2011) (Abdullah and Markandya 2012). In these analyses, electricity usually works out favourably because it can deliver many different energy services (lighting, mobile phone, TV, flat iron, etc.). If these services are purchased individually through traditional energy sources, the costs are often higher than those of electricity (B. Reddy 2015). Finally, the third topic is the financial viability of alternatives to grid electrification, and specifically under which

conditions off-grid electrification is the more financially interesting electrification option for rural households (Deichmann, et al. 2011).

5.1.1 SolarNow's ideas about affordability and financing

Within my case, the focus areas of affordability literature are reflected primarily in the information I gathered at SolarNow offices. The emphasis on affordability is reflected in the SolarNow mission statement; to "*transform the lives of East Africans*" by making "*quality solar accessible through affordable finance*" (SolarNow 2016a). SolarNow plays into the concern that rural households lack access to financial infrastructures by providing the option of buying solar home systems on credit, even to people without traceable financial history. Creditworthiness is assessed by conferring with the social network of a customer, as well as by assessing capital in the form of land and livestock. Guarantees are built into the credit system by using the solar home system itself as collateral (Interview Ronald Schuurhuizen, 2016). This general business model is advertised as an effective way of reducing the impact of lacking access to financial services on rural electrification (Pode 2013). Additionally, in order to make their products both affordable for low-income households, as well as interesting to higher-income households, SolarNow offers a wide array of different system sizes (SolarNow 2016c). Providing solutions to fit the aspirations and financial situation of a household is meant to increase willingness and ability to pay for electricity (Lee, Miguel and Wolfram 2016). Another way in which SolarNow tries to stimulate the willingness of households to pay for their products is by providing after-sales services such as maintenance and warranties, as well as offering a wide array of appliances, from televisions and radios to refrigerators and flat irons, which can be purchased along with a solar home system (SolarNow 2016c). Finally, solar home systems are only financially competitive with grid electricity in areas where the electricity grid is unavailable (Deichmann, et al. 2011). Therefore SolarNow targets rural customers, with a focus on households who are in under- or unserved areas (Interview Ronald Schuurhuizen, 2016). They way in which SolarNow conducts its business shows that they have taken the main concerns about the affordability of electricity as voiced in scientific literature to heart.

5.1.2 User perspectives on affordability and financing

Within the information I gathered through my interviews with, and observations of, households in rural Kenya, I found three notable perspectives on affordability. These perspectives relate to the high upfront costs of electrification, to costs of use of different electricity systems, and to the role of access to credit, and differ significantly from the

perspectives held by scholars and practitioners of rural electrification. Below, I will elaborate on this statement.

5.1.2.1 Investment costs and costs of use

The majority of the people I spoke to have a lot of insight into their current household energy expenses. There were far less people who were confident about the connection costs of electricity and subsequent monthly fees, or of the cost of a solar home system. Despite their doubts about the height of the upfront costs of electrification, most people did think the costs would be prohibitively high. The following quote, form a lady who had a small solar home system which powered three LED lamps and the household phones, said the following about the costs of connecting her house to the electricity grid:

"I don't know how much it will take [to connect to the electricity grid]. *But it's so expensive. And then you don't have any of the cables yet, and you need to pay every month for the bill I guess. So, I would prefer it* [grid electricity]*, but it's much more expensive than the solar."* (CHW1)

Aside from mentioning the high the upfront costs of a grid connection, the respondent alludes to the fact that the upfront costs of getting access to grid electricity do not only consist of the connection fees owed to the utility company. Households need to purchase wiring, switches, sockets, and lamps, as well as hire a technician to install their wiring safely and efficiently so they can enjoy their electricity. Based on information gathered through my interviews, these additional costs can double the upfront costs required to get a grid connection.

Another issue indicated in the previous quote is the fact that this respondent had little insight into the monthly costs of using grid electricity. This is interesting to note in the light of the line of reasoning in literature about willingness to pay for electricity, where the relatively low cost of electricity compared to traditional energy sources plays an important role (Abdullah and Jeanty 2011). This type of literature is very favourable towards electricity, in part because the upfront costs of electrification are offset by a reduction in monthly energy expenditures (B. Reddy 2015). I found that the unelectrified households targeted by electrification initiatives are not necessarily aware of this benefit. Sovacool et al. (2011) suggest that this could also be due to a level of financial illiteracy, which causes people to have little insight in the value of saving money in the future, and to think primarily about the present.

Though there were many respondents who, like the previous respondent, had little idea about the costs of using grid electricity, there were also several, typically from households with access to electricity, who experienced that the costs of using electricity were lower than the amount they usually spent on traditional fuel sources. One respondent with electricity said he felt as if his energy expenses had reduced. However, he did not actually know how much he was spending on electricity, because he had agreed to pay his landlord a fixed monthly rate for rent and electricity. He stated the following:

"I do not feel that burden of the cost of expenditure on fuel, that is paraffin, that I used for light. Because now it is part of my rent. So I reduced the use of paraffin, now I use it just for the sake of cooking. So I feel that the burden has been reduced." (KAN2)

This respondent could not directly compare the cost of electricity to the cost of paraffin, but he indicated that he prefers paying for electricity at the end of the month instead of paying for paraffin daily. The following respondent, who was a home owner and therefore received his own electricity bills, made a clearer comparison between his energy expenses before and after getting access to electricity. He explained how he was better off with electricity, on which he spent around 500 Kenyan shillings per month, and which allowed him not only to use lights, but also to watch TV and to charge his telephone:

"It's a good investment. Because during those days, (…), sometimes you could spend around thirty shillings per day buying paraffin. This adds up to 800 [shillings] *a month, and using only light! We can now use less money, having used light and also electronics."* (KIP2)

Based on information gathered about the costs of traditional energy sources, it is likely that most of the respondents would benefit financially from investing in electricity, assuming that their electricity supply would be reliable. However, due to frequent power outages and voltage drops, I found that most households had not entirely stopped depending on traditional energy sources such as candles and paraffin. Literature also shows that electrified households in Kenya often still spend non-trivial amounts of money on traditional energy sources (Lee, Miguel and Wolfram 2016). This implies that in practice energy expenses could rise instead of fall due to access to unreliable electricity.

Another factor which influences perceptions about the cost of use of electricity is the fact that people have little control over the amount of money they spend each month. This is because, in contrast to traditional energy sources such as paraffin and candles, payment for used

electricity is typically made after consumption, and there is no way to monitor and ration the amount of electricity consumed prior to receiving the utilities bill. The same respondent who was generally happy about the relative cost of electricity compared to traditional energy sources indicated that he had at times been unpleasantly surprised by the electricity bill at the end of the month, which according to him had varied significantly irrespective of the household electricity consumption. He stated the following:

"Sometimes it's higher, sometimes it's low, (...) there is a time we could pay even up to 3000 [shillings]. *I don't know what had happened at that particular time. Many people had complaints about power supply in their homes."* (KIP2)

As mentioned earlier, he was used to paying around 500 Kenyan shillings per month for electricity. With a household income of around 6000 Kenyan shillings per month it was difficult for him to come up with the money to pay for a bill six times as high as expected. There were also respondents who expressed that the cost of use of grid electricity was just generally higher than they had expected, and that as a consequence they were unable to use electricity in the way they had initially wanted. The following quote illustrates this:

"I expected that electricity would have helped me in ironing, and maybe cooking with it. But the bills that came were too high, so I could not do that. And I cannot get rid of it, because I have other people who are renting rooms in my house, and they depend on electricity." (KAN1)

As of 2009, the Kenya Power and Lighting Company (KPLC) offers an alternative payment option for its users, which allows them to 'pay as they go', which means the consumer has to prepay an amount of electricity before being able to use it (Achuka 2015). While this has the potential to solve the problem of bills being problematically high at the end of the month by making electricity consumption more perceptible, and therefore manageable, to the users, few of my respondents had such a prepaid system in their home. This could be because the KPLC slowed down the distribution of prepaid power meters due to a fall in revenue from their prepaid customers (Achuka 2015). An alternative solution, suggested by Peters, Harsdorff, and Ziegler (2009), is for rural electrification projects to include education programmes about household bookkeeping and about the potential for savings provided by electricity, in order to alleviate the issues experienced as a result of electricity bills.

While several respondents indicated that they would be interested in a solar home system instead of grid electricity to avoid monthly bills, the issue of unexpectedly high costs of use is not unique to grid electricity customers. One of my respondents had purchased a solar home system five years earlier at a local hardware store. While initially she was happy with its performance, at the time of the interview she had become somewhat disillusioned by the system because it hadn't reduced her energy expenses to the extent she had hoped. She said the following about this:

"It hasn't changed because sometimes I have to pay to charge those things [the battery]. *When there is no sunlight I have to go to the market where there is electricity to charge it. So I'm paying for it."* (CHW1)

If a solar home system is correctly sized, installed and used, the battery should store enough energy even when it is overcast (Bond, Fuller and Aye 2012). It is likely that her system was not working properly because her battery was overloaded or old, and in need of replacement. The fact that some solar home system components, primarily the batteries, require maintenance and replacement during the lifetime of the solar home system is something my respondent had not been made aware of at the time of purchase. In addition, her solar home system was not large enough to provide points of light in all rooms of her house. As with grid electricity, the continued consumption of traditional energy as a consequence of inadequate electricity systems is an acknowledged fact (Lee, Miguel and Wolfram 2016).

To users, affordability has as much to do with upfront costs as it have to with the costs of use of grid electricity or solar home systems. Unelectrified households have little knowledge about the costs of use of electricity, and consequently about the savings potential of electricity, and electrified households experience the costs of use as problematic because they are difficult to anticipate. The upfront costs required to get access to electricity were generally thought to be high. This is an issue which, according to rural electrification literature, can be solved by improving access to financial services.

5.1.2.2 Access to financial services and credit

On the question of the impact of lacking access to financial services on access to electricity, the people I spoke to held strongly divergent views. While some respondents did agree that access to credit would enable them to invest in electricity, there were also several respondents who indicated that they did not like the idea of taking out a loan to purchase expensive items

such as solar home systems. The following quote, made by a young farmer, illustrated the doubts people have about credit-based purchases:

"Whether I want to buy something on credit will depend on the terms. Because sometimes some terms are harsh, and maybe the sources of income from the farm will fail. So if I have a stable source [of income]*, where I'll be getting money steadily, it's better to buy solar on credit. Because it's easier to pay and you will not feel that burden of buying a solar. That would be okay."* (KAN2)

Hesitations about taking out a loan in order to get access to electricity, be it through a grid connection or by purchasing a solar home system, are informed by the unreliability of the income generated through farming, which make it difficult to comply with stringent repayment terms. This observation is supported by some literature (Gómez Garcia and Montero Bartolomé 2010), though it is not in correspondence with the general sentiment, which is overwhelmingly positive about the positive effects of access to credit on the process of rural electrification (Abdullah and Jeanty 2011) (Glemarec 2012) (Pode 2013) (Rollfs, Byrne and Ockwell 2014). What is interesting to note is that Savings and Credit Cooperatives (SACCOs) are ubiquitous in Kenya (Mathuva and Kiweu 2016). SACCOs provide a structure through which people can borrow money from others within their own community, and with over 5 million members in Kenya there seems to be a significant demand for the financial services offered by SACCOs (Mathuva and Kiweu 2016). This indicates that not all people are hesitant to take out a loan, but also that access to financial services may not be as difficult in Kenya as it is in other poor countries. The effect of improving access to finance may therefore not have the expected impact on the ability of rural households to invest in electricity.

5.1.2.3 Local tactics to increase affordability

Within the context of the high upfront costs of grid connection and solar home systems, the poor access to financial services, and mixed feelings about taking out loans, people have come up with their own ways of increasing the affordability of electricity. I observed two distinct ways in which people reduced the financial burden of investing in access to electricity, and there are likely many variations on these strategies. The first strategy I observed was through the installation of unofficial grid connections, which sometimes happened with the knowledge and consent of the formal owner of the grid connection, but sometimes also without the owner of the connection knowing. In the cases where the

household with the official grid connection was aware of the unofficial connection, the monthly costs of use were divided among all the users of the connection, and sometimes even the upfront costs of connection were shared. I came across one case where people were using the grid connection of their neighbour without his knowledge, which meant that the owner of the connection was billed for electricity used by people who are tapping the connection. According to literature, the sharing of grid connections is a common issue in developing countries, and it causes difficulties for the provider of grid electricity because it leads to non-technical energy losses of which the costs are difficult to recover (Tewari and Shah 2003).

The second way I observed in which people reduced the burden of the high upfront costs of electrification was through modular cash purchases. People built their household system over time, by purchasing the necessary components in succession, often starting with a battery, wiring, and some basic appliances, then larger and more costly appliances, and finally a solar panel to charge the battery or a grid connection to replace the battery altogether (Krause and Nordström 2004). As long as such a system operates solely on battery power the battery needs to be taken to a commercial charging station at the local market, where it is charged for a fee. SolarNow supports modular purchasing as an additional way to make solar home systems interesting alternatives to grid electricity. SolarNow customers can start by purchasing a small solar home system to start, and can later add more solar panels and batteries to their existing system, in order to accommodate more appliances. People also used modular cash purchases to connect to the electricity grid. I visited one household where the connection to the electricity grid was paid for after a harvest, and the necessary electrical work to make use of that electricity was not purchased until a year later, after the next harvest. Modular purchasing an electricity system allows people to invest at times when they can afford to.

Two of the households I visited had an interesting approach to modular cash purchases. They owned appliances such as television sets and food processors without having any form of electricity supply in their home. Lee, Miguel, and Wolfram (2016) observed similar situations in their research. It appears as though people so aspire to watch television that when the possibility presents itself to get a good deal on a television set, they buy it before having the means to power it, in anticipation of the right moment to invest in electricity. A result of this is that people are confining themselves to a specific system when it comes to their anticipated electrification, because appliances work on either alternating current or direct current, but not both. So the type of current required by their appliances to some extent will dictate the possibilities they have for electrification in the future.

What is interesting to note is the fact that practitioners and rural households have both developed strategies to reduce the burden of the high upfront costs of gaining access to electricity, but neither have developed conclusive strategies to mitigate the burden of the costs of use of grid electricity of solar home systems. Other than the discontinued pay-as-you-go project initiated by the Kenya Power and Lighting Company, I have not come across rural electrification projects which specifically attempt to solve this problem.

5.1.3 Closing thoughts on affordability

Based on my analysis of academic literature, data about the perspectives of rural electrification practitioners, and interviews with representatives from rural households in Kenya I have developed four notions relating to the affordability of rural electrification. First, both grid electricity and solar home systems require a, to some users problematically, high upfront investment, and both systems cost money when in use. The upfront cost is a deterrent to rural electrification in general, which suppliers are trying to mitigate by providing access to affordable credit, a policy which is supported by academic literature. However, based on the analysis in this chapter, I suspect that improving access to financial services is not a solution for everyone. This is due to the hesitation some people expressed about taking out loans based on their unsteady income.

Second, several respondents indicated that the cost of use of grid electricity is problematic for them for two reasons; the fact that grid electricity is not reliable enough to significantly cut expenditures on traditional energy sources, and the fact that they have little control over the amount of money they end up spending on electricity. Solar home systems share these issues with grid electricity. Because of the necessity of maintenance, the limited size of most solar home systems, and the continuing dependence on traditional energy sources, the cost of use of solar home systems was higher than users had anticipated.

Third, people have developed creative and low-threshold tactics to increase the affordability of electricity. I found households with unofficial connections to the electricity grid, which allowed them to bypass the high upfront investment required for a grid connection. I also came across households who engaged in modular cash purchases, and in this manner assembled their household electricity systems over time. Both of these tactics target the problem of high upfront costs, and potentially decrease the necessity for financial services to help invest in electricity, but do little to mitigate the issues people experience with the costs of use of electricity.

Finally, and crucially, the views about affordability expressed in academic literature were mostly reflected in the information I gathered at SolarNow offices, and often did not correspond to the views held by the representatives of rural households I spoke to. This indicates that, while affordability literature does focus on how to make electricity more accessible for rural users, the prominent perspective taken in literature is the perspective of providers of rural electrification. This ties in to the issue mentioned in the introduction of this report that little research has tried to understand the wishes, issues, and motivations of non-western technology users (Gómez Garcia and Montero Bartolomé 2010).

5.2 User preferences: grid electricity versus solar home systems

What surprised me somewhat was the extent to which people seemed trust the Kenya Power and Lighting Company (KPLC) to deliver on the promises they made about future grid expansion and a reduction of connection fees (KPLC 2016). Abdullah and Jeanty (2011) found that people were generally distrusting of the KPLC as a result of slow service, corruption, and incorrect billing. In my interviews I did hear about the long processing time for new applications, about unexpectedly high monthly bills which seemed unrelated to actual consumption, and about the unreliability of the electricity supply. However, no one ever expressed explicit mistrust. On the contrary, the people who had not yet gotten access to electricity in their homes were waiting for the moment in which the KPLC would announce a reduction in the connection fees in their local area.

In the case of solar home systems, it was the other way around. Abdullah and Jeanty (2011) suggest that the fact that solar systems are provided by private companies, instils a level of trust among consumers. However, in my experience, people expressed generally unfavourable attitudes towards solar home systems when asked to choose between them and grid electricity. One respondent, who had purchased a solar home system five years earlier, gave me the following response to the question of whether she had plans to apply for a grid connection:

"It can be better. And electricity, it is the easy way." (CHW5)

This particular respondent had a somewhat negative experience with her solar home system, but many people who had no access to electricity at home had similar responses when asked whether they would prefer grid electricity or solar electricity: *"Stima[2] is a lot better"* (ANN2). There was even one respondent who confidently told me the following:

[2] Stima: Kiswahili for grid electricity

"Solar is okay, but I would prefer stima, because solar cannot power televisions and if you charge your phone on solar, the battery will break". (AHE5)

It is possible that the strong misconceptions people have about the nature of solar electricity are a consequence of the persistent problems the Kenyan solar home system market has had with the quality of the products sold (Jacobson and Kammen 2007). While there are many good quality systems on the market, there are also products that perform far worse than promised. This has put a heavy burden of proof on providers of quality solar home systems, who have to overcome negative sentiments about the solar market in order to attract customers. The idea that solar home systems do not provide electricity of the same quality also links back to the idea of energy services described by Reddy (2000), which I discussed in chapter 3. The average solar home system cannot accommodate the same amount of electrical appliances that grid electricity can, and therefore provides fewer electricity services. This influences the perceptions of users about the overall quality of solar home systems, and their willingness to invest in them.

5.3 Transforming peoples' lives

I have found that there is a strong transformational narrative in academic and policy writing about rural electrification, as well as in the stories told by rural electrification practitioners. This narrative is noticeable in the well-accepted correlation between access to modern energy carriers such as electricity, and development, which is an integral part of international development programmes. The United Nations Development Programme (UNDP), for example, has given access to modern energy a prominent place in their latest set of Sustainable Development Goals (UNDP 2016). In academia, there are some papers which examine the proposed correlation between electrification and development (Cook 2011), but more often academic papers assume such a correlation exists, and examine how the transformational potential of electricity can be maximized (for example, (Bond, Fuller and Aye 2012), (Baldwin, et al. 2015)). Companies such as SolarNow advertise electricity as being a life-changing technology through their marketing materials. Part of the SolarNow mission is to "*transform the lives of East Africans*" through the provision of electricity (SolarNow 2016a). For the national governments, non-governmental organizations, and social enterprises driving rural electrification, the 'transforming lives' narrative is an important way of creating moral and financial support for their cause. Crucially to this narrative, rural electrification is said to bring benefits such as increased household productivity and opportunities for income generation, higher light quality for studying, less indoor air pollution

and fire hazards, and more options for entertainment and long-distance communication (Bond, Fuller and Aye 2012).

5.3.1 User perspectives on the transformation afforded by electrification

The idea that electricity will bring transformation is not exclusive to scholars, policy makers, and electricity suppliers. People from unelectrified households often used similar expressions when speaking about the effect electricity might have on their daily life, although they are less specific about the benefits they think electricity will afford. The following quote illustrates this sentiment:

ME: *"What would it mean to you, to have electricity?"*

SHE: *"In fact, it would change my life."*

ME: *"It would change your life? How would it change?"*

SHE: *"I cannot express* […] *I think I would use it for light for reading, and for watching TV"* (CHW3)

Most people in unelectrified households mentioned lights and televisions as reasons to want access to electricity, a few mentioned plans to increase the household income, and none mentioned potential savings or other financial benefits. In general, people without household access to electricity remained vague when describing how they thought electricity would transform their lives. What is interesting is that the idea of electricity changing their lives in the future was also expressed by the few people I came across who owned a solar home system. They were to an extent disappointed by the changes their solar systems had brought, and were looking forward to getting a connection to the electricity grid in the future. This is what was expressed by the following respondent:

"*My life has changed, but not in the way I wanted. I thought that the solar systems would assist me in many things but […] it is not supporting me well. I need electricity because I have a* [furniture] *workshop outside, there. And I need electricity for tools that I can use for grooving joints of legs and some other things."* (CHW5)

This sentiment can be linked back to concept of energy services (A. Reddy 2000) and the question of what really constitutes electrification, which I discussed in chapter 3. In the context of her local community, this lady had more access to electricity than most. And while she may have been happy with her solar home system at first, in the long run she did not experience the expected benefits of access to electricity because the electricity services

provided by her solar home system did not correspond to her aspirations. The development of greater electricity aspirations among solar home system owners is also described by Lee, Miguel, and Wolfram (2016), and could indicate that solar home systems do not provide sufficient electricity services to make people feel as though their household is electrified. It could also indicate that it is important to be somewhat reserved in speaking of transforming lives when advertising solar home systems in particular, and access to electricity in general (Gómez Garcia and Montero Bartolomé 2010). While an optimistic message is necessary to convince donors and users alike to invest in access to electricity, expectations for the benefits of electricity can become so high that disappointment is a probable outcome (Peters and Sievert 2015).

In contrast to the transformational sentiments expressed by unelectrified households and household with a solar home system, among the people I spoke to who had a grid electricity connection, the idea that electricity had transformed their daily lives was less pronounced. When asking respondents with household access to grid electricity what the main way was in which having electricity had changed their life, many of the answers boiled down to one broad topic: convenience. This is illustrated by the following quote:

"Before, you could not find living without electricity rough. When we got electricity, and started using it, then we found it easier" (KES2)

As this respondent explained, having electricity made life easier; many things required less time and effort compared to the situation she was in before. The fact that many respondents spoke of a sense of convenience when talking about the impact of electricity could mean that not many people saw electricity as a necessity; it made life easier, but not to such an extent that they could not go about their business without it. It is possible that the high unreliability of the electricity grid inhibits the integration of electricity into daily life. Because people cannot rely on the electricity, they do not establish essential practices or routines which depend on it. The following exchange gives a sense of this:

SHE: *"When you are used to the electricity now, when it goes off, then, there is a problem. You feel now there is darkness, even if you use the lamp or if you use the D-Lights, it is still dark."* (KES1)

ME: *"So, have you considered getting some form of back-up system?"*

SHE: *"No, because you don't have so much to do with it* [electricity]. *If it is not there, only the light and this one* [the TV] *go."* (KES1)

Aside from the unreliability, the lack of urgency people felt about power outages could be a result of the way electricity is most commonly used: for lighting, watching TV and charging mobile phones (Lee, Miguel and Wolfram 2016). These applications are either fairly easily backed-up with other energy sources, or non-essential to the household, meaning households do not develop a dependency on electricity. According to Bond, Fuller, and Aye (2012) small solar systems, which have just enough capacity for lighting and mobile phone charging, provide roughly as much developmental impact as much larger systems. The notion that the infinitesimal amount of electricity required for lighting provides as much developmental benefits as larger, more capable solar home systems does not correspond with the dependency on electricity seen in rich countries. It is possible that a lack of ideas or knowledge about how to use electricity in the household reduces it from the powerful tool it could be to something more akin to a luxury good. To maximize the development potential of electricity, electrification needs to be accompanied by complementary services such as knowledge transfer (Peters, Harsdorff and Ziegler 2009). For one, knowledge transfer about the possible uses of electricity could get people to see electricity as a productive tool, which they can use to supplement household income, the significance of which I will discuss further on in this chapter.

5.3.2 User perspectives on the benefits of electrification

Based on the information I gathered through my interviews with, and observations of, households in rural Kenya, I have found that the benefits perceived by users of electricity do not entirely correspond to the benefits of rural electrification advanced by scholars and practitioners of rural electrification. The main benefits experienced by users were the use of electric lighting and television, while the use of electricity as a tool for productivity was rarely mentioned. Below, I will elaborate on the benefits of electricity experienced by rural households.

5.3.2.1 The benefits of electric lighting

The fact that electrified households did not report a large change in their day-to-day lives does not mean that people did not experience any benefits from their access to whichever kind of electricity, or that they were unhappy about the investment they had made. I found that, among people with solar lanterns, solar home systems, or grid electricity, the most mentioned

benefit of access to electricity is having electric lighting. This is concurrent with previous research, which shows that people appreciate even the smallest improvements in their indoor lighting (Baldwin, et al. 2015). Many papers on rural electrification mention how electric lights extend the productive time a household has. Electricity allows adults to work and kids to study after dark (Schillebeeckx, et al. 2012). This was also mentioned by several of my respondents, including the following girl:

"Through electricity, we have succeeded in education, because we are not buying paraffin every day. It helps me to read, for school. The light from the, from the electricity, it is better for reading than with candles, because it's clear." (ANN6)

There were also a few adults, teachers and municipal clerks, who mentioned they used their bright electric light in the evening for administrative tasks.

5.3.2.2 The entertainment value of electricity

According to literature, the allocation of electricity is influenced heavily by household power dynamics. This often means that the available electricity is allocated to the activities grownups prefer, such as watching television, instead of studying (Jacobson 2006). This is reflected in how often watching television was mentioned as one of the main benefits of having access to electricity. Most of the time, when people watched television they watched soap operas, as well as the news to keep up to date on developments in the rest of the country. In my experience, soap operas from the Philippines dubbed in English were the most popular television shows, and sitting down to watch a soap opera provided a way to spend time together with family and friends. People often spoke of watching television as a social activity.

"I like watching TV. I go to my neighbour's house to watch. But I can't tell you my favourite programme, I've forgotten!" (CHW3)

Television can serve as an important medium for entertainment and for information. As a medium for entertainment, television imbues electricity with emotional value (Hirmer and Cruickshank 2014). As a medium for information, television can increase the sense of being part of a bigger world (Matinga and Annegarn 2013).

5.3.2.3 The influence of electricity on household productivity

In addition to lengthening days by providing the light by which people study, work, and socialize, having access to electricity can save a lot of time during the day. Many respondents

indicated that having electricity in their homes has changed their day-to-day activities with respect to gathering fuel. Mainly, they no longer need to travel into town every (other) day to buy paraffin or to have their phone charged. This saves them a lot of time, especially considering the following:

"To charge phones, you must move from here to, like, three kilometres to go to charge the phones." (ANN4)

This respondent's only form of transportation was walking, which means that he was spending at least an hour and a half every other day just to charge his mobile phone. Something to consider when discussing the time saved or gained by the use of electricity in rural households in developing countries, is the assumption that this time will be spent productively. This assumption is rooted in western ideas about how people trade-off labour and economic profit, and may not be true for other contexts (Gómez Garcia and Montero Bartolomé 2010). This means that, instead of maximizing the increase in potential productivity as a result of electrification, rural households may use the electricity, and the time it frees up, for entertainment (Gómez Garcia and Montero Bartolomé 2010) (Jacobson 2006).

The increase of household productivity as a result of electrification is a debated topic in rural electrification literature. By many scholars and rural electrification practitioners it is mentioned as an important reason to invest in rural electrification, and a prerequisite for poverty alleviation through electrification (Bensch, Peters and Schmidt 2012). However, there are also scholars who state that access to electricity only plays a minor role in the generation of income of a household, since electric light is at best used for grading papers or evening-time accounting (Jacobson 2006). None of the respondents in this study depended entirely on electricity for their livelihoods, and instead supplemented their previous activities in the manner described by Jacobson (2006). While there were a few respondents who had ambitions to use electricity productively on a larger scale, these respondents were greatly outnumbered by the respondents who had no plans to actively increase their productivity.

The fact that my respondents only sparsely used electricity for income-generating activities does not correspond to the emphasis on productivity increases I saw in academic literature. Many of the people I spoke to who lived in grid electrified households did not regret getting their connection, because they enjoyed the entertainment and convenience provided.

However, few of them regarded the money they spent as an investment which in time would benefit the household financially. One respondent stated the following:

"*Many of my neighbours use their electricity for lighting their homes and watching TV. This does not make sense, since it only costs money.*" (AWA2)

For him, one of the main reasons he had not yet applied for an electricity connection with the KPLC was the idea that electricity cost more money than it yields. As I have stated before, Peters, Harsdorff, and Ziegler (2009) emphasize the fact that electrification practitioners could improve this situation by providing education about the potential to save or even earn money by investing in electricity.

5.3.3 Closing thoughts on the transformational potential of electricity

Based on my analysis of academic literature, data about the perspective of rural electrification practitioners, and interviews with representatives from rural households in western Kenya I have developed the following insights about the transformational potential of rural electrification, and the benefits derived from household access to electricity.

In contrast to what the transformational narrative of scholars and practitioners of rural electrification suggests, I found that the people I spoke to did not experience a transformation of their daily lives as a result of access to electricity. The people with access to electricity, especially the households with solar home systems, were disappointed with electricity in this sense.

This is not to say that they did not experience benefits of having access to electricity, or that they did not enjoy these benefits. On the contrary, users themselves described electricity as a convenient, useful, and fun addition to their daily lives. What people most enjoyed about having household access to electricity was having bright, electric lights and television. However, the lack of productive uses, the unreliability of the electricity grid, and the limitations of solar home systems meant there was little development of essential practices or routines around the use of electricity. The lack of productive use of electricity might be the reason that few people think of electricity as an investment with the potential for financial returns. This idea about electricity reduces the willingness of people to invest in household electricity access.

6 Conclusion and implications

In this final chapter of my thesis I will answer my research question: *Which perspectives do people living in rural households in western Kenya have on investing in access to electricity, and how do these perspectives compare to the prominent perspectives held by scholars and practitioners in the field of rural electrification?* After answering this question, I will discuss which implications this answer has for rural electrification research and practice.

6.1 Conclusion

Through my analysis of literature and data about the perspectives of rural electrification practitioners, I have found that practitioners in the field of rural electrification seem to operate under two powerful assumptions pertaining to the ability and willingness of users to invest in household access to electricity. The first assumption is that access to household electricity has the power to *transform* daily life in rural areas of poor countries. The second assumption, which follows in part from the first assumption, is that the main deterrent of households investing in electricity access is *affordability*. Consequently, the prevalent idea about improving access to electricity revolves around the idea that when all issues with affordability are addressed, rural electrification will follow. However, I have found that the perspectives about affordability of practitioners and users do not always align, and the highly stylized transformational narrative about household access to electricity provides an inaccurate representation of the outcomes of electrification.

In general terms, user perspectives on investing in access to electricity align with the perspectives of scholars and practitioners of rural electrification; users are also concerned with affordability and the benefits provided by electricity. However, there are significant differences between the way these subjects are perceived by scholars, practitioners, and users. Scholars and practitioners of rural electrification focus on reducing the burden of prohibitively high *upfront costs*, and this is indeed an issue which is also mentioned by representatives of rural households. Interestingly, while scholar and practitioners of rural electrification recommend addressing high upfront costs by improving access to financial services, users have developed their own tactics to reduce the burden of high upfront costs. I observed clusters of households which shared grid connections, and households which built their electricity system over time through modular cash purchases. Furthermore, I found that users held diverging views on purchasing expensive items such as solar home systems on credit, mainly due to the uncertain nature of their incomes. For these reasons, providing

access to financial services may not increase rural electrification rates, and specifically the uptake of solar home systems, as much as expected.

In addition to the issue of upfront costs, I found that users mentioned having problems with the *costs of use* of electricity. In the case of grid electricity, respondents had issues with the fact that they were unable to control their energy expenditures because of the way electricity is billed. With solar home systems, I found that users were unaware of the fact that system components often require maintenance or replacement during the lifetime of a solar home system, which led to unexpected costs. Also, both households with access to grid electricity and households with solar home systems were unable to completely cut their spending on traditional fuels because of grid unreliability or solar home system limitations. In contrast, rural electrification literature emphasizes the fact that electricity provides a much higher level of service than traditional energy sources, making it the more economical alternative. This benefit was often not perceived by the respondents in this study.

Furthermore, I found that users thought solar home systems provided electricity of lesser quality than the electricity grid. This links back to the concept of energy services. The average solar home system cannot accommodate the same amount of electrical appliances as grid electricity, and therefore provides fewer electricity services. The unhappiness users expressed about this fact could indicate that solar home systems do not provide sufficient electricity services to make people feel as though their household has been electrified. This influences user perceptions about the overall desirability of solar home systems, and as a consequence their willingness to invest in them.

Finally, in terms of benefits I found that users described electricity as a convenient, useful, and fun addition to their daily lives. What people most enjoyed about having household access to electricity was having bright, electric lights and television. However, the lack of productive uses, the unreliability of the electricity grid, and the technical limitations of solar home systems meant that, at the time of this study, I observed little development of essential practices or routines around the use of electricity. The lack of productive use of electricity might be the reason that people do not think of electricity as an investment with the potential for financial returns, but more as something which provides convenience and entertainment. Ultimately, people who lived in electrified households did not feel that electricity had *transformed* their lives.

In conclusion, I found that the views expressed in academic literature were mostly reflected in the information I gathered at SolarNow offices, and often did not correspond to the views held by the representatives of rural households I spoke to. This indicates that, while rural electrification literature in general and affordability literature specifically does focus on how to make electricity more accessible for rural users, the prominent perspective taken in literature is the perspective of rural electrification practitioners, which does not always align with the perspective of users.

6.2 Implications for future research

Based on the process and outcome of my research I have developed several ideas about possibilities for future research. First, I have noticed that there are quantitative studies about willingness and ability to pay for electricity, which draw on information about traditional energy expenses to estimate the amount people are willing or able to pay for monthly electricity use (Abdullah and Jeanty 2011) (Abdullah and Markandya 2012). These studies have abroad scope and are therefore generalizable, but they provide little to no qualitative information about what influences the willingness of rural households to pay for electricity. There are also a few qualitative studies which, like this research, explore the perceived benefits of rural electrification and the perspectives of people about paying for electricity (Bond, Aye and Fuller 2010) (Matinga and Annegarn 2013). These studies are context-specific, and it is therefore difficult to know whether their insights are widely applicable. It would be interesting if these two streams of research could be combined to provide more robust insights about user perspectives on willingness to pay for electricity in developing countries.

Second, I have noticed that most research into rural electrification in developing countries seems to be geographically localized; some often-featured countries are Kenya, South-Africa and India. This makes sense, since these are countries which have extensive national electrification programmes, as well as relatively well-developed non-governmental initiatives, resulting in many interesting cases to be studied here. However, during an incidental visit to Mozambique it struck me was that the level of electrification seemed to be much lower in than it was in Kenya and Uganda. In light of the objective to achieve universal access to electricity, it seems counterproductive that the countries which are doing relatively well in their electrification efforts are the ones which are extensively studied, precisely because they are doing well. It is important to not overlook these less-studied countries, because the

outcomes of many rural electrification studies are to some extent context specific. This last point is also a relevant point for rural electrification practice.

6.3 Implications for rural electrification practice

While I do not doubt the sincerity of the SolarNow's mission to *"transform the lives of East Africans"* (SolarNow 2016a), I recognize that an optimistic message is necessary for practitioners in order to convince donors and users alike to invest in electricity, and I do believe that electricity has a lot of potential to positively affect daily life in rural Kenya, I think it is important to be slightly reserved in speaking of transforming lives. Overly positive language can lead to unrealistically high expectations which set people up for disappointment. There are a few articles in literature which discuss this issue, and it is expressed well in the following quote.

"*If we consider the somewhat inflated objectives sometimes expressed by project promoters,* [*…*]*, the question of implementing an electrification system takes on a broader dimension*" (Gómez Garcia and Montero Bartolomé 2010, 304)

It might be better to promote electricity as a tool which people themselves can use to shape their own lives in a more fun or more profitable way, instead of as an autonomous force for good. In combination with education programmes about how to use electricity efficiently and productively, this could help in making rural households aware of the economic potential of electricity. People lack information about the fact that electricity is not only nice to have, but that it is potentially a solid investment in the futures of all of the members of a household. Providing these insights could ultimately help companies such as SolarNow to achieve their mission to "*change the lives of East Africans*" (SolarNow 2016a).

.

7 My reflections on doing research

I want to include some of my personal reflections on doing research in East Africa and writing a thesis in this report. The reason for this is that I feel that most of what I have learned during this project pertains to the process of doing research, and not necessarily to the content of my report.

7.1.1 Preparing

During the preparation of my field work I ran into two things which I think influenced my research project. The first thing was making sure SolarNow and I were on the same page with respect to the content and form of my project. As my SolarNow supervisor lived in Kampala, all preparatory contact with him was either through email or through skype. For me it was difficult to discuss my project, and especially my questions and doubts and insecurities about it, through these media. I think happened because conversations are usually conducted hastier and with less attention for each other through skype than they are face-to-face.

The second thing which was difficult for me in the months and weeks before leaving was my mental preparation. I kept going from really excited to extremely nervous and back, to the point of breaking down. This continued until my dad assured me that I could always come back home if I felt there was any reason to do so, because the potential consequences of aborting my research (i.e. taking longer to get my degree) were insignificant compared to my happiness, health and safety. Paradoxically, the knowledge that aborting my research for any reason was a possibility was one of the main reasons why I felt able to conduct my fieldwork.

7.1.2 Doing fieldwork

In planning my fieldwork, I had given myself much more time than perhaps strictly necessary to arrive in East Africa. For me it was great that I was able to take a few weeks to get to know my new environment (even though I fancy myself well-travelled and think I am not easily shocked by new cultures) and especially the company I was working with.

For my fieldwork, I planned to visit Kenya, Tanzania and Rwanda, in that order. In Kenya, my fieldwork went well. This does not mean it was straightforward or easy, but it was more or less as I had expected, and there were as many enjoyable things as there were difficulties and doubts. On the one hand, I got to enjoy beautiful work environments. It was great to notice that it is a thoroughly different experience to visit a country as a researcher than it is as a tourist. For example, when on holiday I used to try very hard to take pictures without

electricity lines running through them – I thought they ruined gorgeous landscapes. As a researcher doing research on access to electricity in remote areas, and seeing how electricity can change peoples' lives, I sometimes actually got a bit emotional seeing electricity lines running through the middle of nowhere. My perspective was completely different. On the other hand, I found fieldwork to be both physically and emotionally draining at times. It was physically draining because travel was not always easy. I found myself in crowded and uncomfortable buses, and I did lots of walking to reach remote homes where public transport does not reach. It was emotionally draining because I felt guilty for asking people to answer my highly personal questions without giving them anything in return (apart from sweets and postcards of the Netherlands), I felt very out of place and uncomfortable because people constantly stared at me and kids followed me around, I felt inept because I was often not able to connect with my interviewees on the level I would have liked to, and I felt very lonely at times, despite the company of my translator. My way of dealing with these emotions was to keep a diary (a.k.a. researcher's notes) in which I wrote down what I had done, who I had spoken to, what I had learned, and how I felt during and after that. Writing all this down also helped me to reflect on how my interviews were going, and whether I was getting the information I needed for my research.

After Kenya, I headed to Tanzania. Around that time, the rainy season had started in East Africa. As a result of heavy and constant rains, I was not able to do any fieldwork on my first day in Tanzania, as my fieldwork involved a lot of time outside. On the second day I was there, I found out that I had come to the country just as they were preparing for their presidential elections, and elections in Africa are often accompanied by violence and rioting. To make sure I wasn't caught up in any potential fighting, I decided to put my research in Tanzania on hold and travel to Rwanda instead, and then come back to Tanzania once the elections were over. In Rwanda, I unfortunately found out that the country has very strict laws when it comes to interviewing people, which are enforced not only by government officials, but also by everyone I tried to speak to; no-one was willing to answer questions as long as I did not have the formal permission from the Rwandan ministry of education. It turned out that the process of acquiring this permit could take up to two months, which was too long for me, so I decided to give up on doing research in Rwanda all together. Because the results of the Tanzanian elections were still out at that time, I decided to return to Uganda for a few days before continuing my fieldwork in Tanzania. In those few days, I was in an accident while I was on the back of a motor cycle, causing a broken shoulder blade. Because of my injuries, I

was not able to return not Tanzania to finish my fieldwork. This series of unfortunate events was a result of oversights in my planning, but also a result of some major bad luck. Everything that could have gone wrong went wrong, but none of the things that prevented me from finishing my fieldwork were out of the ordinary in East Africa. I found that it was important to make good, solid plans when going into the field in a country which you do not know, but for me it was equally important to be flexible when my plans fell apart.

7.1.3 Writing

For me, writing my thesis ended up being the most challenging part of this entire process. Beforehand I felt that, once I had done all of my field work, getting everything down on paper would be a straightforward process. I have learned that this is by no means true.

During the process of writing I found I had trouble adjusting to the new level of autonomy I had. At times I had trouble motivating myself to do anything at all, and at other times, when I was motivated to get things done, progress was still frustratingly slow. This ended up being very confronting on a personal level. I feel like I got to know myself a little better, and I very gradually developed ways to deal with days of low motivation and periods of little progress. This is something I think I will carry on with me throughout whatever I end up doing next.

The fact that I am now finished feels bitter-sweet. On the one hand I'm proud of myself and of the finished product, and I'm glad this project is over. On the other hand, I feel a slight sadness when I think of the fact that going forward I may not have the opportunity to overthink one specific subject as thoroughly as I have this, or to ponder current affairs or the meaning of life or whatever else I want at my complete leisure.

8 Works Cited

Abdullah, S., and A. Markandya. "Rural electrification programmes in Kenya: Policy conclusions from a valuation study." *Energy for Sustainable Development* 16 (2012): 103-110.

Abdullah, S., and P.W. Jeanty. "Willingness to pay for renewable energy: Evidence from a contingent valuation survey in Kenya." *Renewable and Sustainable Energy Reviews*, 2011: 2974-2983.

Achuka, Vincent. *Revenue leak forces Kenya Power to rethink pre-paid meter system.* 25 April 2015. http://www.nation.co.ke/business/Revenue-leak-forces-Kenya-Power-to-rethink-prepaid-meter-system/-/996/2697362/-/ms28p4z/-/index.html (accessed February 29, 2016).

Azimoh, C.L., P. Klintenberg, F. Wallin, and B. Karlsson. "Illuminated but not electrified: An assessment of the impact of Solar Home System on rural households in South Africa." *Applied Energy* 155 (2015): 354-364.

Baldwin, E., J.N. Brass, S. Carley, and L.M. MacLean. "Electrification and rural development: Issues of scale in distributed generation." *WIREs Energy Environ* 4 (2015): 196-211.

Barron, M., and M. Torero. "Household Electrification and Indoor Air Pollution." January 2016.

Bazilian, M., et al. "Energy Access Scenarios to 2030 for the Power Sector in Sub-Saharan Africa." *Utilities Policy* 20 (2012): 1-16.

Bensch, G., J. Peters, and C.M. Schmidt. "Impact evaluation of productive use - An implementation guideline for electrification projects." *Energy Policy* 40 (2012): 186-195.

Bernard, Tanguy. "Impact Analysis of Rural Electrification Projects in Sub-Saharan Africa." *The World Bank Research Observer* 27, no. 1 (2010): 33-51.

Bhattacharyya, S.C. "Introduction." In *Rural Electrification Through Decentralised Off-grid Systems in Developing Countries*, by S.C. Bhattacharyya, 3-12. London: Springer-Verlag, 2013.

Bond, M., L. Aye, and R.J. Fuller. “Solar lanterns or solar home lighting systems - Community preferences in East Timor.” *Renewable Energy* 35 (2010): 1076-1082.

Bond, M., R.J. Fuller, and L. Aye. “Sizing solar home systems for optimal development impact.” *Energy Policy* 42 (2012): 699-709.

Cook, P. “Infrastructure, rural electrification and development.” *Energy for Sustainable Development,* 2011: 304-313.

Corbin, J., and A. Strauss. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory.* 3rd. Thousand Oaks, California: SAGE Publications, Inc., 2008.

Creswell, J.W. *Research design: qualitative, quantitative, and mixed methods approaches.* 4th. Thousand Oaks, California: SAGE Publications, Inc., 2014.

Deichmann, U., C. Meisner, S. Murray, and D. Wheeler. “The Economics of Renewable Energy Expansion in Rural Sub-Saharan Africa.” *Energy Policy* 39 (2011): 215-227.

Doherty, B., H. Haugh, and F. Lyon. “Social Enterprises as Hybrid Organizations: A Review and Research Agenda.” *International Journal of Management Reviews* 16 (2014): 417-436.

Energy Regulatory Commission. *10 year power sector expansion plan 2014-2024.* Nairobi: Energy Regulatory Commission, 2014.

ESMAP. *Beyond Connection: Energy Access Redefined.* Executive Summary, Washington DC: The World Bank Group, 2015.

Glemarec, Y. “Financing off-grid sustainable energy access for the poor.” *Energy Policy* 47 (2012): 87-93.

Gómez Garcia, V., and M. Montero Bartolomé. “Rural electrification systems based on renewable energy: The social dimensions of an innovative technology.” *Technology in Society* 32 (2010): 303-311.

Gonzáles-Eguino, M. “Energy poverty: An overview.” *Renewable and Sustainable Energy Reviews* 47 (2015): 377-385.

Hansen, U.E., M.B. Pedersen, and I. Nygaard. “Review of solar PV policies, interventions and diffusion in East Africa.” *Renewable and Sustainable Energy Reviews* 46 (2015): 236-248.

Hirmer, S., and H. Cruickshank. “The user-value of rural electrification: And analysis and adoption of existing models and theories.” *Renewable and sustainable energy reviews* 34 (2014): 145-154.

International Energy Agency. *Africa Energy Outlook.* Paris, France: International Energy Agency, 2014.

Jacobson, A. “Connective Power: Solar Electrification and Social Change in Kenya.” *World Development,* 2006: 144-162.

Jacobson, A., and D.M. Kammen. “Engineering, institutions, and the public interest: Evaluating product quality in the Kenyan solar photovoltaics industry.” *Energy Policy* 35, no. 5 (2007): 2960-2968.

Kiplagat, J.K., R.Z. Wang, and T.X. Li. “Renewable energy in Kenya: Resource potential and status of exploitation.” *Renewable and Sustainable Energy Reviews,* 2011: 2960-2973.

KNBS. *The 2009 Kenya Population and Housing Census - Volume 2: Population and Household Distribution by Socio-Economic Characteristics.* Nairobi: Kenya National Bureau of Statistics, 2010.

Kolk, A., and D. van den Buuse. “In search of viable business models for development: sustainable energy in developing countries.” *Corporate Governance* 12, no. 4 (2012): 551-567.

KPLC. *Electrification Project.* 2016. http://kplc.co.ke/content/item/1119/electrification-project-.

Krause, M., and S. Nordström. *Solar Photovoltaics in Africa - Experience with Finance and Delivery Models.* New York: Global Environment Facility, 2004.

KWFT. *Clean and Renewable Energy Loans.* 23 November 2016. https://www.kwftbank.com/products/borrow/clean-renewable-energy-loans.

Lee, K., E. Miguel, and C. Wolfram. *Appliance Ownership and Aspirations among Electric Grid and Home Solar Households in Rural Kenya.* CEGA Working Papers, Berkley: The Center for Effective Global Action, 2016.

Lee, K., et al. "Barriers to Electrification for "Under Grid" Households in Rural Kenya." *Working Paper Series No. WPS-039* (Center for Effective Global Action, University of California), 2014.

Levin, T., and V.M. Thomas. "Can developing countries leapfrog the centralized electrification paradigm?" *Energy for Sustainable Development*, 2016: 97-107.

Mathuva, D.M., and J.M. Kiweu. "Cooperative social and environmental disclosure and financial performance of savings and credit cooperatives in Kenya." *Advances in Accounting* 35 (2016): 197-206.

Matinga, M.N., and H.J. Annegarn. "Paradoxical impacts of electricity on life in a rural South African village." *Energy Policy*, 2013: 295-302.

Modi, V., S. McDade, D. Lallement, and J. Saghir. *Energy Services for the Millennium Development Goals.* New York: Energy Sector Management Assistance Programme, United Nations Development Programme, UN Millennium Project, and World Bank, 2006.

Mukherjee-Reed, A., and D. Reed. "Partnerships for Development: Four Models of Business Involvement." *Journal of Business Ethics* 90 (2009): 3-37.

Murphy, J.T. "Making the energy transitions in rural East Africa: Is leapfrogging an alternative?" *Technological Forecasting and Social Change* 68 (2001): 173-193.

Ondraczek, J. "The Sun Rises in the East (of Africa): A Comparison of the Development and Status of Solar Energy Markets in Kenya and Tanzania." *Energy Policy* 56 (2013): 407-417.

Pedersen, M.B. "Deconstructing the concept of renewable energy-based mini-grids for rural electrification in East Africa." *WIREs Energy Environ* 5 (2016): 570-587.

Peters, J., and M. Sievert. *Impacts of Rural Electrification Revisited - The African Context.* Ruhr Economic Paper #556, Bochum: Ruhr-Universität Bochum, 2015.

Peters, J., M. Harsdorff, and F. Ziegler. “Rural electrification: Accelerating impacts with complementary services.” *Energy for Sustainable Development* 13 (2009): 38-42.

Pode, R. “Financing LED Solar Home Systems in Developing Countries.” *Renewable and Sustainable Energy Reviews* 25 (2013): 596-629.

REA. *About REA.* 2016. http://www.rea.co.ke/index.php?option=com_content &view=article&id=87&Itemid=475.

—. “REA News.” Vol. 4. no. 7. 31 December 2013.

Reddy, A.K.N. “Chapter 2: Energy and Social Issues.” In *World Energy Assessment: Energy and the Challenge of Sustainability*, by United Nations Development Programme, 44. New York: United Nations Development Programme, 2000.

Reddy, B.S. “Access to modern energy services: An economic and policy framework.” *Renewable and Sustainable Energy Reviews* 47 (2015): 198-212.

Rollfs, P., R. Byrne, and D. Ockwell. *Financing Sustainable Energy for All: Pay-as-you-go vs. traditional solar finance approaches in Kenya.* STEPS Working paper 59, Brighton: STEPS Centre, 2014.

Salmon, C., and J. Tanguy. “Rural Electrification and Household Labor Supply: Evidence from Nigeria.” *World Development* 82 (2016): 48-68.

Schillebeeckx, S.J.D., P. Parikh, R. Bansal, and G. George. “An Integrated Framework for Rural Electrification: Adopting a User-Centric Approach to Business Model Development.” *Energy Policy* 48 (2012): 687-697.

Seelos, C., and J. Mair. “Social entrepreneurship: Creating new business models to serve the poor.” *Business Horizons* 48 (2005): 241-246.

SolarNow. *Our Mission.* 21 November 2016a. https://www.solarnow.eu/our-story/#about-solarnow.

SolarNow. *Client Service - FAQ.* 21 November 2016b. https://www.solarnow.eu/client-service/.

SolarNow. *Solar Solutions.* 21 November 2016c. https://www.solarnow.eu/solar-solutions/.

SolarNow. *About SolarNow.* 4 February 2017. https://www.solarnow.eu/our-story/.

Sovacool, B.K. “The political economy of energy poverty: A review of key challenges.” *Energy for Sustainable Development* 16 (2012): 272-282.

Tewari, D.D., and T. Shah. “An assessment of South African prepaid electricity experiments, lessons learned, and their policy implications for developing countries.” *Energy Policy* 31 (2003): 911-927.

UNDP. *A new sustainable development agenda.* 2016a. http://www.undp.org/content/undp/en/home/sdgoverview/.

UNDP. *Goal 7: Affordable and clean energy.* 2016b. http://www.undp.org/content/undp/en/home/sdgoverview/post-2015-development-agenda/goal-7.html.

Van der Vleuten, F., N. Stam, and R. Van der Plas. “Putting solar home system programmes into perspective: What lessons are relevant?” *Energy Policy* 35 (2007): 1439-1451.

Verschuren, P., and H. Doorewaard. *Designing a Research Project.* The Hague: Eleven International Publishing, 2010.

Waithaka, M.M., P.K. Thronton, M. Herrero, and K.D. Sheperd. “Bio-economic evaluation of farmers' perceptions of viable farms in western Kenya.” *Agricultural Systems* 90 (2006): 243-271.

Zerriffi, H. “Chapter 1 - Rethinking Rural Electrification.” In *Rural Electrification: Strategies for Distributed Generation*, by H. Zerriffi, 1-23. Dordrecht: Springer Netherlands, 2011.

Appendix A – overview of respondents

Respondent	Gender	Household size	Sources of income	Main energy sources
AHE1	Female	1	Clothes stall in town	Paraffin, charcoal, gas
AHE2	Female	6	Vegetable stall in town & renters	Firewood, charcoal, solar lantern
AHE3	Female	3	Cobbler & employee	Paraffin, charcoal
AHE4	Female	3	Teacher	Charcoal, firewood, car battery
AHE5	Male	8	Teacher & crop farming	Firewood, charcoal, M-KOPA
AHE6	Male	8	Crop farming	Firewood, electricity
AHE7	Male	8	Plumber & shop in town	Electricity, charcoal
AWA1	Female	9	Tailor & shop in town	Firewood, solar lanterns
AWA2	Male	18	Farming & contract work	Solar lanterns, paraffin, charcoal
MAS1	Female	4	Waiter & small restaurant	Electricity, paraffin, charcoal
MAS2	Female	15	Crop farming	Paraffin, charcoal, firewood
MAS3	Male	8	Janitor	Paraffin, firewood
MAS4	Male	9	Crop farming & shop in town	Paraffin, firewood
CHW1	Female	6	Crop farming	Solar panel, firewood, paraffin
CHW2	Male	4	Crop farming & chickens	Paraffin, firewood, solar lantern
CHW3	Female	4	Crop farming	Paraffin, firewood, batteries
CHW4	Male	6	Crop farming	Paraffin, firewood, solar lantern
CHW5	Female	6	Farming, furniture workshop	Solar panel, firewood
KAN1	Female	4	Crop farming	Firewood, electricity, solar lanterns

KAN2	Male	3	Crop farming & chickens	Charcoal, gas, paraffin, electricity
ANN1	Male	5	Farming & contract work	Electricity, paraffin, charcoal
ANN2	Male	1	Contract work (harvesting)	Paraffin, firewood, batteries
ANN3	Female	6	Crop farming	Electricity, firewood, paraffin
ANN4	Male	5	Farming (crops, cows, chicken)	Electricity, firewood
ANN5	Female	6	Crop farming	Paraffin, charcoal, firewood
ANN6	Female	4	Security guard, farming	Electricity, charcoal
KES1	Female	7	Crop farming, police officer	Gas, firewood, electricity
KES2	Female	4	Crop farming, cattle, employment at ministry of culture	Electricity, charcoal, gas
KIP1	Male	8	Crop farming	Electricity, firewood
KIP2	Male	4	Crop farming	Electricity, firewood, gas
KIP3	Male	4	Logger (woodworker)	Electricity, firewood
LIT1	Male	7	Crop farming	Paraffin, firewood
LIT2	Female	6	Crop farming	Paraffin, firewood, charcoal
LIT3	Male	6	Kenya Power technician	Solar lanterns, paraffin, charcoal, gas
LIT4	Female	5	Tea farming & picking	Solar lanterns, paraffin, charcoal
LIT5	Female	4	Tea farming & picking	Electricity, firewood, charcoal

Appendix B - MSc. Theses in the Field of Technology for Global Development

2016

16.05 Mutia Prabawati: Sustainability of rural electrification projects: Case Study of Private Sector Intervention in Indonesia.

16.04 Si Liu: Jatropha Biofuel Development in Cultivation And Processing In China from 2007 to 2012: A Field Study.

16.03 Rodrigo González López: Identifying enabling and hindering factors to design better business models for rural electrification: Rural Uganda case study.

16.02 Hasna Afifah: Evaluation of State-Sponsored Rural Electrification Project in Indonesia: A case study of Pengantap Hamlet, West Nusa Tenggara and lessons from process and learning-based approach.

16.01 Joaquin Corella Puente: Augmenting the SNM framework as a practical tool for sustainable innovation in the South. Design and implementation of technologies for small-scale farmers in Northern Mexico.

2015

15.03 Jonathan Rodriguez Polit: Exploration of the User-Value of Rural Electrification through Solar Home Systems in Southwestern Uganda: A Case Study.

15.02 Mara van Welie: NGOs' transformative approaches. Exploring how Cordaid can contribute to a fundamental change of the sanitation system in urban informal settlements in low-income countries.

15.01 Peter Kuin: No view from nowhere; studying diverging stakeholders' framework to reduce conflict over water resources in Loitokitok

2014

14.06 Eric Gold: Minimizing implementation failure in rural energy projects in development. A responsible innovation approach.

14.05 Bipashyee Ghosh: Sustainability appraisal of emerging trajectories in solar photovoltaic and urban systems in India and Thailand. A multi-criteria mapping analysis.

14.04 Ariane Biemond: African Cotton Production in Transition; requirements for achieving a breakthrough of sustainable cultivation in the Ethiopian cotton sector.

14.03 Iliana Lykissa: A socio-technical evaluation of Solar Home Systems in Uganda: A case study with SolarNow.

14.02 Benedikt Wirmer: A functional approach to guide sustainable innovations in the sanitation chain. Malawi.

14.01 Maro Roussou: The application of participatory methods to co-develop sustainable solutions for domestic hot water and filtration of grey water. Promotion of effective participation of an indigenous school in rural Mexico.

2013

13.07 Joep de Boer: Building a brickmakers' cooperative in Lubuk Alung, Indonesia; an analysis of justifications and conflict situations emerging in the process of building the cooperative.

13.06 Julian Vargas Talavera: Exploring the potential of small biodigesters for electricity production in developing countries. A multi-level analysis on possible adoption in Uganda and Bolivia.

13.05 Sander Dikken: Socio-economic assessment of niche opportunities for sustainable fish- and shellfish cultivation with micro algae. Cases in the Netherlands and Tanzania.

13.04 Joosje Oosterbaan: Housing towards prosperity: an actor-network analysis of the enactment of an urban redevelopment policy and grassroots vision in the Beetham a neighbourhood of Port of Spain, Trinidad and Tobago.

13.03 Roché Mahomedradja: The role of expectations and the societal impact regarding the use of Jatropha as a biofuel feedstock: Insights from India in pursuit of a biodiesel industry.

13.02 Kristine van Tubergen: "Partnering up in Base of Pyramid projects".

13.01 Martijn Pastoors: Jatrophamania: A multi-perspective evaluation of Jatropha initiatives in Tanzania and Lombok, Indonesia.

2012

12.07 Todo Hotma Tua Simarmata: Developing Transition Paths toward Sustainable Solar PV Development for Rural Electrification in Indonesia.

12.06 Arina Schoonbeek: Sustainable Business Model: Analyzing the Activities of Renewable Energy Organizations for Poverty Reduction in Indonesia and the Great Lakes Region in Africa.

12.05 Harini Challapally: Clean Development Mechanism's (CDM) contribution to clean energy technology development in India.

12.04 Willem Giesbers: Dutch private sector-driven development cooperation policy. An institutional analysis.

12.03 Fernando Flores Gallegos: Social Capital: the linking piece for a sustainable development puzzle? Mexico.

12.02 Frans van Herwijnen: Prepaid water in Namibia: Understanding the ongoing transition.

12.01 Lisanne Saes: Prepaid water in Namibia: The impact of prepaid household water meters on the inhabitants and the municipality of Otjiwarongo.

2011

11.04 Rosa Kuipers: Success factors for the logistics of human nutrients in urban areas for use in agriculture. Philippines/India.

11.03 Naomi Baan Hofman: Cultivating under Contract. An Actor-Network perspective on the socio-technical shaping of farmers' practices in north India.

11.02 Jacqueline Kooij: Microhydropower in Indonesia. Reflecting on learning processes.

11.01 Bart Hellings: Using Carbon Credits for Social Entrepreneurship: A case study at Diligent Tanzania ltd.

2010

10.06 Otto Maria Jandl: Barriers for the employment of floating invasive weeds for biogas production in local communities in West African Developing Countries.

10.05 Michiel Roks: Size and Sustainability: The treatment of smallholders in sustainability certification of biomass for energy purposes. Tanzania.

10.04 I. Kahraman: Analyzing the Barriers and opportunities for the Turkish PV Market.

10.03 Sanne Heijnen: The impact of small scale renewable energy projects in least developed countries - a baseline study. Tanzania.

10.02 Souliman Nnafie: Assessing Political Responsibility of Transnational Advocacy Networks through Social Network Analysis. An Empirical Study

10.01 Suyash Jolly: Upscaling of niche experiments in PV solar energy for transition to sustainability in India.