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Statement of Originality

"I hereby declare that this dissertation has been composed by me and is based on my own work"

Signed: Joseph Dawson

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Pay As You Go Solar Home Systems in Zambia: Socio-technical transitions towards transformative change

Figure i: VITALITE's Chipata Compound Hub (Photo: Author's own)

Abstract

Globally, between 1.2 and 1.5 billion people lack access to electricity. Over half this number, around 620 million, live in sub-Saharan Africa. This is despite the fact that electrification has been shown to have a profoundly positive impact on many human development outcomes. Due to the geographic, economic and political remoteness of many unelectrified populations, it seems unlikely that a conventional 'universal copper grid' will provide them with access in the near future. However, trends in the mobile communications and photo-voltaic industries have successfully been harnessed to bring distributed solar generation to over 500,000 households in sub-Saharan Africa, creating transformative change. This has been enabled by innovative distribution models developed by mobile network operators (MNOs), and the rise of mobile money, which allows households to pay for solar equipment in regular micro-instalments. The organisations distributing and operating these Pay As You Go Solar Home Systems are primarily based in East Africa. This study investigates the potential for their success to be replicated in Zambia, through research conducted with VITALITE, a company pioneering the technology in Zambia. The study employs a socio-technical transitions lens to analyse data collected from early PAYG SHS adopters in Zambia, others who could benefit from the system, and company staff.

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1. Introduction

1.1 Energy and electricity access in SSA

Globally, between 1.2 and 1.4 billion people lack access to electricity (IEA, 2015). Over half this number, around 620 million, live in sub-Saharan Africa (SSA) (IEA, 2014). With the increasingly connected, globalized, neoliberal nature of the world, the importance of access to electricity in enabling people to have the freedom to 'lead the kind of lives they value – and have reason to value' (Sen, 1999) is growing ever stronger. Indeed, it is so important that it is beginning to be widely accepted that access to electricity should be considered a human right (Winther, The Impact of Electricity: Devlopment, desires and dilemmas, 2008). However, despite multilateral programmes such as the UN's Sustainable Energy for All, and the recognition of the importance of electricity access to achieving the Millennium Development Goals (UNDP, 2007), progress towards universal electrification has been slow. In sub-Saharan Africa alone, 620 million people, almost 70% of the population lack access to electricity, and due to population growth, this number is rising. Of these 620 million, 80% live in rural areas, where the electrification rate is just 14.2% (IEA, 2014). Within the current paradigm in which the 'modern infrastructure ideal' of 'universal and uniform coverage by a single network' (Furlong, 2014, p. 140) is the primary source of electricity, these figures are not projected to change significantly by 2030 (OECD/IEA, 2012).

In addition to an energy access crisis, the world is also facing a climate crisis. The dominant model of electricity production is carbon intensive and low efficiency (Girod et al. 2013) The emissions resulting from fossil-fuel powered, grid based electrification have become a key driver of climate change. It is clear therefore that the 'modern infrastructure ideal' (Furlong, 2014) is unlikely to represent the best solution to these twin crises. Within the modern infrastructure ideal, power is generated centrally, then distributed through a network (Furlong, 2014). This is embodied in the physical infrastructure, but is also true of the political and economic infrastructure of the system; the power to decide who gets to use electricity, for how long and for what purpose resides in 'central' institutions, be those government departments, or large energy companies either private or parastatal. As such, remoteness and isolation, along either a geographic, economic or political axis, frequently results in an absence of electricity (Alstone et. al 2015).

This is especially true in SSA, where electricity generation and distribution is often primarily the domain of the state. The required infrastructure for grid electricity is expensive both to build and to operate and maintain. Cost recovery therefore requires some combination of high population densities, high average income, or high demand for electricity from industrial or commercial customers. Unelectrified populations in SSA however, are likely to be either highly dispersed (geographically remote), poor (economically remote), or frequently both (Szabo et al. 2013). Uneconomic or only marginally economic electrification is unlikely to occur unless it is deemed to be politically expedient in some way. Any manifestation of remoteness from political power therefore becomes an additional barrier to electrification. A population's political alignment, or lack of any particular alignment, or ethnic background, or poor or corrupt central representation may either be invisible to the grid, or actively discriminated against

(Bhattacharyya, 2013). Those without strong land rights, or living in informal settlements may not have the legal status necessary to even request a grid connection (Alstone et al., 2015).

To a certain extent then, the lack of access to electricity in SSA could be said to be caused by remoteness its populations along several axes. However, it is important to note that the causality also runs in the other direction; lack of access to electricity can be seen as causing or exacerbating those population's isolation. The extent of the enmeshment between electricity and capitalist markets is such that it is very difficult to reap the benefits of one without the other. Without access to electricity, unable to produce or consume at the requisite speeds, off-grid communities can be almost completely ignored by 'electro-capitalism' (MacDonald, 2009). This increases geographic, economic and political remoteness: an electricity supply brings not only power, but visibility; it acts as a signal, designating consumers and producers of the goods of electro-capitalism. Geographic remoteness is not only defined by distance, but also the transport infrastructure linking locations. Without the signal of modernity that electrification provides, the likelihood that modern transport infrastructure will arrive decreases. Economic remoteness is increased by the fact, already stated, that unelectrified communities are unable to produce or consume at the requisite speeds to fully participate in electro-capitalism. When a section of the population's proportional economic contribution falls, governments are less accountable to that population, as they provide smaller proportions of tax revenue (Ross, 1999), increasing political remoteness. Furthermore, electricity provides communication and connectivity with other parts of society, and in doing so, magnifies voices (Winther, 2015). The voices of the electrified are projected farther and more loudly through technology, and are therefore far more likely to be heeded than those lacking access. Equally, electricity also enables communication to flow in the opposite direction. The connectedness that electricity can bring is illustrated by the opinion of an 'older man in Ikisaya village in Kenya', who expressed his expectations that electricity and television would bring with them a feeling of inclusion and national identity: "When I have seen what the President looks like, I will also feel as being part of Kenya"' (Winther, 2015, p. 160).

In addition to the high level, systemic benefits of electrification in reducing isolation, empirical evidence from a variety of studies validates the connection between electrification and poverty alleviation on an everyday, functional level. It is the first KWh of electricity delivered that provides the greatest developmental impact (Goldemberg et al., 1985) (Chaurey & Kandpal, 2010). This is corroborated by the variety of studies which document the positive impact of high quality lighting: the first KWh of electricity is frequently used for lighting. It has been shown to increase the number of hours children spend studying (Gustavsson, 2007), and improve test scores (Kent, 2015). Jacobson found that it improved business performance by allowing administration to be done in the evenings, freeing up daylight hours for more productive work (Jacobson, 2007). For retail businesses, being able to stay open past sunset has been found to have benefits of up to $12/day (Obeng & Evers, 2010).

It also allows households to reduce use of kerosene, batteries and candles. In SSA, these are the most commonly used energy sources for lighting and are expensive, often representing up to 30% of a households monthly expenditures (Pode, 2013). Furthermore, for this high cost, the quality of light is low, potentially causing eyesight problems. The smoke from burning causes respiratory problems. The severity and extent of kerosene related illness is such that it has been shown to have a measurable effect on economic productivity in several SSA nations (Duflo et al., 2008). Open flames from both kerosene burning and candles represent a significant safety hazard, especially in densely populated, informal settlements (Alstone et al. 2015).

The connectivity that electricity provides is a further boon economically. For farmers, up to date weather forecasts and market prices, provided by radio or mobile phone enables better planning, and has been shown to increase profits by up to 60% (Palmer & Pshenichnaya, 2015). For a variety of businesses there is the opportunity to advertise more widely on radio and television. Mobile phones enable networks of suppliers, businesses and consumers to be built, increasing market efficiencies (Molony, 2009).

The contribution of electricity to human development is undeniable. In addition to the evidence presented by the impact it has on this variety of disparate areas, there is a strong correlation between a country's electrification rate and its Human Development Index (HDI) score, both across time and across countries (Alstone et al. 2015). However, the modern infrastructure ideal for providing electricity is highly problematic. It is problematic practically: extension of electricity grids to electrified areas is uneconomic in the majority of cases, while the generation of electricity within such a model is a key contributor to GHG emissions. It is also problematic ethically: it is potentially undemocratic, concentrating economic and political power in the hands of a few.

As such, it seems a paradigm shift is required in the provision of electricity. In the Global North, the universal, uniform networks are so embedded, so ubiquitous, and have a natural monopoly of their respective spaces to such an extent that they have become so stable that they are 'essentially immune to change or external influence' (Furlong, 2014, p. 140). However, this is not the case in SSA. In SSA there is no reason to follow the Global North in taking take a universal single network as either the departure or end point for improving energy services.

Acknowledging and engaging with the existence of electro-capitalism as a system allows electrification to be viewed not as a goal in itself, but as an enabling factor for a set of practices. Furthermore, electrification is recognised as not solely a technological issue, or an economic issue, but an issue embedded within a system of multiple stakeholders with different priorities, capacities and goals (Holtorf et al., 2015). This in turn allows the goalposts to be moved: electrification of SSA no longer means the nigh-on impossible task of stretching millions of kilometres of copper connections across the continent between white-elephant power stations. Instead it means providing populations with the means to take part in those practices of electro-capitalism that they have the capacities to benefit from and reason to value (Holtorf et al., 2015).

1.2 Synergies between Mobile Communication Technologies and Energy Access

C.K. Prahalad, wrote in the 'Fortune at the Bottom of the Pyramid' that "when the poor at the BoP [Bottom of the Pyramid] are treated as consumers, they can reap the benefits of respect, choice and self-esteem, and have the opportunity to climb out of the poverty trap" (Prahalad, 2009, p. 125). In order for the BoP to be treated as consumers, one of two things needs to happen: the goods demanded by the BoP need to fall in price, or their income needs to be raised (Kumar et al., 2010). Trends over the last 15 years in two key technologies have begun to meet both conditions: mobile phones and photo-voltaic (PV) solar.

Over 65% of adults in SSA own a mobile phone, while 75% of the population is covered by mobile networks (Pew Research Centre, 2015). The growing ubiquity of Mobile Communication Technologies (MCTs) has provided visibility to unelectrified communities. As an electrical appliance that maintains its functionality with limited access to electricity, requires an extensive infrastructure and entails a fee-for-service, the mobile has is an unmistakable signal of the capacity of the off-grid poor to participate in electro-capitalism, if the technologies and price-points are appropriate (Kumar et al., 2010). Ferguson (1999) worried that the advent of cellular technology might result in the poorest parts of the world never becoming 'hooked up', because it "allows businesses and elites to ignore their limited and often malfunctioning national telephone systems and do their business via state-of-the-art satellite connectivity, bypassing altogether the idea of a universal copper grid providing service to all" (Ferguson, 1999, p. 225). However, he was proved wrong, as mobile phones have become the archetypal leapfrog technology, rendering the 'universal copper grid' almost obsolete (James, 2009). As mobiles have done for communications, there is potential for distributed generation to do for electricity, enabling electrification of poor, rural communities by going 'beyond the modern infrastructure ideal' (Furlong, 2014).

In addition to signalling the readiness of the off-grid BoP to participate in electro-capitalism, the rapid spread of mobile phones and the associated networks and infrastructure has provided a model for off-grid electrification to follow, and a number of leverage points for increasing the pace and scale at which it can disrupt existing energy regimes, which are particularly useful for small scale PV-solar technologies (Nique & Opala, 2014). The most successful instance of leveraging these aspects of the MCT industry has been the advent and proliferation of companies offering Pay-as-you-go (PAYG) Solar Home Systems (SHS). The economic viability of small-scale PV technologies has increased in the last decade due to the twin trends of rapidly falling costs of production for PV technology, and rapid development of super-efficient appliances (particularly LED lamps) which allow small solar panels and batteries to power a relatively wide range of appliances for a reasonable amount of time (Nordman & Bugossi, 2015).

Around 15 companies in SSA have now established themselves with such offerings, with more attempting to break into the space. Upwards of 500,000 PAYG SHS have reportedly been sold throughout SSA since they were pioneered by M-KOPA in Kenya in 2011 (Energypedia, 2016). The vast majority of these have been sold in Kenya, Tanzania and Uganda.

Table 1.2: Characterstics of Typical SHS (Wirnekci & Kumar, 2015)

System Type	System Features
Pico Solar Home System	$100-$250 4-25 Watt Solar Panel Internal lithium-ion battery 2-6 LED lights Mobile phone charging Radio User-installed
Large Solar Home System	$150-$1000 30-200 Watt solar panel External Lead Acid Battery 4-10 LED lights Mobile phone charging Radio DC fans, television, refrigerators. Technician installed

The majority of the SHS available on PAYG schemes tend to be of the PICO variety. However, some companies, most notably Mobisol are starting to offer larger systems, primarily for running small DC TV's and refrigerators (Energypedia, 2016).

The PAYG distribution model for SHS can be split into two sub-sectors: rent-to-own and fee-for-service. In both models, customers are provided with an SHS, mostly requiring a small down payment or commitment fee. In both models, the SHS is equipped with machine-to-machine (M2M) technology, which allows the SHS to be switched on and off remotely. Customers make payments largely via mobile money, but also cash, either for a set amount of electricity, or a set amount of time of use. In the rent-to-own ownership model, this payment also goes some way towards paying for eventual ownership of the SHS. In the energy-as-service model, the payment is just for the use of the system, with no prospect of potential ownership. The asset ownership model has the advantage that once the full amount has been paid, no further payment is necessary for use of the system and it is switched on permanently. However, since this essentially works as a loan, it requires that companies 'to build out a full in-house credit/finance function, complete with risk assessment and portfolio management staff and processes one might see at a financial institution', which in turn raises costs, making the required payments higher than for the energy-as-service model (Winieki & Kumar, 2014).

The primary leverage point that MCTs have provided for PAYG SHS has been mobile money services: a well-used, familiar platform for making small, regular payments. Alternatively mobiles are used for verifying payments, in the form of numerical tokens (Alstone et al. 2015). This has helped reduce the impact of customers' geographic remoteness. M2M technology allows remote monitoring and operation of decentralised energy systems. This enables remotely activated cut-off switches, which prevent use when fees or loan payments have not been completed (Nique & Smertnik, 2015). Together, these aspects make it feasible to extend finance to economically and geographically remote populations: payments can be small and regular, and are enforceable at very little cost to the supplier (Krolikowski, 2014).

Providing SHS to geographically remote populations has required successful 'last mile' distribution strategies. The mobile network operators' (MNOs) agent distribution model has provided an excellent template which provides an excellent template (Nique & Smertnik, 2015). The vast majority of mobile phone users in SSA use pre-paid phones which must be topped up with airtime. Although the exact model for distributing airtime varies between MNOs and between countries, they tend to follow something approaching the following 'hub and spoke' model. Maintaining and operating the facilities required to sell airtime to each MNO customer, given their low incomes and geographic remoteness would be uneconomic. Instead, the task is delegated to 'agents', who essentially act as 'micro-franchisees' of the MNO (Anderson & Kupp, 2008). They take on the task of last mile distribution of airtime, and in return receive training, commission for the airtime they sell, and the ability to use the companies branding on their shop or kiosk. In such a model, MNO's maintain several strategically located hubs, from which they can sell or dispatch to their agents. This reduces distribution costs for MNOs, and allows organic growth of networks to wherever the service is most required. The efficacy of such a model is demonstrated by the number of airtime agents and their distribution: in Kenya alone there are currently 96,000 registered MNO agents providing 'last mile' distribution (Nique & Smertnik, 2015). The model would require adapting for distribution of off-grid energy products (for example it seems likely more training of agents would be required). However, it is possible to fit all the equipment required to light a small home for 8 hours a day, charge phones and power a radio into a shoebox (Winieki & Kumar, 2014); if it is possible to deliver a shoebox of scratch cards to a location, then it is possible to deliver such solar equipment.

Two of the most successful PAYG solar companies, M-KOPA and Fenix International, have been able to use these elements of the MCT industry especially well by forming deep, exclusive partnerships with MNOs (Safaricom and MTN Uganda respectively). In addition to smoothing the integration process of PAYG SHS payments into their mobile money services, this has also given these companies the ability to leverage the MNOs' distribution networks, brand recognition, and its large customer base. Indeed, this has been recognised by several sources as one the key facilitators of M-KOPA's fast growth (Wills, 2013), (Rollfs, Byrne, & Ockwell, 2014b).

1.3 Socio-technical transitions and PAYG SHS

If the project of electrification is to shift away from growth of a universal copper grid towards distributed generation, then measuring the success of endeavours to provide electrification needs an evaluative tool that takes this into account. A socio-technical transitions (STT) framework could provide such a tool. The usefulness of such a tool is evidenced by its capacity to explain the PAYG SHS in achieving 'widespread, transformative change' (Ockwell & Robert, 2016, p. 11). STT approaches originated in studies of technology transfer in the Global North, and the main body of the literature still focuses on the Global North (Furlong, 2014). Its potential usefulness in analysing issues of energy access in the Global South is beginning to be recognised, with several papers being published in the last two years advocating socio-technical design for off-grid energy solutions (Ockwell & Robert, 2016). However, despite the prominence in the media and apparent success of PAYG SHS this study could only identify one other which applied an STT approach to PAYGO SHS (Rollfs, Ockwell, & Byrne, 2014a) (Rollfs, Byrne, & Ockwell, 2014b). Rolfs' study was based solely on interviews with high-level actors within the PAYGO SHS space such as company directors, and lacked any data from users or field staff. This present study will therefore attempt to evaluate the potential for success of PAYG SHS using an STT approach informed primarily by quantitative and qualitative data gathered from users and field staff.

Socio-technical transitions occur when society transfers from 'one set of stable social and technical configurations that perform a 'function' in that society to a new set' (Ockwell & Robert, 2016, p. 18) that somehow outperform the existing set. Technologies exist within these socio-technical configurations, or regimes, which include the economics of providing that technology, the institutions and regulations which govern its use, the dominant social practices for purchasing the technology, and how it is used to fulfil different functions. To be widely adopted, new technologies must be able to develop a socio-technical configuration which has some significant advantage over the existing one (Raven, 2007).

Perhaps the most important aspect of the socio-technical configuration to consider is the informal institutions embedded in society such as practices, norms and conventions, which define how given functions are met by particular technologies (Klintenberg et al., 2014). These informal institutions are particularly important as drivers and barriers to uptake of new technologies: adoption by users is not driven by the technical specifications and capacities, but how well that technology aligns with 'dominant social practices', or offers 'opportunities to realise new practices' (Raven, 2007). This includes not only the form and function of the technology, but also purchasing patterns and affordability: however well a new technology aligns with existing use practices, if it is significantly less affordable, or if purchasing it is considerably more inconvenient, then this represents a considerable barrier to uptake. According to Pode (2013), affordability is constituted by the appropriateness of the upfront price, total cost and payment flexibility to the benefits of the technology and the income of the end user.

This is an issue addressed which is addressed by PAYG SHS. The functionality of the systems directly aligns with the three most common and valued energy practices of providing lighting, facilitating communication through mobile phones, and entertainment through radios and television. Furthermore, many of the companies offering PAYG SHSs initially saw themselves as being in direct competition with kerosene, with kerosene being the incumbent technology. As such, their model was designed with a pricing structure that mimicked the small, frequent purchases of energy as and when it was needed, and a price point slightly lower than that of kerosene, so that savings would be realised immediately (Rollfs, Byrne, & Ockwell, 2014b). The payment mechanism also aligns with existing socio-technical practices. Over 65% of adults in SSA own a mobile phone, while in 2013, the total number of mobile money accounts overtook the number of traditional banking accounts. For many in SSA, mobile money is the most familiar method for financial transactions after cash (Pew Research Centre, 2015).

Networks of actors with appropriate skills and knowledge both of the technology itself and of the social practices it fulfils form a further significant part of a socio-technical configuration. They are needed to ensure efficient distribution, operation and maintenance. This means those who supply and construct the technology need to be aware of its end use, financial providers need to be aware of the users' constraints, end users need to be well educated in the use and maintenance of the technology. A system with the capacity to make reliable, efficient repairs needs to be in place (Pueyo, 2013). Furthermore, actor-networks determine the speed and effectiveness of knowledge dissemination. Access to resources is also facilitated through actor-networks. The effectiveness of these networks is defined by their breadth and depth: the number and variety of actors, and their level of commitment (Rollfs, Byrne, & Ockwell, 2014b).

For PAYG SHS, the finance and the technology are both provided by the same company, and cost recovery is dependent on the consumer using, and therefore paying for the product. The companies' revenue stream is dependent on their products being functional. As such they have developed wide networks of technicians and agents. Some have also created education programmes for their customers to ensure they can operate and maintain the SHS effectively (Mobisol, 2015). The breadth and depth of the PAYG SHS networks is also strengthened by the inclusion of the mobile network operators (MNOs) who provide the mobile money services used to pay for the SHSs. The success of the business models for mobile money services are underpinned by low tariffs on a high volume of small transactions (Jack & Suri, 2011). They therefore also have an incentive to see increased penetration of PAYG SHSs.

1.4 Overview of Zambia

Zambia is a landlocked country in Southern Africa, with a population of 14.5 million, and a GDP per capita of $1500. Of those 14.5 million people, 60% live in rural areas, while the population density of the country as a whole is low, at around 13 people per square kilometre (The World Bank, 2015). The electrification rate was once quite promising by SSA standards as noted by Ferguson:

> *"in Zambia… the electrification of the townships was a compelling symbol of inclusion… electricity… would link all of the country's citizens in a universal, national grid of modernity" (Ferguson, 1999, p. 243).*

However, the townships and compounds have grown, without a corresponding growth in electricity infrastructure. The grid is consistently over-loaded, resulting in frequent and prolonged periods of load shedding, meaning that even those 35% of electrified people in urban areas are often without power (Haanyika, 2008). In rural areas the electrification rate still stands at 2%. The relative poverty of the rural populations, coupled with their low density and the size of the country means that grid connections are unlikely to be extended out of the main towns for several decades (Lemaire, 2009). As such, it seems that small scale distributed generation systems could be of great benefit to the off-grid populations of Zambia; even the smallest system still provides the all-important first kilowatt hour of electricity.

There are currently several companies selling SHS in Zambia. However, these primarily sell large systems with inverters to wealthy homes as alternatives to generators or grid connections. There is some momentum gathering behind PAYGO SHS. Several sources of donor funding are encouraging existing companies to attempt to break into the space. One company, VITALITE, began selling PAYG SHS in January 2016, and to date have sold 480 systems.

1.5 Research aims and questions

1.5.1 Research Aim

> *To provide an analysis of the potential of PAYG SHS to drive widespread transformative change in the Zambian energy sector, towards providing BoP access to the practices and benefits of electro-capitalism.*

1.5.2 Research Questions

Having been presented with the opportunity to conduct field research with VITALITE, a company offering PAYG SHS in Zambia, and given the lack of a granular STT analysis in existing literature, this study will achieve the research aim through gathering and analysing data from individual PAYG SHS users, non-users and both office and field staff. The research will aim answer to answer the following questions in order to assess the potential of PAYG SHS in Zambia.

1. What are the existing socio-technical practices of energy use and access within VITALITE's target market?
2. How well do VITALITE's PAYG SHS offerings align with those practices or provide opportunities to stretch them?
3. What are the nature of the actor-networks engaged in the spread of PAYG SHS in Zambia?

2. Methodology

2.1 Overview

This study will use a literature review and stakeholder interviews, following Holtorf et al. (2015) to gather the data needed to build a case study of a company providing PAYG SHS in Zambia within an STT framework. A comparison of the findings of the case study with the findings of the literature review will be used to assess the viability and potential impact of such models in Zambia.

The literature review will identify the key drivers and barriers to widespread electrification and important impacts and co-benefits. It will also explain why an STT lens is particularly suitable for examining electrification through PAYG SHS in SSA. This will provide useful context in which to situate the data gathered through fieldwork in Zambia, working in conjunction with VITALITE. The research will consist of the following components: semi-structured interviews, informal interviews and focus groups with key staff at VITALITE, structured interviews with VITALITE's PAYGO SHS customers and structured interviews with a sample of people drawn from the residents of the localities of VITALITE's hubs.

2.2 VITALITE

2.2.1 Introduction

VITALITE is a company based in Lusaka which provides a variety of energy products, including fuel efficient cookstoves, solar lanterns and PAYG SHSs. The company is described by its founders and directors, Sam Bell and John Fay as a social enterprise, in that its primary goal is to provide access to clean energy to the BoP in Zambia.

2.2.2 VITALITE's PAYG SHS

2.2.2.1 Technical specifications

VITALITE's primary PAYG SHS offering, the PAYGO Standard Pack, consists of a 15W solar panel, lithium-ion battery, the unit for which also contains the operating system, one variable brightness lamp (80-200 lumens), one 100 lumen lamp, one portable solar lantern, mobile phone charging set with four different chargers for different phone types, a rechargeable, portable radio, and in infrared remote control for operating the system. The solar lantern can be charged from the system or directly in the sun, and also has a USB port for charging small electronic devices. The radio has a USB port and memory card slot. Apart from the radio, the components are manufactured by fosera, a German solar engineering firm. All components of the system come with a two year warranty, apart from the radio, which has a one year warranty. The expected useful lifespan of the system is from seven to ten years. From one day's full charge, the battery can provide around eight hours of light from the lamps, although this is reduced if the load on the battery is increased by simultaneously charging phones, the lantern or radio outside daylight hours.

Figure 2.1: A VITALITE PAYGO Standard Pack mounted on a demonstration board. (Photo: Author's own)

2.2.2.2 PAYG finance model

There are several options for purchasing the system. It can be bought outright for the 'cash and carry' price of K1750 ($175). However, the majority of VITALITE's customers choose a 'PAYGO Plan', where repayments are made over 12, 18 or 24 months. On these plans, they pay an initial minimum commitment fee of K300 (although they are encouraged to pay more if they can afford it). This is followed by a daily payment of K5, K4 or K3 for 12, 18 or 24 months respectively.

Once a customer has decided on a plan and paid the commitment fee, they are registered into VITALITE's back end software, Lumeter. Customers can then make their daily payments either at a VITALITE hub or to a VITALITE agent (see below), or by mobile money. Once a payment is made, it is logged by the person taking payment in Lumeter using either a smartphone, tablet or computer. Lumeter then automatically generates a numerical token and sends it to the customer's phone in an SMS, which the customer inputs to their system with the remote control. This unlocks the system allowing it to be used. Customers can make any number of daily payments in one transaction. For example, a customer on the 12 month plan could pay K50 for 10 daily payments. In this instance, the token the customer received would unlock the system for 10 days (240 hours from the time the token was inputted). Lumeter tracks all payments and remaining balances.

If customers miss a day's payment, this is also recorded by Lumeter. If the cumulative days missed in a year exceed 30, the customer is charged a penalty fee of 10% of their remaining balance, which is added to this remaining balance. If it exceeds 60 days, a further 15% is levied. If it exceeds 90 days, or if 30 days are missed consecutively, the full remaining balance becomes due within 1 month, or VITALITE have the right to reclaim the system.

2.2.2.3 Distribution

The SHS are distributed through three main channels. The two most established channels are VITALITE hubs and VITALITE agents. VITALITE's 'hubs' are essentially shops from which VITALITE staff sell VITALITE products and offer associated services, including receiving PAYGO payments. Currently, VITALITE have hubs in five of Lusaka's compounds – Chipata Compound, Chawama, Kanyama, Matero and Mtendere – Monze, a small town 120 miles southwest of Lusaka and Chipata Town, 350 miles east of Lusaka. The populations served by the Lusaka hubs are almost entirely urban, those served by Monze and Chipata Town mostly rural.

VITALITE 'agents' are not employees, but are given training by VITALITE, then pay deposits to take SHS to sell for a commission. They can also earn commission when they receive PAYG payments for tokens. VITALITE are also beginning to develop a network of partner organisations throughout Zambia who can sell VITALITE products and offer associated services for commission. Currently Rainlands Timber is serving a mix of rural and urban populations in Kitwe, in the Copperbelt region. Negotiations are ongoing with NWK, an agri-services business with around 100 outlets throughout Zambia.

2.3 Interviews: Staff

Initially, unstructured interviews were held with VITALITE's directors and management team in order to gain a general overview of the company, identify issues for further investigation and inform the design of the user and non-user interviews. This was followed by a focus group with the staff responsible for managing the hubs (Sales and Service Reps (SSRs)), in which they were encouraged to talk about their experience of demonstrating and selling the system, maintaining customer systems, selling tokens, and interacting with customers. This further informed interview design and provided useful qualitative data on VITALITE's actor networks.

At the end of 5 weeks working with VITALITE, follow up interviews were conducted with the VITALITE directors and management team. These were semi-structured, with the structure designed mainly to answer research questions 3, as well as provide some more context for the data gathered from the user and non-user interviews. The semi-structured form kept the focus on the key themes, while allowing the participants space to bring to light and elaborate on whichever issues they felt were most relevant to that particular topic (Russel, 2006).

Table 2.1: Semi-structured interviews with VITALITE staff

Interview Number	Interviewees	Role within VITALITE	Focus of interview
1	Sam Bell & John Fay	Directors	• Overview of VITALITE's networks • Goals for PAYG SHS • Key challenges facing VITALITE
2	Jorg van Gaal	Operations Manager	• Agent Distribution Model
3	Leah Stemeroff	Process Manager	• Relationship with MNOs

2.4 Interviews: Users

Structured interviews were conducted with 37 PAYGO SHS customers. Firstly, these sought to uncover the basic demographic and socio-economic statistics of PAYGO SHS users. Further questions investigated the socio-technical practices associated with energy source choice, purchase and use both before and after acquiring a PAYGO SHS (See Appendix I).

To select participants VITALITE's customer list was randomised by assigning each customer a randomly generated number, then sorting by that number. The first fifty on that list were then called and then invited to an interview at the hub at which their system was registered, in order to minimise the effect of distance to interview location effecting sample selection. The interviews were conducted through local enumerators in order to avoid the deference effect and overcome potential language barriers (Russel, 2006). Participants had their travel costs covered, and were incentivized through a K20 token for their PAYG SHS.

2.5 Interviews: Non-users

Structured interviews were conducted with 55 non-users. In composition these mirrored the customer interviews to a large extent, to establish baselines of demographic and socio-economic statistics, and socio-technical practices. After this data had been collected, the participants were provided with an information sheet about the PAYGO system, and asked further questions about their thoughts on the system. The data collected from these interviews enables a better identification of potential drivers and barriers to uptake through comparisons with the data from user interviews (See Appendices II and III).

The sample was selected through street intercepts in two randomly selected locations in each of the following areas in which VITALITE have hubs: Chipata Compound, Kanyama, Matero, Mtendere, and Monze. Conducting interviews in Chipata Town was considered, but rejected due to logistical difficulties and time constraints. For the reasons listed above, these interviews were conducted through enumerators. Participants were paid K10 for their time.

2.7 Methodological limitations

One of the key limitations of this methodology is that interviews with users were conducted at VITALITE hubs, therefore potentially giving the participants the impression that the interview was a VITALITE endeavour. This could have changed the way they answered questions; for example, wanting to please the company they were indebted to (deference effects (Russel, 2006)), or trying to convince VITALITE to provide more services. An attempt to counter this was made by having the enumerators explain that the interview was not a VITALITE endeavour, but part of a study was being conducted for Edinburgh University.

Sample selection also presents a possible limitation; due to time constraints it was not possible to offer users multiple interview days; as such several declined due to formal employment constraints. For non-users, the number interviewed in each location (≈10) is unlikely to be a representative sample of those populations. While the locations for the street intercepts were chosen randomly by assigning random numbers to grid squares (Russel, 2006), those locations could also have influenced responses.

A final constraint is that the interviews required people to report average monthly values for various elements. Two factors hindered this; enumerators reported that participants were sometimes quite unsure, and variable incomes across months meant that it was difficult to calculate for others. As such, figures provided can only be taken to provide support for a broad outline of practices, rather than as precise population statistics.

2.8 Results and Analysis

The results of the literature review are reported in Chapter 1, and will inform the following analysis and discussion.

Data from users and non-users interviews will be analysed and reported in Chapter 3 as follows. Mean responses for questions regarding energy source choice, expenditure energy use and purchasing patterns will be calculated and compared across several groups: users before and after purchase of PAYG SHS, non-users, rural and urban households, and households with a grid connection and those without. Due to the limitations previously described, confidence intervals for these means and differences would not be especially meaningful, and since the aim of this study is to describe socio-technical practices rather than discover energy statistics, will not be calculated.

This data will be used to build up a picture of the socio-technical practices surrounding energy in the populations surveyed, and how well the practices surrounding PAYG SHS align with them. Due to the sampling limitations outlined above, This will be further informed by content analysis of open ended questions regarding changes that PAYG SHS have brought to respondents lives and the fairness of penalties for late payments. Information gathered for staff interviews and the focus group will also provide some context.

The results of staff interviews will be reported in Chapter 4 in a description of VITALITE's actor-networks and the binding features and challenges of the relationships within them.

3. Alignment of PAYG SHS with existing socio-technical practices

The socio-technical practices involved in energy usage will be split and analysed in the following categories: energy source choice, expenditure on energy, uses of energy and purchasing practices.

3.1 Energy source choice and expenditure

Table 3.1: Average monthly expenditure and percentage of income spent on energy by respondent group

	Total		Rural		Urban	
	Users	Non-users	Users	Non-users	Users	Non-users
Mean monthly income (K)	2908	1686	2607	769	3100	2096
Mean monthly expenditure (K)	201.6	176.5	88.7	116.3	270.3	195.4
Mean % of income spent on energy	12.8	13.4	10.9	17.3	13.9	11.6

The % of income spent on energy also varied considerably between the top and bottom quartile by income.

Table 3.2: Percentage of income spent on energy by income quartile

	Users	Non-users
Top quartile by income	5.0	8.2
Bottom quartile by income	31.1	20.5

However, the actual amount spent on energy did not vary as much: the coefficients of variance for percentage of income spent on energy, and total amount spent on energy were 0.7 and 1.2 respectively. Combined with the data regarding energy source choice and expenditure by source (Table 3.3) this could suggest that there is a minimum energy requirement that needs to be satisfied for a certain quality of life, and once that amount is reached, the marginal benefit of each unit of electricity approaches the marginal cost. This is in line with predictions by Chaurey & Kandpal (2010) units of energy have diminishing marginal utility.

Table 3.3: Monthly expenditure on energy sources for all respondents

	All households (n=93)		Rural households (n=29)		Urban households (n=64)	
Energy sources	**Mean monthly expenditure (K)**	**Percentage of participants using source**	**Mean monthly expenditure (K)**	**Percentage of participants using source**	**Mean monthly expenditure (K)**	**Percentage of participants using source**
Grid connection	193.3	63.8	135	38.7	207.9	75
Generator Fuel	150	5.3	100.0	3.2	212.5	6.3
Candles	43.9	57.4	31.2	45.2	48.4	62.5
Batteries	67.7	23.4	65.4	32.3	69.7	18.7
Kerosene	47	5.3	80.0	3.2	38.8	6.2
Mobile charging	32.8	5.3	32	9.6	34.0	3.1

As demonstrated by the fact that the total percentages are far over 100%, very few households used just one source of energy for non-cooking related domestic use. The most common energy source used across all users was grid electricity; The connection rates found was much higher than the statistics found in the literature review of 35% (urban) and 2% (rural) (Lemaire, 2009). For those that had a grid connection, it was represented the highest monthly expenditure 100% of the time. Candles and batteries were the next most common energy source: in total 62.1% all respondents used either candles or batteries or both. This number was higher in urban areas (66.1%) than in rural areas (58.1%). Respondents reported that load shedding was a greater problem in Lusaka than it was in the surrounding rural areas, for political reasons. The explanation that emerged both from interviewees and the SSR focus group was that Lusaka, being a stronghold for the ruling party, the Patriotic Front (PF), suffered more load shedding because the majority of the inhabitants vote PF regardless of their electricity supply, while those in rural areas required more persuading that the PF were a reliable, competent government. As such, households with a grid connection in Lusaka buy candles and batteries to use as a backup source of lighting during the daily 8 hours of load shedding, whereas those with a grid connection in rural areas have no such necessity. Amongst households without a grid connection, the number using candles and batteries rose to 68.6%, with the remaining electrified households using solar lanterns (11.4%) firewood (11.4%), diesel generators (5.7%) or kerosene (2.9%) for lighting.

The literature review found that most sources cited both kerosene and mobile phone charging as the major energy costs for off-grid households (Ahlborg & Hammar, 2014) (Pueyo, 2013); however, this research found little evidence for that in Lusaka or the surrounding rural areas. Kerosene did not seem to be widely available, and two respondents said that Zambian's viewed it as 'dirty' and 'unsafe'. For mobile phone charging, a variety of informal practices seemed to be prevalent: friends' and neighbours' houses and businesses, and places of work were the places agreed upon by the SSR focus group as the most usual places to charge mobile phones if you did not have a grid connection. However, paying for mobile charging was more common in rural areas, possibly because it is less likely in these areas to have neighbours or a place of work with a grid connection.

For users of the PAYGO SHS the percentage of households with a grid connection was much lower than for non-users. This was particularly true for rural households where only 15.4% had a grid connection. The percentage of households using other sources was higher for all sources apart from generators. In terms of expenditure, there were some differences in average monthly expenditure, illustrated by table 3.4

Table 3.4: User energy expenditure before and after PAYG SHS purchase, by energy source

	All households (n=37)		Rural households (n=13)		Urban households (n=24)	
Energy sources	**Mean monthly spend (K)**	**Percentage of participants using source**	**Mean monthly spend (K)**	**Percentage of participants using source**	**Mean monthly spend (K)**	**Percentage of participants using source**
Grid before	192.1	51.3	150.00	15.4	197.06	70.8
Grid now	147.8		125.00		150.63	
Generator fuel before	325.00	5.4	.00	0	325.00	8.3
Generator fuel now	50.00		.00		50.00	
Candles before	59.1	72.9	44.50	61.5	65.21	79.2
Candles now	2.8		.00		4.05	
Batteries before	91.1	37.8	86.67	46.1	94.38	33.3
Batteries now	9.9		1.67		16.00	
Kerosene before	38.8	10.8	.00	0	38.75	16.7
Kerosene now	8.8		.00		8.75	
Mobile phone charging before	33.5	10.8	33.00	15.4	34.00	8.3
Mobile phone charging now	.00		.00		.00	
Mean total before	201.6	100	112		270.6	
Mean total after	81.4		23.6		119.3	

In terms of energy source choice and expenditure, the PAYGO SHS can be seen to align existing with the socio-technical practices: it almost completely replaces spending on all sources of energy other than grid electricity. This provides evidence that it can satisfactorily fulfil the functions that those sources were providing. For those with a grid connection who bought the system it fulfilled the same function as candles and batteries; providing a backup for periods of load shedding. For those without a grid connection it became the main source of energy. Only 15% of rural users had a grid connection, while 51% of urban users had a grid connection.

Combined with the information about load shedding in urban verses rural areas, this suggests households are using the SHS for different purposes. Rural and urban off-grid households use it as their primary source of energy. Urban households with a grid connection use it in place of candles and batteries as a backup during periods of load shedding. Rural households with a grid connection have no need for the system, because they do not suffer from load shedding.

From an affordability perspective the evidence is mixed. The aim of the PAYGO payment structure is to mimic existing energy expenditure patterns. For urban users, the total cost of the SHS is less than the amount that they save from reduced spending on other sources. However, for rural users, the K120 per month is more than they spend on average on all energy sources. Potential affordability problems are also highlighted by table 3.1 which shows users to have significantly higher incomes than average in both urban and rural areas.

3.2 Energy use

The uses of energy are heavily constrained by the energy source being used. A grid connection provides far more functionalities than batteries, while batteries support a wider range of functions than candles. Expenditure on energy sources other than grid electricity is almost entirely focussed on provision of lighting. In addition to this, non-users ranked lighting as the most valuable feature of the SHS, and the LED lights were the most frequently used feature by users. The combination of these results with the data on energy source choice reveals lighting to be the most important function that energy fulfils.

3.2.1 Lighting

Table 3.5: Mean lighting hours/day

Respondent group	Mean hours of lighting/day
Total	4.6
With grid connection	5.0
Without grid connection	3.9

Lighting itself is primarily useful in that it facilitates other activities. In addition to its availability, the extent to which it enables those activities is also dependent upon its quality (Alstone, Gershenson, & Kammen, 2015). Candles, torches powered by disposable batteries and kerosene provide a far lower quality of light (in terms of lumens) than LED lamps or incandescent bulbs. As such it might be expected that those without a grid connection, as well as lighting there hosue for less time, spend less time engaged in the activities that lighting enables, such as studying, income related work such as book keeping, or housework, as evidenced by table 3.5

Table 3.6: Hours spent engaged in various productive activities

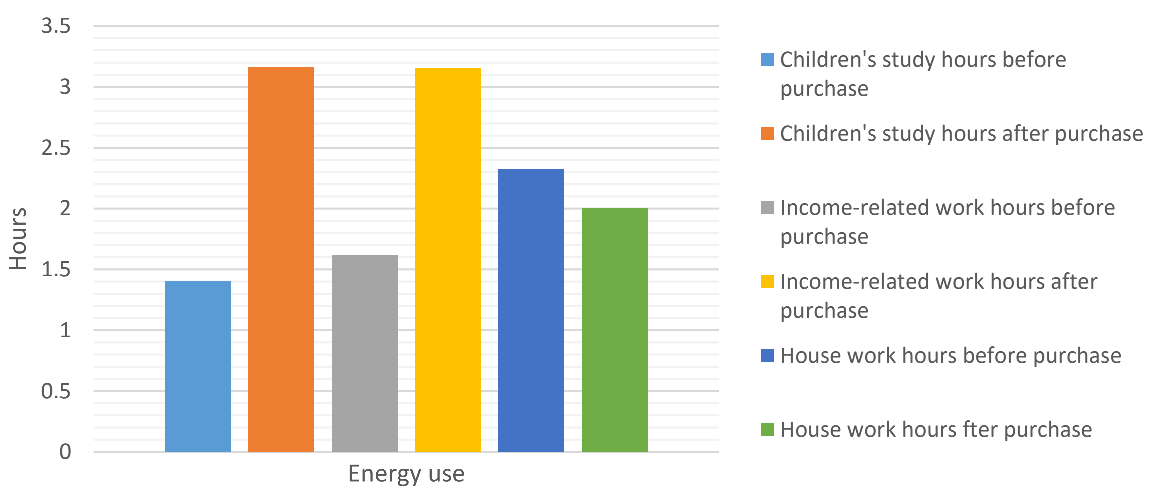
	Children's study hours	Income-related work hours	Housework hours
With grid connection	2.0	2.9	3.5
Without grid connection	1.2	1.2	2.4

Here, the SHS aligns with and stretches existing practices, in that it can provide high quality electric light for up to 8 hours a day. As well as increasing total lighting hours, the increase in quality also allows more productive work to be done.

Table 3.7: Lighting hours/day before and after using SHS

	Lighting hours/day
Before PAYG SHS purchase	4.16
After PAYG SHS purchase	5.89
Using PAYG SHS	5.22

Figure 3.1: Mean reported hours spent on lighting dependent activities before and after purchase of PAYG SHS



This provides further evidence of the SHS ability to fulfil and go beyond the functions of candles and batteries. There is a clear and significant increase in the amount of time children spent studying, and in income-related work hours. 41% of users mentioned the improvement in their children's ability to study when asked about the impact the system had on their lives. The data on housework is less clear. Some households reported that the better quality lighting that the SHS provided allowed them to work more quickly and efficiently, thereby reducing the number of hours spent on housework. Some reported that the longer hours of lighting meant they had more time for housework, and therefore did more. Further research would therefore be required to investigate the effects of PAYGO SHS on the changes to unpaid domestic work and gender effects that such changes might entail.

In addition to allowing people to spend more time on income-related work at home, the system had further impacts on business productivity. The portability of the system, combined with the brightness of the LED lamps encouraged several shop owners to transport the system between their houses and their shops, reporting that they can stay open longer and that the 'light attracts customers'.

3.2.3 Other energy uses

In terms of lighting, the PAYGO SHS clearly aligns with existing socio-technical practices, and allows them to be stretched. However, while lighting maybe the most valued use of electricity, for those with a grid connection there are other uses and functions which the SHS does not fulfil.

Table 3.8: Appliances of grid connected households

Appliance	Percentage of grid connected households who own appliance
Television	91
Fridge	81.9
Stove	65.5
Iron	42.5
Radio	54.6

For urban households who might use PAYG SHS as a back up to their grid connection, this adversely affects affordability; the system is unable to meet all their energy needs and hence they must continue paying for grid electricity. When users were asked about what additional features they would like to be included in their SHS, a television and longer battery life were rated equally as the two most desirable additions. Non-users ranked electric lighting as the most valuable feature in an SHS, and television the second most valuable. This is in line with Jacobson's findings that once basic lighting needs have been met, entertainment and communication comes next (Jacobson, 2007).

While a radio was not highly valued as feature of an SHS by non-users, for users it was used just as frequently as the LED lights and lantern; all three features were used on more than four days a week by over 85% of respondents. It was particularly valued by rural off-grid users, for whom this number rose to 95%. Rural off-grid users seemed to feel a new sense of connectedness with the wider Zambian community. Several users reported that they were now 'always up to date with current affairs', and were informed about 'some useful new products from adverts'. One mentioned that the radio meant they could 'listen to gospel music' even when they could not get to church.

3.3 Energy purchasing patterns

3.3.1 Existing Purchasing Patterns

Table 3.9: Existing purchasing patterns

	Rural		Urban	
Source	**Average purchases/ month**	**Average travel time/purchase (mins)**	**Average purchases/month**	**Average travel time/purchase (mins)**
Grid connection	1.6	35.4	1.5	20.5
Candles	4.9	20.2	9.4	11.5
Batteries	3	27.2	5.8	16.88
Mobile phone charging	6.7	31.6	6	15.5

Average total travel time for rural households: 99.2 minutes

Average total travel time for urban households: 76.4 minutes

The majority of grid connections were prepaid; tokens were purchased from a ZESCO outlet, or a partner supermarket. Respondents expressed a preference for only buying one token per month, but they sometimes misjudged the amount of electricity they would use, and so would have to go twice. There were two purchasing patterns distinguishable for candles and batteries, both present in both urban and rural areas. One reported habit was to buy candles and/or batteries as part of a weekly or fortnightly grocery shop; these households had purchasing frequencies of 2-4 per month and relatively high travel times (up to 100 minutes in rural areas, and 30 in urban). The second reported habit was to purchase candles and/or batteries on an as-needed basis from a neighbourhood shop. These households had purchasing frequencies of 15-30 per month, and travel times of less than 15 minutes. The frequency of use of mobile phone charging facilities was similar across rural and urban households; this frequency is likely governed by the number of days the phones' batteries last.

Monetary travel costs are not reported here; very few households paid for transport to purchase energy, and those that did were the households that combined their energy purchases with other necessary trips.

With the decrease in use of candles and batteries, the reported frequency of purchases and hence total time spent travelling also decreased sharply. However, this was replaced by the travel time to hubs.

Table 3.10: Purchasing patterns for PAYG SHS tokens

	Average frequency of token purchase at hub/month	Total time taken travelling to purchase tokens/month
All users	3.1	82.6
Rural users	1.1	75
Urban users	4.4	90.7

The total travel time for rural users was slightly lower than for rural households in general. For urban households it was slightly higher. This can be explained by the fact that urban households stuck to the practice of purchasing energy little and often. However, because hubs are more sparsely distributed than shops selling candles and batteries, their travel times increased. Further evidence that there is here a misalignment between the existing socio-technical practices and those of the PAYG SHS come from the non-user surveys, where just under 70% respondents reported that they believed travelling to purchase tokens would be 'somewhat inconvenient' or 'very inconvenient'.

3.3.2 Mobile money

The theory of mobile money enabled PAYGO is that people do not have to travel to make payments. However, this only works if there are mature mobile money services which people are willing to use. MNO's report penetration of mobile money services in Zambia to be up to 30% of adult population. However, Interview 3 suggested that this was something of a distortion. MTN and Airtel customers with a sim card and compatible phone are now automatically registered for a mobile money account, which gives an artificially high user count. One Airtel employee gave a rough estimate that the number of active users is actually closer to 2%. This study found that 20% of respondents used mobile money. However, of this 20%, average usage frequency was less than once per week. Furthermore, the areas surveyed are relatively well serviced by MNO's in terms of mobile money kiosks and signal coverage, and are heavily advertised to (Interview 2). However, respondents still frequently cited lack of knowledge about mobile money services (65%), inconvenience of adding money to accounts (30%) and lack of signal coverage (33%) as key barriers to them using mobile money. It therefore seems likely that penetration rate would fall further as distance from population centres increases and the level of service from MNOs decreases. A further barrier cited by 32% of respondents was that they did not feel any benefit of using it because there were so few other people to transact with. Taken in combination, these factors suggest that mobile money services in Zambia are a long way behind those in East Africa.

3.4 Summary and Discussion

Three main 'sets' of socio-technical practices emerge from the data. They belong to three different types of households: those with a grid connection who experience shedding, those with a grid connection who do not experience load shedding, and those without a grid connection. Each set of practices have differing degrees of alignment with PAYGO SHS, which will be discussed in turn.

In the first set, a household's energy practices revolve around having a grid connection. It provides electricity for lighting, charging phones and for television, as well as for fridges and stoves, and as such fulfils the function of enabling activity within the home after dark, communication and entertainment. Such households light their homes for around 5hrs a day. Regular load shedding impedes the fulfilling of these functions through grid electricity for households in Lusaka, and so they purchase candles and/or batteries to reduce load shedding's impact. While this allows them to keep lighting hours constant, the quality of light is reduced: while essential housework can go on, it becomes more difficult to do income related work, and for children to study.

The functionality of the PAYGO SHS means that it is aligned with the practice of having a back-up source of energy ready for periods of load shedding to provide lighting for essential tasks. It stretches this practice in that the quality of light is better, allowing a greater range of activities to continue during load shedding, including children studying and income related work. Furthermore, it enables users to charge phones during periods of load shedding. For these households, being able to use electricity during load shedding also provided a sense of social upliftment. Users enjoy appearing 'advanced' when people notice their electric lights during load shedding, and feel 'somehow important' when others come to charge phones at their house.

Households attempt reduce the inconvenience of paying for electricity by judging how much they will use in a month, and purchasing just one prepaid token of that amount. 89% of these households are from urban areas, and so more likely to make other energy purchases either on a day by day as needed basis, or weekly. Even though the SHS largely replace these other sources, temporally, purchasing patterns seem to remain the same. As VITALITE hubs are far less widely distributed than shops selling candles and batteries, this increases the time spent travelling to make energy purchases. So while the PAYGO system enables users to continue with their existing practice of purchasing energy little and often, it increases the time-cost of this practice.

From an affordability perspective, the view is mixed. As previously stated, the PAYGO payment plan allows the flexibility for users to continue paying for energy in a pattern as before. The total cost for users also seems align very well with existing spending. The monthly cost of an SHS on an 18 month payment plan is K120[1]. The average monthly expenditure by users on the back up sources of energy that it replaces is K117. However, the average monthly income of a user with a grid connection is 58% higher than that of non-users with a grid connection. Despite this, average expenditure on energy sources other than grid electricity is very similar for user and non-user households, at K119. It is possible therefore that the upfront cost, the K300 commitment fee which is proving a barrier to lower income households: while 97% of non-users

[1] All respondents were on an 18 month plan

with a grid connection believed that the flexible PAYGO payments made the system more affordable for them, only 43% thought that the SHS was affordable overall, commenting that they were 'committed to other things', and that it would 'take some time to save up' to pay the K300.

The second set of practices are very similar to the first set, but from households living in the rural areas around Lusaka with a grid connection. For these households, load shedding is not an issue. They therefore do not tend to buy candles or batteries, and as such have little need for the SHS; it fulfils fewer functions than a grid connection, and neither does it provide the opportunity for these households to engage in new practices or stretch existing ones.

The third set of practices are observed by households without a grid connection. Although they only represent 36% of participants in this study, such practices could represent up to 80% of households in Zambia (Lemaire, 2009). Energy for lighting is provided by candles and/or batteries. They are used to provide an average of 3.9 hours of light/day. The poor quality of the light means that income-related work hours and children's study hours are low. Phones tend to be charged either at neighbours' houses or places of work. However in rural areas where it is less likely to have neighbours or a place of work with electricity, some use paid-for charging facilities. The PAYGO SHS completely fulfils all these energy functions, as evidenced by the fact that for this group of users, expenditure on other energy sources after purchase of an SHS falls by 85%. The SHS also allows them to be stretched significantly, by providing higher quality lighting, as evidenced by figure 3.1.

The majority of these households surveyed lived in rural areas. As such, candles and batteries are more likely to be purchased as part of a general grocery shop once or twice a month than on a daily or weekly basis. This practice is transferred to their purchase of tokens for the SHS. The frequency of energy purchases and the average total travel time for energy purchases in fact falls after purchase. One user provided a potential explanation for this phenomenon, stating that now he had the system he could 'budget more precisely', both financially and in terms of energy use. Rather than estimating how many candles and batteries he would need in a month or a week and sometimes running out, necessitating further trips, he could pay for the precise number of day's electricity that he would need or could afford.

Again, the affordability perspective is mixed. The positive aspects are very similar to those for the first set: the flexibility of PAYG allows people to match their existing energy spending pattern, both in terms of frequency and travel time as discussed previously, and also total amount. Users in this category had a reduction in spending on other sources of energy of K138.31/month, compared to the PAYGO payments of K120/month. However, the average monthly income of the mainly rural households in this group was K2015, 162% higher than the rural household average of K769. For non-users without a grid connection who still had some monthly energy expenditures, those expenditures were K44/month on average, meaning that a PAYGO SHS would necessitate a K74/month increase, or just under 10% of average monthly income. Only 27% of respondents without a grid connections perceived the system to be affordable for them.

One affordability issue which affects a large proportion of households using the third set is that of variable income. Rural households' income are likely to vary seasonably due to dependence on agricultural produce. The average fluctuation of monthly income reported by rural households in this study was ±40% of mean monthly income. That is, if their mean monthly income was K1000, then income for a given month might be expected to be anywhere between K600 and K1400. This has knock on effects for the amount that they are able to spend on energy products in any given month. This was reflected in rural participants' responses to questioning about their perceptions of the penalties applied for missing payments on their SHS. Their answers were indicative of a hand to mouth existence, with difficulties accommodating unexpected expenses, and they felt that the penalty system was unfair and did not take this into account. The phrase 'it takes time to find money' or some very close variation was used by 69% of rural users, but did not feature once in the responses of urban participants. Several participants who used this phrase went on to elaborate that if a crop failed, or they had some unexpected expense such as a funeral during a low income (one where they are growing, rather than selling produce), then it would take them several months to recover, during which time they could easily miss enough days to incur a penalty or even forfeit the system.

4. VITALITE's actor-networks

VITALITE's actor-networks can be split into four sub-networks: supply networks, operation and distribution networks, customers, and other actors such as regulatory bodies and other solar companies in Zambia. This chapter will focus on operation and distribution networks. Interview 1 revealed supply networks to be in relatively good health, while the PAYG SHS space is not yet well developed enough in Zambia for government actors to take interest or other solar companies to have a significant influence. Furthermore, several sources emphasise that the depth and breadth of operation and distribution networks for existing PAYG SHS suppliers in East Africa have been critical in their success (Alstone et al. 2015), (Nique & Smertnik, 2015), (Rollfs et al., 2014a). The depth is ensured by ensuring that actors in the network have as strong a stake as possible in providing appropriate service to the companies' customers, as well as the capacity to deliver that service. Given that PAYG SHS have been designed in part to combat the barriers to electrification posed by geographical remoteness, it is also necessary that operation and distribution networks have the breadth appropriate for that task. In East Africa the support of MNOs has been vital in this regard, in terms of providing the capacity to process payments quickly and efficiently, and providing solutions to geographical remoteness by the leveraging existing distribution networks and branding.

4.1 MNOs

The support of MNOs is vital for being able to process payments through mobile money efficiently, which requires Application Programme Interface (API) integration. Without this, if customers want to pay for tokens through mobile money then VITALITE staff have to manually check VITALITE's mobile money account, then process the token through Lumeter, which is both time consuming and results in a significant time delay for the customer receiving their token. Nique & Smertnik (2015) remark upon the potential synergies between MNOs and PAYG companies. MNOs' mobile money services rely on high volumes of low value transactions to be profitable (Jack & Suri, 2011); PAYG companies have the potential to drive this high volume of transactions. M-KOPA already provides Safaricom's m-Pesa service with over 10,000 transactions per day (M-KOPA, 2015). Mobile money is in desperate need of a kick-start in Zambia. However, interviews 1 and 3 suggested that neither MTN nor Airtel acknowledge the potential of PAYG energy to drive mobile money growth, and as such are not especially invested in their role in the PAYG SHS niche in Zambia. Interview 3 also reported that this problem is further exacerbated by the high turnover of staff at MNOs, which results in difficulties recruiting them to the goals of the niche. As a result of these factors, API integration with Airtel took around six months longer than anticipated, while it still has not been delivered by MTN.

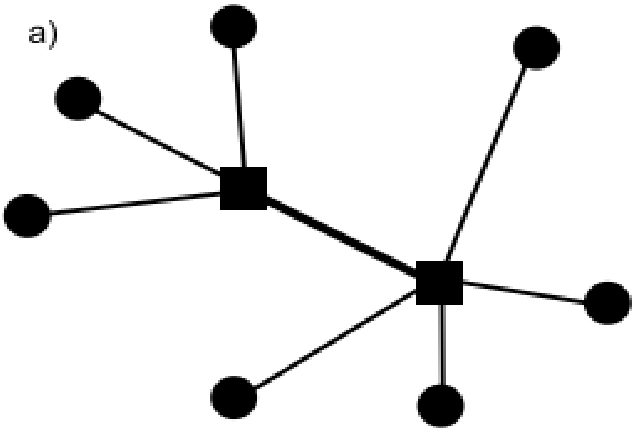
Furthermore, mobile money is still in its infancy in Zambia, and it remains very unclear which, if either of Airtel and MTN will be most successful in implementing mobile money services. As such, entering into a deep, exclusive partnership with one or the other represents a high risk, and would represent an additional barrier to uptake by restricting customer choice.

4.2 Alternative operation and distribution networks

The backbone of VITALITE's current distribution and operation network are the SSRs. The depth of the relationship is primarily secured through the fact that they are employees of VITALITE, over whom the company have a high degree of oversight due to the digital nature of the business (Krolikowski, 2014). All actions relating to PAYGO SHS are logged and tracked through Lumeter. It is therefore relatively easy to spot unusual activity or gaps in activity, and take appropriate action. They are given extensive training to ensure they have the capability to instruct customers on the operation and maintenance of their system. Weekly meetings allow discussion and resolution of any issues, and for the SSRs to give feedback and advice both to each other and to management, which helps engender a sense of ownership and belonging.

However, hubs are relatively costly to operate, and difficult to manage across large distances: they require two fulltime staff, rent and maintenance (Interview 2). To reach large proportions of VITALITE's target market in rural Zambia, and provide customers with the ability to purchase tokens in a way which is no more difficult or costly than their existing energy practices would require an unfeasibly large number of hubs in remote locations. If VITALITE are to succeed without the deep relationships with MNOs and without a mature mobile money market, their hubs need to be true to their name and operate within a 'hub and spoke' model. If the hubs and spokes of MNOs networks cannot be leveraged in the same way as in East Africa, then VITALITE need to develop their own network.

Figure 4.2: Basic hub and spoke network. The squares represent hubs, the circles 'micro-franchisees', connected to the hubs by spokes (Anderson & Klupp, 2008), (Kemmeny et al. 2011, p. 23).



Initially the micro-franchisees were mobile agents. Commitment from these agents was intended to be engendered through their commission structure. In order to take systems to sell, they must deposit the commitment fee for those systems (K300) into a Lumeter account, and must take a minimum of three systems, meaning a total deposit of K900. For each system they sell, they receive the K300 commitment fee from the customer, plus K75 commission to their Lumeter account. For tokens purchased by customers, agents receive a 5% commission.

However, the credit in Lumeter can only be used to pay the commitment fee for more systems. This means that agents are committed to sell at least 4 systems to make a cash profit. They are required to give customers the same level of instruction as SSRs. As such, prospective agents also need fairly extensive training in how to use Lumeter, and how to operate, maintain and teach the system.

However, VITALITE found that customers were not getting all the appropriate information, especially regarding repayment schedules and loan agreements (Interview 2). While VITALITE had good oversight over some aspects of agents' behaviour through Lumeter, they had less oversight over the teaching aspect. In response to this, new two day training programmes have been implemented, ending with an exam with a fixed pass mark for becoming an agent. Furthermore, many agents were not selling enough systems after the initial four to justify the costs of running them. A suggested reason for this was that the lack of awareness surrounding PAYGO SHS means that selling systems incurs high time and travel costs, and so individual agents struggled to sell at a fast enough rate for their commissions to adequately compensate them for the work required. Furthermore, for an individual mobile agent, the travel cost of reaching a customer who wished to purchase a token could easily outweigh the commission. VITALITE's focus is now therefore on recruiting agents with an existing shop or retail business, as well as attempting to create partnerships with established, nationwide distributors (Interview 1).

One such organisation is NWK, an agri-services company. It has over 100 national depots, and being an agri-services company, these are largely in rural areas which VITALITEs's hubs would struggle to serve. Again, their commitment to the success of VITALITE's PAYGO SHS is motivated by the commission earned, which is the same as for individual agents. However, it is hoped that they will be able to leverage their existing infrastructures, networks and customer bases to drive greater sales volumes and reduce the cost per sale, resulting in the K75 commission being sufficient to create a deeper commitment. (Interview 1). Furthermore, given the established nature of the potential partner organisations, and the minimal costs of holding the SHS in stock, partner organisations do not need to immediately sell large numbers to generate an income. This approach comes closer to the MNOs 'micro-franchisee' model, in that it combines economic incentives, training and leveraging of existing distribution networks to reduce the geographic barriers to last mile distribution.

4.4 Discussion

VITALITE's distribution and operation networks are given depth by ensuring all participants have a stake in the success of PAYG SHS. All PAYG distributors need high levels of penetration to provide consistent, long term revenue streams from commission on token purchases. This also requires them to maintain and operate existing SHS to a high standard, which VITALITE give them the training to do. VITALITE also have a high degree of oversight over their distribution and operation networks thanks to the digital nature of the payment system.

The lack of commitment and engagement from MNOs means that VITALITE cannot leverage their agent networks, customer base or branding in the same way that PAYG SHS in East Africa could, reducing the starting breadth of their distribution and operation networks. While data on energy and token purchasing patterns suggests that their current model is operating well, Lusaka and the surrounding rural areas are unusually densely populated, and so a small number of hubs and agents can serve a large population. However, in order to increase overall penetration in Zambia and reach more isolated populations VITALITE therefore need to grow their own distribution network. This requires recruiting a high number of capable new agents, which presents a challenge. Education outcomes in Zambia are poor, and the proportion of GDP spent on education is just 0.8% (The World Bank, 2015). Interviews 1 and 2 both reported that as a result of this, finding agents who are capable of fulfilling the requirements of the role is difficult.

It is therefore unlikely that PAYG SHS will spread in Zambia as quickly as in East Africa. This may well have an effect on the commercial finance available to the PAYG SHS niche in Zambia, by reducing its attractiveness to investment by reducing returns speed and increasing risk. Inability to raise capital poses a serious challenge to PAYG SHS. It is a very capital intensive business (Interview 1). Essentially the financial burden of providing energy services fall on the company providing PAYG SHS until the initial sales cost has been recouped, which can be up to 24 months (Interview 1), (Nique & Smertnik, 2015). This puts a strong pressure on cash flow. In order to expand and maintain the supporting infrastructure PAYG SHS therefore need access to debt financing or outside sources of working capital. VITALITE currently rely on donor funding, but this may only supply a fraction of the working capital required, and is insecure; funding cycles tend to only last for a couple of years, and the orientation of funding bodies frequently changes, depending on the vogue development tool of the moment. Fenix and MKOPA both secured upwards of £10million in commercial investment and debt financing within two years of beginning operations enable them to scale to their current size (M-KOPA, 2015), (Wesoff, 2015). Their partnerships with MNOs, giving them already established distribution networks, customer base, branding and payment platforms meant they were viewed as less risky.

5. Conclusions

5.1 Towards widespread, transformational change

Perhaps the most important aspect of VITALITE's PAYGO SHS that suggests that it can drive widespread, transformational change is the extent to which it aligns with existing socio-technical practices of energy consumption for the majority of the Zambian population, and provides opportunities to stretch those practices and develop new ones. By reducing the price of electricity, it enables the bottom of the pyramid to be treated like consumers, giving them an entry point to electro-capitalist markets.

The alignment with existing socio-technical practices results from the system begin able to fulfil the same functions as the main energy sources of the current regime: batteries and candles for lighting, and electricity supplied to other people (whether paid for or not) for charging mobile phones. Stretching these practices is enabled through the higher quality of lighting that the system provides. Evidence from users suggests that the system does indeed bring the some of the key co-benefits of electrification. Time children spent studying and time engaged in productive activity both increased. Rural users benefited from the increased connectivity brought by the radio. The adaptability of the system is also a potential driver of widespread transformational change, as evidenced by the variety of sets of socio-technical practices it aligns with and stretches, such as being able to take it between business and home.

PAYGO SHS also helps overcome the barriers of remoteness. In terms of economic remoteness, even if it does not reach the very bottom of the pyramid, (as will be discussed in the following section), its standalone, decentralised nature means that it can reach into communities where grid electrification would be uneconomical. The supporting infrastructure required to reach each new community has a low cost: that of training a new agent to operate in that community. Once that has occurred, then the agent acts as a conduit to the rest of the supporting infrastructure: via their mobile phone they connect their community to the digital infrastructure of PAYG, which in turn gives VITALITE a mechanism and oversight through which to extend finance for energy to those communities. Geographic remoteness is reduced in the same way. To a certain extent, political remoteness becomes a non-issue, as decisions over who gets electrified are taken out of the hands of politicians.

5.2 Barriers to widespread, transformational change

However, some barriers to widespread, transformative change still remain. The two largest barriers are the issue of affordability, and the issue of creating an effective distribution and operations network without the assistance of a mature mobile money service or the deep support of MNOs.

While the daily payments match existing energy expenditure well, the commitment fee still presents an insurmountable barrier to many Zambians. For rural Zambians dependent on agriculture, the variability of their income, combined with the penalties for missing both cumulative and consecutive days present another affordability barrier.

The issue of the commitment fee is fairly easy to solve; JF and SB reported that K300 was 'at the high end', and that there was scope for reducing it. Further investigation would need to be done to uncover the point at which the commitment fee acts as a barrier to those who cannot afford the daily payments, but not to those who can.

The issue of variable income is more difficult to solve. Mobisol run education programmes on budgeting, encouraging farmers to make higher payments when in their high income months (Interview 1). This could also be combined with encouraging those with variable income to choose the 24 month plan, to give them more flexibility in the amount they have to pay. May rural respondents gave the opinion that a longer grace period, of between 60 and 90 days would be more appropriate, as after an unexpected expenditure or loss of income, 2-3 months was the amount of time they expected it to take to recover. However, increase in the length of the grace period would have to be balanced against issues of cash flow, repayment enforcement and credibility for VITALITE.

The agent and partner distribution model has the potential to be successful, as evidenced its success in other contexts, and the oversight that VITALITE has over its agents. The difficulty lies in the fact that these networks will have to be created from scratch, and that the agents will require fairly extensive training. Its likely success will be dependent on whether the networks can be grown quickly enough, with a high enough level of human capital at an appropriate cost to increase penetration to an extent where VITALITE becomes an attractive investment option for commercial investment and debt financing.

5.3 Concluding Remarks

Electrification through PAYG SHS has underpinned widespread transformative change in East Africa by enabling the BoP to participate in the socio-technical and socio-economic practices of electro-capitalism. The bridging capacity of mobile phones and their associated infrastructure has created an environment in which this is possible, while the precise matching between existing socio-technical practices and those which surround use of PAYG SHS as enabled fast and deep proliferation. In Zambia, the alignment between existing energy practices and PAYG SHS still exist. However, the enabling environment provided by MCTs and MNOs is far less mature. As such, the pace of change in Zambia is likely to be much slower. However, given the positive impact and affordability of PAYG SHS, if networks for widespread distribution can be created, that change could indeed be transformative.

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Appendix I: User Interview

VITALITE PAYGO customer survey

User Name: **Occupation:** **Area:**

PAYGO ID:

Section 1: Background, Energy Usage and Expenditure

1. **How many people live in your household?**

2. **a) How much is your average monthly household income?**

   b) How much does this vary?

3. **Do you have a grid (ZESCO) connection?**

4. **Do you own any other solar products?**

   Number of solar lanterns:

   Number and features of Solar home systems:

   Other:

5. **Do you have a diesel or petrol generator?**

6. **What electrical appliances do you own?**

7. a) How much did you spend per month on other energy products before you bought the Vitalite system?

Source	Amount (K)
Zesco electricity	
Fuel for a generator	
Other solar products	
Candles	
Batteries	
Kerosene	
Mobile phone charging	
Charging or using a Radio or TV	
Other:	

b) How much do you spend per month on these products now?

Source	Amount (K)
Zesco Electricity	
Fuel for a generator	
Other Solar Products	
Candles	
Batteries	
Kerosene	
Mobile phone charging	
Charging or using a Radio	
Using a TV	
Other:	

8. How often did buy/pay for these sources? How much time and money did you spend on *travel* for each trip?

Source	Frequency (per month)	Amount (K)	Time (minutes)
Electricity			
Fuel for a generator			
Other solar products			
Candles			
Batteries			
Kerosene			
Mobile phone charging			
Charging or using a radio			

Using a TV			
Other:			

9. **How often do you buy/pay for these sources now? How much time and money do you spend on *travel* for each trip?**

Source	Frequency (per month)	Amount (K)	Time (minutes)
Electricity			
Candles			
Batteries			
Kerosene			
Mobile phone charging			
Charging or using a radio			
Using a TV			
Other:			

10. **Which of the following do you think best describes your experience of the system (choose one option from section A, one from B.**

A

Saves you money and is more convenient than other sources of energy	
Saves you money but is less convenient than other sources	
Does not save you money but is more convenient than other sources	
Does not save you money and is less convenient	

B

Provides all of your energy needs during load shedding	
Provides some of your energy needs during load shedding	
Provides an insignificant amount of your energy needs during load shedding	
Is too expensive to use as a backup during load shedding	
Load shedding is not an issue for me	

Section 2: Paying for the system and mobile money

11. a) How frequently did you use mobile money before you purchased the system? On which service provider?

Frequency (per month)	Provider

b) How often do you use mobile money to buy tokens for your system?

Frequency per month:

c) How often did you add money to your mobile money account before you bought the system? And now? How much time and money did you spend on travel for each trip? And now?

	Frequency (per month)	Amount (K)	Time (minutes)
Before system purchase			
Now			

12. a) Do any of the following prevent you using mobile money more frequently in general? (Choose a maximum of 3)

Transaction fee is too high	
Don't trust the system	
Not aware of it	
Adding credit is too inconvenient	
Lack of signal coverage	
Don't know how to use it	
None	
Other:	

b) Are there any other factors that prevent you from using mobile money to buy tokens for your system?

13. a) How often do you buy tokens for your system at a Vitalite hub? How much time and money do you spend on *travel* for each trip?

Frequency (per month)	Amount (K)	Time (minutes)

b) How often do you buy tokens from a mobile Vitalite agent who visits your area?

Frequency per month:

14. How do you feel about the penalties for missing 30 then 60 then 90 days of payment?

15. Have the PAYGO payments altered your spending on any products other than energy and lighting products?

Section 3: Using the system

16. a) When you bought your system, did you receive training or instructions on how to install it, use it and make payments?

b) Afterwards, how confident did you feel in each of these aspects?

Installation	Very confident	Somewhat confident	Somewhat unconfident	Very unconfident
Usage	Very confident	Somewhat confident	Somewhat unconfident	Very unconfident
Making Payments	Very confident	Somewhat confident	Somewhat unconfident	Very unconfident

17. How frequently do you use each of the functions of the system?

Function	Frequency (days per week)				
	6-7	4-5	2-3	1	<1
LED Lights					
Solar Lantern					
Mobile phone charging					
Radio					

18. Does this vary? What factors affect how much you use the system week-by-week?

19. **a) How many hours/day did you light your home before you bought the system? For how many do you light your home now?**

	Hours/day
Before purchase	
After purchase	

b) How many of your current lighting hours are provided by the Vitalite SHS?

Hours/day:

20. **a) How many hours per day did children spend studying in your house before you bought the system?**

Hours/day:

b) How long do they spend studying now?

Hours/day:

21. **a) How long did people spend doing income-related work in your household before you bought the system?**

Hours/day:

b) How long do they spend now?

Hours/day:

22. **a) How long did people spend doing housework (including cooking) in your house before you bought the system?**

Hours/day:

b) How long do they spend now?

Hours/day:

23. **How much has your household's use of mobile phones changed since you bought the system?**

Large increase	**Small increase**	**No change**	**Small Decrease**	**Large Decrease**

24. **a) Have you ever had any problems using or paying for your system? Could you describe them?**

b) How did you resolve them?

c) How satisfied were you with the way in which they were resolved?

Very satisfied	Somewhat satisfied	Somewhat dissatisfied	Very dissatisfied

25. a)What other features would you like from a solar home system (please rank from one to 5)?

Features	Ranking
More lights	
More mobile phone charging points	
TV	
Refrigerator	
Longer battery life	

b) Are there any other additional features you would like?

d) Would you be willing to pay more for these features? How much more?

26. What other changes has the system brought to your life? Are these positive, neutral or negative changes?

Appendix II: Non-user Interview

VITALITE non-user PAYGO survey

Home area: **Occupation:**

Section 1: Background, Energy Usage and Expenditure

1. **How many people live in your household?**
2. **a)How much is your average monthly household income?**

   b) How much does this vary from month to month?
3. **Have you heard of Vitalite?** (If no, skip to question 7)
4. **How did you hear about Vitalite?**
5. **What do you know about Vitalite products?**
6. **Are you aware of Vitalite's PAYGO Solar Home System?**
7. **Do you have a grid (ZESCO) connection?**
8. **Do you own any solar products?**

   Number of solar lanterns:

   Number and features of Solar home systems:

   Other:
9. **a) Do you have a diesel or petrol generator?**
10. **What electrical appliances do you own?**

11. a) How much do you spend per month on the following energy sources?

Source	Amount (K)
Zesco electricity	
Fuel for a generator	
Solar products	
Candles	
Batteries	
Kerosene	
Mobile phone charging	
Charging or using a Radio or TV	
Other:	

12. How often do you buy/pay for these sources? How much time and money do you spend on travel for each trip?

Source	Frequency (per month)	Amount (K)	Time (minutes)
Electricity			
Fuel for a generator			
Candles			
Batteries			
Other solar			
Kerosene			
Mobile phone charging			
Charging or using a radio			
Using a TV			
Other:			

Section 2: Mobile money

13. a) How frequently do you use mobile money? On which service provider?

Frequency (per month)	Provider

b) How often do you add money to your account? How much time and money do you spend on travel for each trip?

	Frequency (per month)	Amount (K)	Time (minutes)
Before system purchase			
Now			

14. a) Do any of these factors prevent you using mobile money? (Choose maximum 3)

Transaction fee is too high	
Don't trust the system	
Not aware of it	
Adding money to my account is too inconvenient	
Lack of signal coverage	
Don't know how to use it	
None	
Other:	

Section 3: Perceptions of VITALITE's PAYGO SHS

*****Provide VZ PAYGO SHS Information Sheet*****

15. What are your initial thoughts on the system?

16. Do you think the VZ system would:

Save you money by replacing all of your spending on other energy sources?	
Save you money by replacing some of your spending on other energy sources?	
Not save you money but be more convenient than current sources	
Not save you money and be less convenient	
Provide all of your energy needs during load shedding	
Provide a some of your energy needs during load shedding	
Provide an insignificant amount of your energy needs during load shedding	
Be too expensive to use as a backup during load shedding	

17. **What features would you most like in an SHS? (Please rank from 1st choice to 5th choice)**

Features	**Ranking**
Lighting	
Mobile phone charging points	
TV	
Refrigerator	
Radio	

18. **How true are the following statements for you?**

a) **The system is affordable for me**

Very true	**Somewhat true**	**Somewhat untrue**	**Very Untrue**

b) **The system would be affordable for me if it could replace more of my other energy sources**

Very true	**Somewhat true**	**Somewhat untrue**	**Very Untrue**

c) **The flexible payment system makes the system more affordable for me**

Very true	**Somewhat true**	**Somewhat untrue**	**Very Untrue**

d) **Travelling to purchase tokens would be a great inconvenience**

Very true	**Somewhat true**	**Somewhat untrue**	**Very Untrue**

e) **I would be likely to use mobile money to purchase tokens**

Very true	**Somewhat true**	**Somewhat untrue**	**Very Untrue**

f) **I would feel uncomfortable taking out a loan like this**

Very true	**Somewhat true**	**Somewhat untrue**	**Very Untrue**

19. **How likely are you to purchase a Vitalite PAYGO SHS in the future?**

Very Unlikely	**Somewhat unlikely**	**Somewhat likely**	**Very likely**

20. What improvements would you make to the system?

21. How likely would you be to purchase the system if these improvements were made?

Very Unlikely	**Somewhat unlikely**	**Somewhat likely**	**Very likely**

22. a) How many hours/day do you light your home with electricity, candles or batteries?

23. a) How many hours per day do children spend studying in your house?

Hours/day:

24. a) How long do people spend doing income-related work in your household?

Hours/day:

25. a) How long do people spend doing housework (including cooking) in your house?
Hours/day:

26. **How many mobile phones does your household own?**

27. Do you have any other comments about:

The affordability of the system:

The usefulness of the system:

Appendix III: Non-user info sheet

- fosera high tech solar panel
- fosera LSHS 1500 battery pack
- fosera lamp 200 lumen
- fosera lamp 100 lumen
- Sun King Eco portable solar lamp
- Solar charged radio with USB and memory card input
- Phone charging set with 4 different outlets for any phone
- Infrared remote control
- 2 year warrantee on the full system* and customer care from VITALITE

* The radio has a one year warrantee

Pay a minimum commitment fee of 300, then make regular payments on one of the following payment plans:

(there is also the option to purchase the system for a one off 'cash and carry' payment of K 1750)

PAYGO PLAN	12 MONTHS (358 DAYS)	18 MONTHS (540 DAYS)	24 MONTHS (723 DAYS)
DAILY PAYMENT	K 5	K 4	K 3
WEEKLY PAYMENT	K 35	K 28	K 21
TOTAL COST	K 2090	K 2460	K2469
DISCOUNT when paying within 12 months		K 300	K 300

For any questions please contact Vitalite:

+260 97 6147432 +260 96 7147432 +260 95 5147432

Or visit the Head Office in Rhodespark, Lubwa Road 15, Opposite International Labour Organisation (ILO)

Your regular payments contribute towards the total cost of the system, and also provide you with the tokens you need to operate the system.

For example:

If you are on the 18 month plan and pay K4, you will receive a token to operate your system for one day. If you pay K12, you will receive a token to operate your system for 3 days. If you miss days, the system will turn off.

Once you have purchased enough tokens to meet the total cost, you will completely own the system and it will be unlocked permanently for you to use as you choose. If you are on the 18 or 24 month plan and make the total payment within 12 months, you will receive a K300 discount.

You can buy tokens either:

At one of Vitalite's hubs, located at the following locations in Lusaka: Chipata Compound, Kanyama, Matero, Mtendere and Chawama and in Monze and Chipata Town,

from a Vitalite agent,

or

you can pay with Airtel Money.