# Developing Sustainable Product-Service System Business Models for Energy Provision in South African Urban Informal Settlements

**by**

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# DECLARATION

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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# ABSTRACT

Deep socio-economic inequalities are still a reality in spite of South Africa being regarded as an upper-middle-income country. Informal settlements, in particular, reflect these inequalities. It is estimated that 10 per cent of the population live in rural or urban informal settlements. Urban informal settlements are the fastest-growing household sector in South African cities, accommodating more than 4 million people. Although these dwellers might have secured a living space in urban society, they are still excluded from city amenities and suffer tremendous hardships. Providing sustainable energy services to these communities is a complex and challenging undertaking. Blanket, national grid electrification policies are incapable of adequately serving the various types of informal settlements, each offering unique challenges. A singular inflexible technology supply response does not consider the dynamic and highly unpredictable nature of the urban informal community fraught with challenges and market barriers. To address this challenge, both governmental and non-governmental enterprises started operating in this space by providing energy through alternative means than that of the grid. Product-service system business models offer a promising solution to the market barriers existing in the informal context, due to the consideration of sustainability, multi-stakeholder collaboration and end-user desirability.

This study set out to develop a tool to consider the multiple trade-offs in the urban informal context for developing a sustainable product-service system business model. A framework (manifesting as a tool) was developed using an adapted grounded theory methodology – the conceptual framework analysis technique. The usefulness of the developed tool was tested during a focus group with experts in the energy sector. Within the focus group environment, the tool successfully achieved the development of a sustainable product-service system business models by allowing the experts to visually map out the various trade-offs. Considered among the multiple trade-offs were the energy needs and desires of an informal community. The information was gathered by distributing a questionnaire to 100 participants living in an urban informal settlement. These were collected using a questionnaire administrated by three field researchers. A post-focus group evaluation survey revealed experts see much potential in the developed framework.

Thus, using the framework developed in this study, new and existing energy provision enterprises can be assisted to provide sustainable energy services to the urban poor.

# OPSOMMING

Hoewel Suid-Afrika as 'n boonste middel-inkomste land beskou word, is daar steeds diep sosio-ekonomiese ongelykhede tussen verskillende groepe mense. Informele nedersettings, spesifiek, reflekteer hierdie ongelykhede. Na raming leef ongeveer 10 persent van die bevolking in haglike omstandighede in informele landelike of stedelike nedersettings. Stedelike informele nedersettings is die vinnigste groeiende huishoudingsektor in Suid-Afrikaanse stede met ongeveer 4 miljoen inwoners. Hoewel hierdie groep mense nou wel deel is van die stedelike samelewing, is hulle nog uitgesluit van die stedelike voordele en is blootgestel aan erge ontberinge. Die verskaffing van volhoubare energie dienste aan hierdie stedelike gemeenskappe is kompleks en vol uitdagings. Die historiese gebruik van 'n nasionale elektrisiteitsvoorsieninsprogram vir beidie formele en informele energie verskaffing is nie in staat om die verskillende tipes nedersettings, met unieke omstandighede, voldoende te voorsien nie. So 'n onbuigbare energie voorsieningsbeleid hou nie die dinamiese en onvoorspelbare karakter van die informele stedelike gemeenskap in gedagte nie. Regerings en nie-regerings organisasies het nou dus reeds begin om alternatiewe energievoorsieningsmoontlikhede te ondersoek. Deur die oorwgeging van volhoubaarheid, die samewerking met verskillende belangwekkende rolspelers, asook die eindgebruiker se behoeftes, verskaf produk-diens sisteem besigheidsmodelle 'n belowende oplossing vir die hindernisse van die informele konteks.

Die doel van hierdie studie was om 'n instrument te ontwikkel wat die veelvuldige kompromieë in die informele stedelike konteks in aanmerking neem vir die ontwikkeling van 'n volhoubare produk-diens sisteem besigheidsmodel. Die raamwerk, wat manifesteer as 'n instrument, was ontwikkel met die hulp van 'n aangepasde gegronde teorie metode – die konseptuele raamwerk analise tegniek. Die bruikbaarheid van die ontwikkelde instrument is gedurende 'n fokusgroep getoets met kenners in die energie bedryf. Die instrument was suksesvol om die kenners by te staan om 'n volhoubare produk-diens sisteem besigheidsmodel te ontwikkel deur die verskillende kompromieë visueel uit te beeld. Die energie behoeftes en begeertes van die informele gemeenskap was onder andere in ag geneem tydens die bespreking van die verskeie kompromieë. Die inligting rakende die gemeenskap se energie behoeftes en begeertes was ingesamel deur die verspreiding van 'n vraelys aan 100 huishoudings met die hulp van drie veldwerkers. 'n Evaluasie vraelys na afloop van die fokusgroep het getoon dat kenners in die energie bedryf baie potensiaal in die ontwikkelde raamwerk sien.

Die gevolgtrekking is dus dat die raamwerk wat in die studie ontwikkel is, kan help om nuwe en opwindende volhoubare energiedienste aan die stedelike armes beskikbaar te stel.

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May we all be driven by eternity - Soli Deo Gloria.

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**Avg. -** Average

**BOP** – Base of the Pyramid

**BMC** – Business Model Canvas

**BMO** – Business Model Ontology

**CFA** – Conceptual Framework Analysis

**DRE** – Distributed Renewable Energy

**EUC-BMC** – End-User-Centred Business Model Canvas

**MCDA** – Multi-Criteria Decision Analysis

**PSS** – Product-Service System

**SHS** – Solar Home System

**TBL** – Triple Bottom Line

## Important Terminology:

**Energy Services –** The manner in which energy supply is used in a household, such as cooking, lighting, space heating and so forth

**Informal settlement** – A settlement that is "…characterized by inadequate housing conditions; deficient urban services (water supply, sanitation, drainage, solid waste disposal, and roads and footpaths); unsanitary and dehumanizing living conditions; extremely high densities (of both people and dwellings); and, frequently, long travel distances to job opportunities" (Majale 2008:271)

# CHAPTER 1: BACKGROUND AND OVERVIEW OF STUDY

## 1.1 Background

Globally, the importance of access to energy was emphasised through the United Nations establishing it as a separate goal (No. 7) in their 2015 adopted Sustainable Development Goals (SDG). This SDG7 aims to ensure access to affordable, reliable, sustainable and modern energy services for all by 2030 (United Nations, 2016). Energy services indicate the manner in which energy supply is used in a household, such as cooking, lighting, space heating and so forth.

Access to energy is regarded as essential to achieving other development goals ranging from "eradication of poverty through advancements in health, education, water supply and industrialization, to combating climate change" (United Nations, 2016:11).

The majority of the 1.1 billion people without access to energy live in rural areas in developing countries (IEA, 2017). However, with rising urbanisation rates, the growing population of over 880 million people living in informal settlements in developing countries are increasingly attracting energy policy attention (UN -Habitat, 2016). With the second fastest-growing urban population globally, the cities of Africa are predicted to continue growing from a 40% urbanisation level in 2014 to a 56% urbanisation level in 2050 (UN-DESA, 2014). Most African governments are unable to meet the housing demand posed by the rapidly growing urban population, resulting in the proliferation of informal settlements.

The South African population is predominantly urban and urbanisation trends show that this will continue to increase. Currently, 64% of the country's approximate population of 52 million people, live in towns or cities and this value is expected to increase to 70% by 2030 (Statistics South Africa, 2011). As with other African governments, the South African government does not have the capacity to provide housing to all urban residents. As a result, informal dwellings are increasingly being established on whatever space can be found (and defended). Today, there exist approximately 2700 different informal settlements in South Africa (SACN, 2011).

Figure 1 illustrates that South African informal settlements can be categorised according to their formality, legality, legitimacy (from the state's perspective) and whether they were planned or not (Smit, Musango, Kovacic & Brent, 2017). The blue arrows in Figure 1 indicate that settlements evolve and/or devolve over

time; thus, the settlement types are not static. Providing service delivery such as electricity to these different informal settlements offers unique challenges for each type of settlements.
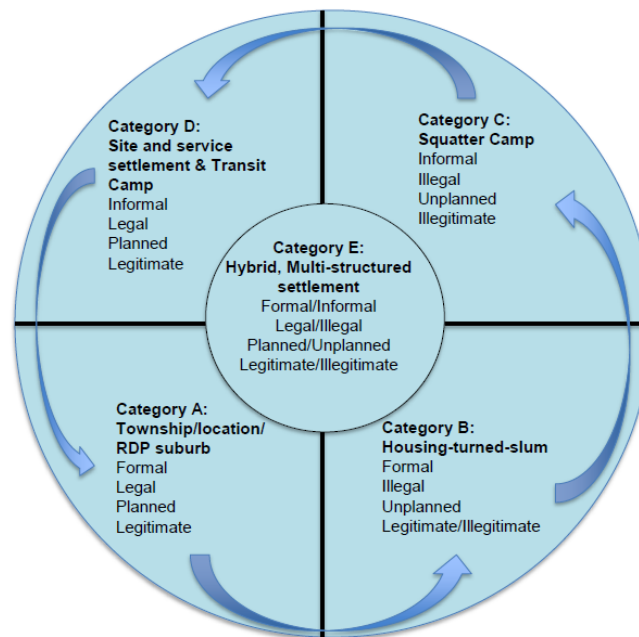


**Figure 1: Typology of South African urban informal settlements (Smit *et al.*, 2017:113)**

The provision of energy through grid electrification was previously reserved for formal housing. In an effort to accomplish energy access for all, the South African government opted to provide grid electrification to qualifying informal dwellings. Blanket, national grid electrification policies are ill equipped to address the diverse range of unique challenges existing in the different types of informal settlements (Gaunt *et al.*, 2012).

As a result, households living in informal settlements make up almost a third of the remaining electrification backlog (Tait, 2015). Those ineligible for grid connections rely on unclean use of fuels for cooking and lighting, buying electricity from their neighbours and stealing from the grid. This respectively results in commonly occurring fires and respiratory illnesses; paying more for electricity; a decrease in network stability as well as the risk of lethal electrocution (Sustainable Energy Africa, 2014). Those with a grid connection may still suffer from energy poverty as constrained networks in densely populated areas provide limited and/ or unreliable supply. In addition, poor households often experience irregular and varying sources of income that do not allow the purchase of enough electricity that would last them the entire month. Consequently, those living in informal settlements with a grid connection often also resort to using unclean fuels (wood, coal and paraffin) (Sustainable Energy Africa, 2014).

The global energy access initiative is building momentum, along with the consideration of the developing world adopting a clean, low-emission development path (Aitken, Thorne, Thorne & Kruger, 2015). To accomplish SDG 7 within informal settlements in South Africa and to alleviate energy poverty, a diversified energy supply response (beyond that of grid electrification) is necessary to ensure flexibility for the different and dynamic informal settlement contexts (Keller 2012; Tait, 2017; Sustainable Energy Africa, 2017; Wolpe

& Reddy, 2018). The alternative energy supply sources (such as mini-grids, gas and so forth) can either act as the primary means of access to those without- or those waiting for grid electrification; or act as a supplementary supply source to the grid. Pilot projects for both primary- and supplementary means of access have been conducted in South African urban informal settlements. These pilot studies were conducted by non-governmental enterprises (often in partnership with the local government) such as iShack and MicroCare as well as governmental enterprises (acting as a separate entity to the entity providing grid electrification) such as CityPower.

The urban informal context has multiple market barriers such as profitability and technical feasibility that needs to be overcome by these energy provision enterprises. Also, given the historical context of post-Apartheid South Africa, grid electrification is not merely regarded as a technical solution by those living in informal settlements, but a symbol of legitimacy and equality from the state (Smit, Musango & Brent, 2019). Given this preference for grid solutions, those living in informal settlements will evaluate any alternative energy solution very critically. Rejected alternative solutions have experienced vandalism through service delivery protests.

Runsten, Fuso Nerini and Tait (2018) argue the use of static guidelines and focusing on a single energy supply source would not be suitable to the dynamic circumstances within the different types of South African informal settlements. Instead, they focused on what were important trade-offs that needed to be considered to ensure sustainability when providing alternative energy solutions. As their study was limited to considering trade-offs for different energy supply options, they called for future work to make use of the business model lens to consider enterprise-wide trade-offs for the delivery of sustainable energy provision.

A business model is defined as the holistic logic of how an enterprise creates, delivers and captures value (Osterwalder, Pigneur, Clark & Smith, 2010). A business model can therefore be seen as a unit of analysis that allows the comprehension and analysis of the business logic of an enterprise (Adrodegari, Saccani and Kowalkowski, 2016). Multiple authors have utilised the business model concept as a conceptual tool to consider the various requirements energy provision enterprises have to address in low-income markets.

PSS (Product-Service System) business models, in particular, have been deemed promising to ensure sustainability when providing energy in low-income contexts (Da Costa Junior, 2013). A PSS is a specific type of value proposition that is not limited to products *or* services, but offers an integrated combination of *both* products and services that are jointly capable of fulfilling end-user needs. The mix of products and services is provided in a system consisting of "... networks of [stakeholders] and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models" (Mont, 2002:240). This description not only highlights the relationship between

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PSS business models and sustainability, but also suggests multiple-stakeholder collaboration and a focus on offering desirable solutions that meet end-user (informal settlements residents) needs.

## 1.2  Research Problem

It can be concluded there is a need for a tool that would assist an energy provision enterprise to consider the multiple trade-offs within the urban informal context to allow the development of a PSS business model that is sustainable, considers multi-stakeholder collaboration as well as end-user desirability. A careful study of the literature reveals that existing tools in literature address some, but not all of these requirements.

## 1.3  Research Aim and Objectives

After considering the background information, the aim of the study is to design a framework that facilitates the development of a sustainable PSS business model for energy provision enterprises in a South African urban informal context.

The above aim is supported by the following objectives:

Research Objective 1: Evaluate the context of energy provision in South African urban informal settlements with the aim of identifying concepts emerging out of the literature

Research Objective 2: Deduce a framework to assist in the development of sustainable PSS business models in the South African urban informal context

> Sub-Objective 2.1: Reduce the number of concepts (identified in Objective 1) by integrating and grouping the different concepts together
>
> Sub-Objective 2.2: Identify current tools available in literature and evaluate their adequacy in the context of this study
>
> Sub-Objective 2.3: Develop a framework (based on the evaluation findings of Sub-Objective 2.2) that adequately addresses the reduced concepts of Sub-Objective 2.1

Research Objective 3: Verify and validate the developed framework in the context of a specific case study

> Sub-Objective 3.1: Determine the energy supply mix realities and desires of households within urban informal settlements, using a specific case study
>
> Sub-Objective 3.2: Validate the developed framework with experts in industry, using a specific case study and formulate an adapted framework

## 1.4 Significance of the study

Local government, which is mandated with the provision of basic services including electricity, may use this study to inform the rollout planning and implementation of energy technologies in urban informal areas. This study comes at a time where municipalities in the Western Cape of South Africa are increasingly providing tenders to non-governmental energy provision enterprises that could act as interim service providers. The developed framework will assist new and current energy provision enterprises to develop their business models and assist them in considering the change they hope to bring to unserved communities – it will therefore contribute to their success and lead to improved living conditions in these communities.

This research adds to understanding the energy consumption patterns, preferences and perceptions of urban informal residents for different energy services and their accompanying technologies.

Financial stakeholders, such as banks and other funding organisations, may decide to introduce different financial models that could make off-grid and grid-compatible technologies more financially accessible to urban informal households. Investors may be convinced of the need to increase investment in off-grid technologies.

## 1.5 Scope and limitations of the study

Reflecting the predominant focus in literature and policy, this study will focus on the provision of energy services for households. The provision of energy for productive activities related to enterprises and energy services for community facilities such as street lighting and buildings will not be considered.

This study is limited to the energy provision for urban informal settlements in South Africa and aims to draw from findings from a case study in Stellenbosch, named Enkanini. Lessons can be drawn from this case study, which may inform energy provision initiatives in the future in both urban and rural settings within other low-income and developing contexts.

The developed framework will be described conceptually using literature and be used in a focus group setting to develop theoretical solutions for the Enkanini case study. Using the framework for developing solutions with the aim of implementing them in the real-world falls outside the scope of this study.

## 1.6 Ethical implications of the research

This study contained human participation and thus was submitted for ethical clearance to ensure that it complies with the Stellenbosch University's guidelines on ethical aspects of scholarly and scientific research.

## 1.7   Research Methodology and Design

The primary goal of this study was to develop a sustainable product-service system business models for energy provision in South African urban informal settlements. Therefore, initially, this study set out to use grounded theory, which is an accepted method for constructing theories by gathering and analysing data. However, Jabareen's (2009) systematic adaptation of grounded theory methodology was more appropriate for achieving the goal of this study. Therefore, it was decided to use the Conceptual Framework Analysis (CFA) technique of Jabareen (2009) to form the backbone of this research design. The CFA consists of eight phases, covering all aspects of the research.

The study was divided into three main parts conducted according to the CFA technique. As the research method was spread out over three sections, it was decided to include a summary diagram (Figure 2) at the beginning of each chapter. The reasoning behind this presentation was to provide context to the reader by confirming which of the CFA phases are relevant for that specific chapter – a reminder of the research method that will be used.
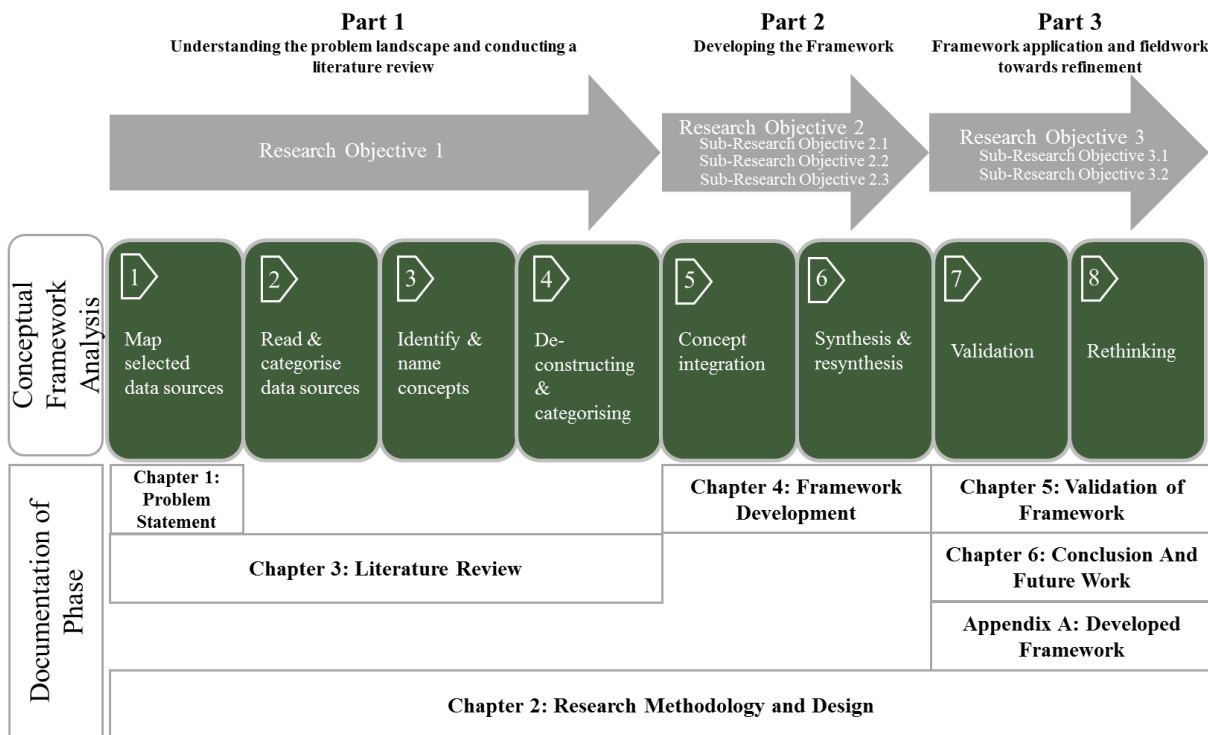


**Figure 2: Example of context diagram to be included in remainder of document**

The first part aimed to achieve objective 1. For this reason, a narrative literature review was conducted to understand the problem landscape and identify important concepts within multi-disciplinary literature fields. The second part of the research was conducted in order to reach objective 2 and its sub-objectives. Part two of the research involved the integrating and grouping of concepts. It also included the design and presentation of the proposed framework. Part 3 of the study was conducted in order to address objective 3 and its sub-objectives. This final section was used to validate the framework established in the previous section. Primary research was conducted to reach this objective. A survey was conducted using 100 urban informal settlement

households as sample. A non-probability sampling technique was used in distributing the carefully constructed electronic questionnaire. After the completion of the survey, a focus group discussion was held with industry experts to further evaluate the framework.

The research design and methodology used in this study will be explained in detail in Chapter 2.

## 1.8 Chapter Outline

The following section briefly outlines the study.

**Chapter 1: Introduction –** This chapter introduces the topic of the thesis. The importance of access to sustainable energy services for impoverished South African informal urban settlements is explained. The research question, the objectives and the methods used to conduct the search are presented.

**Chapter 2: Research Design and Methodology –** Discusses the research paradigm, research methodology, along with the data collection and analysis methods utilised in order to achieve each of the research objectives.

**Chapter 3: Literature Review –** A review of four fields of literature (energy access; base of the pyramid (BOP), business models and PSS) is conducted to identify the essential concepts relevant to sustainability.

**Chapter 4: Framework Development –** Concepts are integrated into key concepts that are synthesised into a conceptual framework consisting of different modules. The different modules of the conceptual framework are designed using the critical review of tools existing in literature to evaluate to what extent they address the key concepts previously defined. Together, the sum of these modules forms an appropriate whole – a framework that facilitates the development of sustainable PSS business model development framework that is fitting to the context of this study.

**Chapter 5: Framework Validation** – Presents and discusses the results/findings from both the questionnaire conducted with the urban informal community as well as the focus group and post-focus group survey for the validation of the developed framework.

**Chapter 6 – Conclusion and Recommendations –** This study draws to a close through conclusions and recommendations established from this study. Through the development of a generic framework, this study provides the platform for other interesting studies to emerge.

## 1.9   Chapter 1 Conclusion

About 10 per cent of the South African population live in rural or urban informal settlement (Department of Energy, 2014a). A large percentage of these households, in particular, the urban informal settlements, do not have access to energy services. Blanket, national grid electrification policies have been incapable of adequately serving the various types of informal settlements. Providing sustainable energy services to these highly dynamic and mostly unpredictable communities is fraught with numerous challenges and market barriers. By considering sustainability, multi-stakeholder collaboration and end-user desirability, product-service system (PSS) business models offer a promising solution to the market barriers existing in the informal context. This study aimed to develop a tool to consider multiple trade-offs in the urban informal context to allow the development of a sustainable PSS business model for the provision of energy services. This chapter provided some background information on the topic.

In the next chapter, the research methodology and design will be presented.

# CHAPTER 2:   RESEARCH METHODOLOGY AND DESIGN

Chapter 1 elucidated the need for developing a new framework within the nascent research field of energy provision through sustainable PSS business models in low-income contexts. This chapter provides an overview of the research design, explaining the research paradigm, and various aspects of the research method in order to achieve this goal. However, because theory is the outcome and not the basis of this study, it would have been problematic to determine the theoretical and conceptual terms before data collection, that is, the literature review. Therefore, the research method is presented in this chapter before the literature review in the next chapter. As demonstrated in Figure 3, Chapter 2 spans across the entire research study as it addresses how the grounded theory methodology was adapted for creating a sustainable PSS business model development framework. The research design consists of three parts, as illustrated in Figure 3 below. Part 1 consists of phases 1–4 and describes the research design and methodology employed to reach objective 1. Part 2 involves phases 5 and 6 in order to achieve the second objective and sub-objectives. In Part 3, phases 7 and 8 will be used to achieve objective 3 and its sub-objectives. In the following section, the research dimension will be explained.
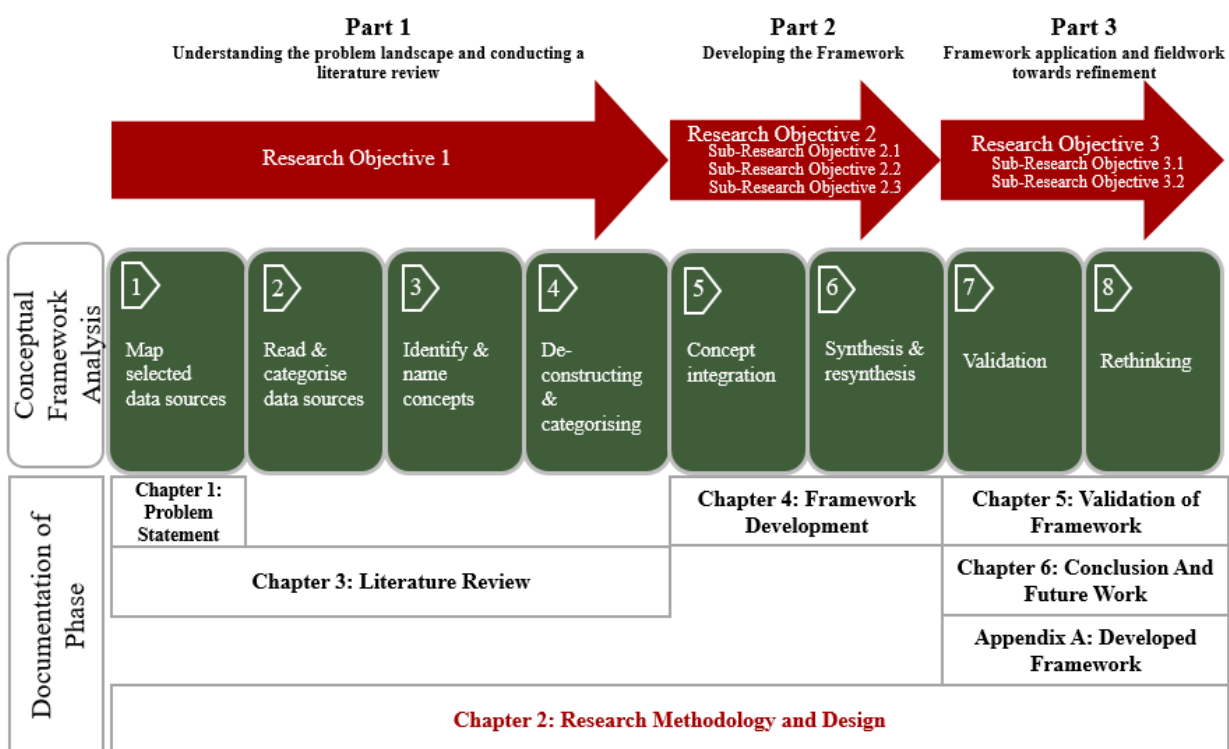


**Figure 3: Context Diagram - Chapter 2**

## 2.1 Research Methodology

Mouton (2013) makes a broad classification of research studies according to two dimensions. These dimensions are empirical vs non-empirical studies and the use of primary vs existing/secondary data. Mouton (2013) regards empirical studies as those that are experimental or observational rather than theoretical and regards non-empirical studies as those that are based on theory.

The research in this study aims to expand and refine existing theories and frameworks in literature, supported through inductive and logical argumentation. This study is therefore of a non-empirical nature, which predominantly makes use of existing data or information. Figure 4 demonstrates that the research in this study is classified among conceptual studies, philosophical analyses and studies that undertake theory and model building.
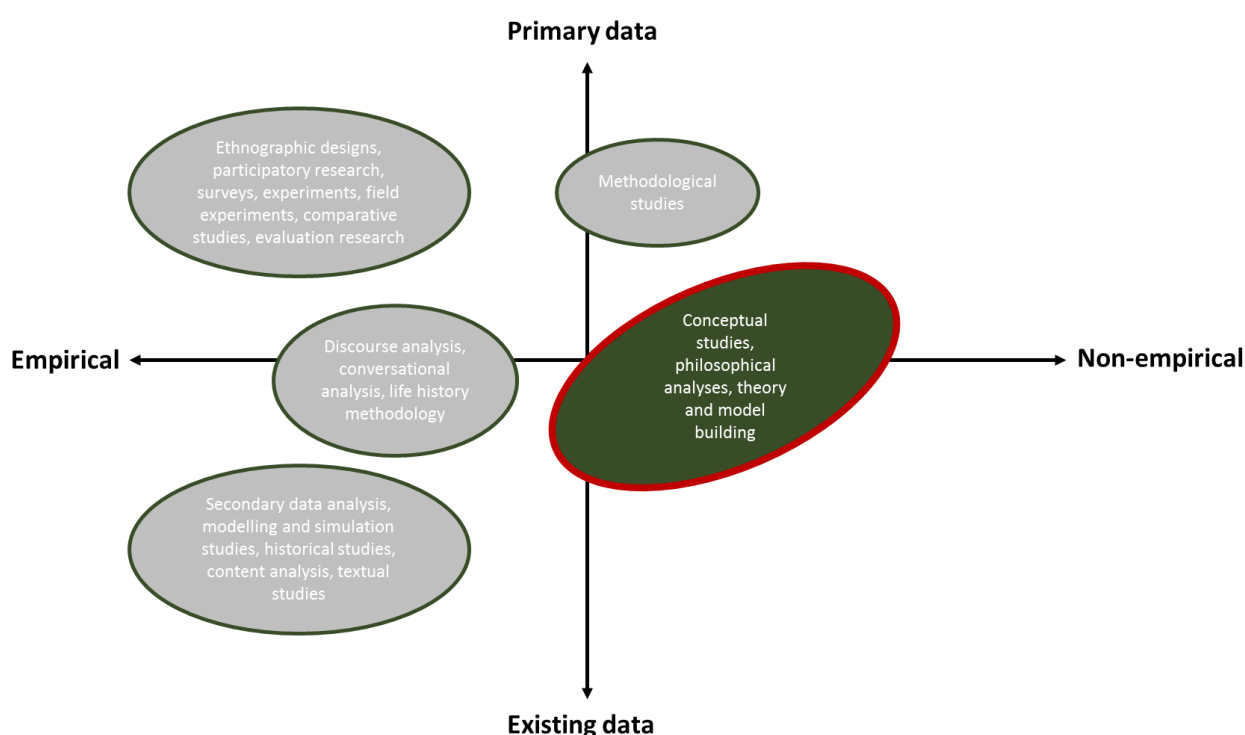
**Figure 4: Research Design Map** (Mouton, 2013)

Edmondson and McManus (2007) emphasise the consideration of the maturity of a research field to influence the choice of a research approach. They state that a qualitative approach is fitting for new theory building within nascent research fields, whereas a quantitative approach is appropriate for supporting theory generation in mature research fields. A mixed-methods approach is recommended for intermediate research fields.

Despite the increasing number of publications on energy provision through sustainable PSS business models in low-income communities, the understanding of the research field is still poor. Consequently, the theoretical maturity of this research field can be regarded as nascent. For this reason, a predominantly qualitative approach was chosen for this study.

Beyond considering this research field as nascent, energy itself is deemed multidimensional in nature (Bhatia & Angelou, 2014). To gain a good understanding of energy as a phenomenon requires the study of multiple bodies of knowledge within different disciplinary fields. Jabareen (2009) advocates the use of grounded theory (one type of qualitative methodology) over other, descriptive qualitative methodologies when generating theory from multiple bodies of knowledge within different disciplinary fields.

Multiple qualitative methodologies, such as thematic analysis, narrative content analysis and conceptual analysis, strive to analyse the existence of particular words, themes, concepts, and so forth within texts (Jabareen, 2009). These methodologies are limited in their time-consuming data preparations, their challenge of relating textual data with other data and their underlying theoretical basis that is not regarded as robust (Carley, 1993). They are therefore best suited for providing descriptions and not for generating theory (Jabareen, 2009). Due to its primary characteristics, grounded theory is regarded as adequate for deriving a framework that links multiple bodies of knowledge within different disciplinary fields (Jabareen, 2009).

Since its introduction to literature in 1967 by Glaser and Strauss (1967), grounded theory has become a widely used methodology for analysing qualitative data. In fact, Bryant and Charmaz 2007) consider grounded theory to be arguably the most commonly used qualitative methodology. Bryman, Bell, Hirschsohn, Dos Santos, Du Toit, Masenge, Van Aardt and Wagner (2016) argue that two central features underpin the grounded theory methodology: theory development data (that is, information) and an iterative and recursive exercise. In the iterative and recursive exercise, the collection and analysis of data coincide – continually referring to each other. Grounded theory derives its name from this iterative process of data referral, as it strives to develop a *theory grounded* on data (Adolph, Kruchten & Hall, 2012). Over the years, grounded theory has evolved, with Glaser (1992) publishing new work on grounded theory after a disagreement ensued between the original authors Glaser and Strauss (1967) surrounding the methodology. Today, there is no consensus to provide a definitive account of the methodology (Bryman *et al.*, 2016).

Jabareen (2009) emphasises the importance of considering the assumptions made regarding the epistemological stance and the theoretical perspective taken when developing a theoretical framework through the grounded theory methodology. The epistemology of a study refers to what is considered as acceptable knowledge (Bryman *et al.*, 2016; Creswell, 2009). Crotty (1998:8) states, "Epistemology is concerned with providing a philosophical grounding for deciding what kinds of knowledge are possible and how we can ensure that they are both adequate and legitimate".

Charmaz (2000) argues that the grounded theory associated with Glaser and Strauss (1967) takes an objectivist epistemological stance as it intends to reveal that a reality has an existence that is external and independent of social actors. It therefore leads to the objectivist stance, which considers that the researcher does not influence the object of inquiry (phenomenon). Charmaz (2000:521) maintains that grounded theory should take a constructivist epistemological stance as the "social reality does not exist independent of human action". The constructivist stance considers the researcher and the phenomenon in question as interlinked as they interpret it in their own, unique way.

As demonstrated in Figure 5, epistemology is embedded in the theoretical perspective that is adopted for a research study (Crotty, 1998). The theoretical perspective is described as the philosophical viewpoint that informs the chosen methodology. Multiple theoretical perspectives such as positivism (and post-positivism), interpretivism, critical enquiry, postmodernism and feminism can be taken for a research study (Crotty, 1998; Gray, 2014). The interpretive theoretical perspective is commonly linked to qualitative research methodologies and constructivism. Interpretivism is grounded in the premise the social world (people and their institutions) is intrinsically different from the natural world and requires a research logic that reflects the distinctiveness of humans (Bryman *et al.*, 2016). Figure 5 illustrates the different elements of the research methodology, as explained by Crotty (1998).
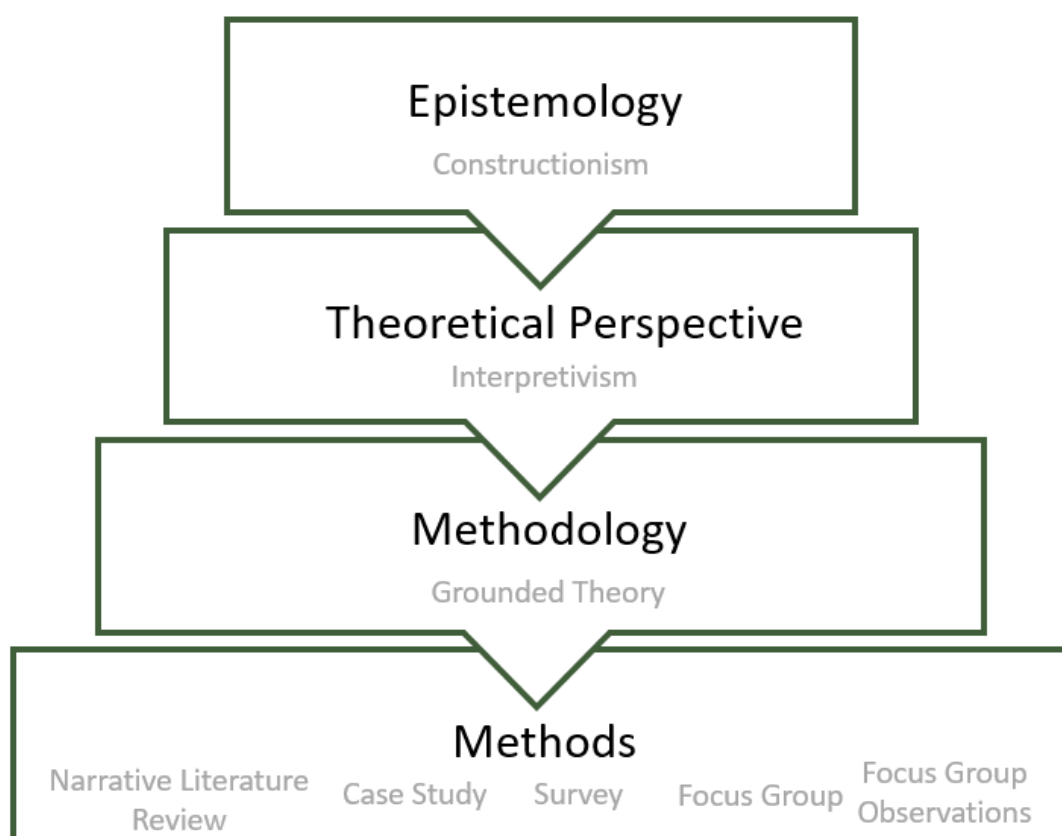


**Figure 5: Different elements surrounding the research methodology (adapted from** Crotty (1998)**)**

Similar to the work of Charmaz (2000), this study takes a constructivist epistemological stance and an interpretivist theoretical perspective while making use of the grounded theory methodology (as demonstrated in Figure 5). This epistemological stance and theoretical perspective correspond to that of Emili (2017), whose study represents the most extensive work that has been conducted on energy provision through sustainable PSS business models in low-income communities. The methods used in this study will be discussed in Section 2.3.

As the purpose of this study is to develop a framework that can be used as a tool, Section 2.2 describes the approach of Jabareen (2009) that makes use of grounded theory to develop a conceptual framework.

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## 2.2   Framework Development Process

This section outlines the methodology of the framework development process, as proposed by Jabareen (2009).

Jabareen (2009:51) defines a conceptual framework "... as a network, or 'a plane', of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena". Concepts are regarded as ".. the building blocks of theory..." and the "… labels that we give to elements of the social world that seem to have common features and that strike us as significant". (Bryman *et al.*, 2016:33). It should be noted that every concept has a history and that all concepts relate back to other concepts (Jabareen, 2009).

The use of a conceptual framework to link multiple bodies of knowledge within different disciplinary fields is critical, as multi-disciplinary phenomena do not possess a "skeletal framework" (Jabareen, 2009:50). The lack of skeletal structure (which a framework provides) puts subsequent researchers (who refer to existing literature) at a disadvantage, as they do not have a strong starting point of departure for conducting analysis, making observations and creating new questions. A framework, therefore, allows progressive improvement and reorganisation of how the different bodies of knowledge interact within a multidisciplinary phenomenon (Morse, Hupcey, Penrod, Spiers, Pooler & Mitcham, 2002).

As model building also forms part of theory generation studies, the difference between models and frameworks should be made. Ilott, Gerrish, Laker & Bray (2013) distinguish between models and frameworks by stating that models "... tend to be more prescriptive, specific and with a narrow scope, "whereas conceptual frameworks "... are descriptive, showing relevant concepts and how they relate to each other".

Frameworks can be developed and be used as tools to address real-world problems (Khodor, Halme & Walker, 2004). A tool is defined as "... an instrument for performing a procedure" (Karimi, 1988:13). Therefore, this study aimed to develop a framework that can be used as a tool for those in the energy sector who want to design a sustainable PSS business model for an energy provision enterprise that operates in the urban informal context.

It is imperative to consider the limitations of a methodology before applying it in a research study. One criticism is that the data analysis and theory generation exercise is time-consuming (Bryman *et al.*, 2016). Charmaz (2008) asserts that the quality of the data analysis and theory generation exercise is highly dependent on a researcher's abilities as it is influenced by his or her subjectivity. Grounded theory is additionally characterised by the freedom and flexibility it provides for researchers (Jones & Alony, 2011).

Jabareen (2009) identified an absence of a systematic method to build conceptual frameworks in grounded theory (and other qualitative methodologies). He subsequently developed a structured approach for conceptual framework development – named the Conceptual Framework Analysis (CFA) technique. This systematic CFA approach of Jabareen (2009) addressed the common criticisms of grounded theory. Jabareen (2009) created structure in an otherwise flexible methodology and provided practical tools that assisted in improving the researcher's ability to undertake the possible time-consuming exercise of data analysis and theory generation.

The iterative methodology of the CFA technique is composed of eight phases. A description of the phases is listed in Table 1.

**Table 1: Overview of the CFA technique**

| Phases | Descriptions of Phases |
|---|---|
| Phase 1: Map selected data sources | • Map the spectrum of multidisciplinary literature of the phenomenon being studied<br>• Conduct an extensive review of the multidisciplinary literature<br>• Undertake initial interviews with researchers and from various disciplines whose work focuses on the targeted phenomenon |
| Phase 2: Read and categorise data sources | • Read collected literature, categorising by discipline and scale of importance |
| Phase 3: Identify and name concepts | • Read and reread the selected literature to discover concepts<br>• Develop a list of multiple (and sometimes contradictory) concepts |
| Phase 4: Deconstructing and categorising concepts | • Deconstruct each concept to identify its main primary attributes, characteristics, role and assumptions<br>• Develop a four-column table where the columns are respectively populated with:<br>  o Names of the different concepts<br>  o Description of the different concepts<br>  o Categorisation of each concept's ontological, epistemological and methodological role<br>  o References for the different concepts |
| Phase 5: Concept integration | • Reduce the number of concepts by integrating and grouping concepts together |
| Phase 6: Synthesis and resynthesis | • Iteratively synthesise concepts into a theoretical framework |
| Phase 7: Validating the conceptual framework | • Seeks validation from "outsiders", for example, researchers and practitioners who have knowledge of the specific phenomenon |
| Phase 8: Rethinking the conceptual framework | • A framework representing a multidisciplinary phenomenon is dynamic and may be altered after new insights have been gained |

The instructions in the CFA phases were predominantly followed in this study. Section 2.3 states where adaptations were made and how the phases form part of the research design of this study.

## 2.3  Research Design

This section describes the research design for this study and the integral role of the CFA technique to its development. Figure 6 provides an overview of the research design of this research study and demonstrates how the eight phases of the CFA technique forms the backbone of this study's research design. The eight phases of the study's research design are divided into three distinct parts, with each addressing a research objective (and its corresponding sub-objectives). Figure 6 further illustrates where the different research design phases are documented.
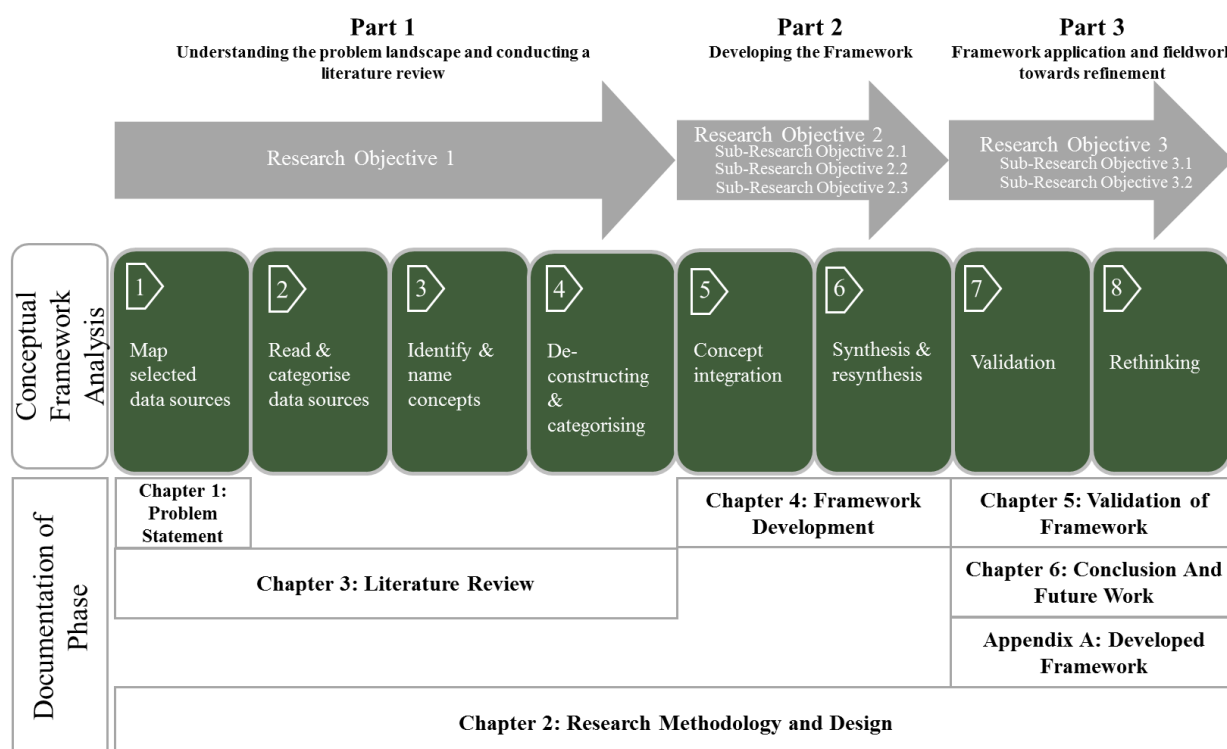
**Figure 6: Research design of this study**

The remainder of the section details how the eight phases of the research design were carried out and to what extent they correspond to the eight phases of the CFA technique.

### 2.3.1  Part 1

This part of the research study aims to address research objective 1:

> *Research Objective 1: Evaluate the context of energy provision in South African urban informal settlements with the aim of identifying concepts emerging out of the literature*

As this study's chosen relationship between the theory and research is inductive rather than deductive, theory is the outcome of the study and not the basis of it. It would therefore be problematic to determine the main theoretical and conceptual terms before data collection, that is, a literature review (Bryman *et al.*, 2016). Morse *et al.* (2002:68) assert "... qualitative inquiry that commences with the concept, rather than the phenomenon itself, is subject to violating the tenet of induction, thus is exposed to particular threats of invalidity".

Consequently, a narrative literature review was conducted as opposed to a systematic literature review as it is "... less focused and more wide-ranging than systematic [literature] reviews" (Bryman *et al.*, 2016:97). As characterised by research studies making use of an interpretative theoretical perspective, this study's view of the literature changed as it was reviewed (Bryman *et al.*, 2016). This flexible approach of continuously shifting the focus of a research study as new insights are gained for framing a problem statement that is responsive to real-world problems, reducing the risk of investigating preconceived problems. The process of framing the final research problem is stated below. The central point motivating the framing of the problem statement is marked in bold text.

The real-world problem posed to the researcher was the lack of access to grid electricity for 14 per cent of the South African population (IEA, 2017). It was decided to focus on urban informal settlements for three reasons. Firstly, informal settlements form close to a third of the remaining electrification backlog of the country (Department of Energy, 2014b). Secondly, most of the studies in the energy access literature focus on the low-income rural context, whereas the urban low-income context is underrepresented. Lastly, the focus on urban informal settlements is convenient due to the researcher's access to a research centre in a nearby urban informal settlement.

As per CFA phase 1, an initial scanning of a spectrum of multidisciplinary literature was conducted for energy access within a South African urban informal context. It was evident that the current national housing and electrification policies created a scenario where the state was unable to provide electrification to all urban informal households. Multiple case studies showed **non-governmental entities** (specifically those using renewable energy technologies) had become the interim vehicle to provide energy access to the eligible dwellings waiting for grid electrification (most waiting for at least for 9 years (Swilling, Tavener-Smith, Keller, Heyde & Wessels, 2013)). These energy access enterprises may receive a subsidy from the state for the services they provide to these eligible settlements. In settlements that are ineligible for grid electrification, alternative ways of energy access would serve as the primary, long-term solution to energy (electricity) access. These energy provision enterprises would not receive a subsidy from the state but operate in a market-based manner within the settlement.

It was found there existed multiple market barriers for energy access enterprises providing energy access to either eligible or ineligible households. In addressing the energy access challenge, the researcher set out to focus on assisting energy access enterprises in overcoming common market barriers that their business model could encounter within the different types of informal settlements. The **business model** concept was selected for use as it was commonly used in energy access literature and provided a suitable lens for enterprise analysis.

On further inspection of energy access literature in low-income contexts, the work of Practical Action (2015) provided inspiration in terms of the consideration of the necessary enabling environment and supporting inputs, services and finances required to overcome market barriers for the business model of a renewable energy provision enterprise (Figure 7). The rationale behind the initial focus on renewable energy was because of its popularity in energy access literature.
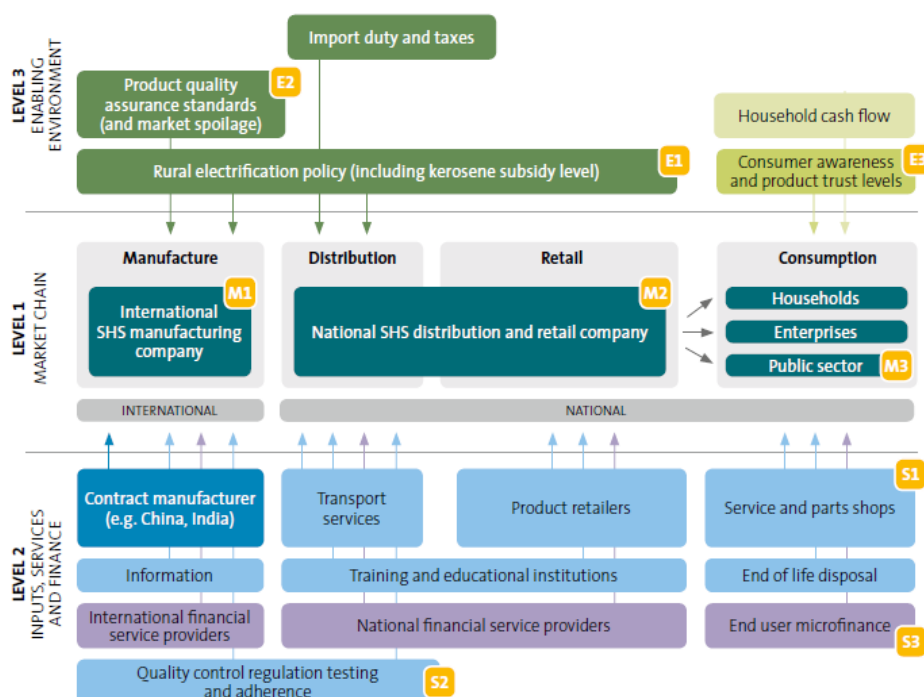
**Figure 7: Necessary value chain interventions for a solar home system (SHS) enterprise** (Practical Action, 2015)

Following this initial scan of the literature, the researcher followed the suggestion of CFA Phase 1 and engaged with researchers and practitioners from multiple disciplines who work in the South African urban informal context. After discussions with more than 15 researchers and practitioners, it became clear the urban informal context is highly dynamic and largely unpredictable. This was most notably evident in how vastly different local governments applied national housing and energy policies. The manner in which policies were applied was chiefly influenced by the socio-political climate of the specific informal settlement in question. This dynamic and unpredictable environment made it infeasible to determine the necessary enabling environment and supporting inputs, services and finances to overcome market barriers. It was discovered that this has also been the conclusion of other researchers in the South African urban informal context (Keller, 2012; Runsten, Fuso Nerini & Tait, 2018; Smit, Musango & Brent, 2019). Although it was infeasible to develop static guiding specifications, the need for an enterprise to consider the multiple trade-offs existing in the urban informal context became evident. Studies such as Runsten *et al.* (2018) developed holistic indicators for the urban informal context. These indicators assist in considering the multiple **trade-offs existing between the various sustainable development dimensions** when evaluating different energy supply alternatives. Runsten *et al.* (2018) confirmed the need for considering trade-offs through the business model lens in its suggestion for future work to be conducted in the South African urban informal context. The consideration of the multiple trade-offs and constraints made it clear the success of energy access initiatives depended on **multiple stakeholder involvement and cohesion**.

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An extensive review of literature made it clear that following a market-chain (value chain) approach, such as that of Practical Action (2015), often leads to communities rejecting technologies, as it may not meet their specific energy needs and/ or be suited to their socio-cultural context. Before offering an energy solution to communities, best practice in the energy access literature suggested that energy services priorities and other energy desires should first be determined. It was consequently decided that a **technology-neutral** approach should be followed by the research study to determine what energy supply options would best suited for the community in question.

It was further discovered within the researcher and practitioner engagements (and confirmed by academic literature), that even those households with access to a grid connection suffer from energy poverty, as it is unaffordable to them. This increased the scope of the research problem and expanded the focus of the study from energy *access* to energy *provision* enterprises, as these enterprises would not offer energy access to the communities that already have a grid connection, but only provide additional energy. Energy provision enterprises also include the energy access enterprises (providing energy to those without previous access) - it is therefore a fitting term to use to encompass the focus of this study. It was also found that governmental entities (that act as separate entities to the entity providing grid electrification) provide alternative means of energy supply, such as mini-grids, that supplement the electricity grid in some communities. **Governmental entities** and the consideration of a **grid connection** within the bundle of energy supply sources that could be supplied to a community were consequently included in the focus of the study.

An exhaustive literature review was conducted on methods to develop a technology-neutral business model for energy provision enterprises. These business model development methods additionally needed to consider the multiple trade-offs existing within the different dimensions of sustainability as well consider the involvement of multiple stakeholders. No framework corresponding to these requirements were found in literature. The PSS concept was furthermore found to be a promising value proposition to address multiple challenges within the urban informal context. The need for such a framework that would facilitate sustainable PSS business model development was documented in sections 1.2 and 1.3.

Consequently, CFA Phase 2 ensues in the literature review in Chapter 3. It was determined that the most important bodies of literature to consider would be energy access; BOP (low-income contexts); business models and PSS, as well as how these bodies of literature align with sustainable development. As per CFA Phase 3, an extensive review of the literature was conducted to discover the important concepts emerging from these bodies of literature. Each review of a body of literature will conclude with a three-column table listing the concept names, descriptions and references, respectively (as instructed by CFA phase 4). Categorising the ontological, epistemological and methodological role of each concept is not included in the table, as it is deemed unnecessary information for constructing the framework of this study.

In totality, phases 1, 2, 3 and 4 of Part 1 allow research objective 1 to be completed.

### 2.3.2 Part 2

This part of the research study aims to address all the sub-objectives of research objective 2:

*Research Objective 2: Deduce a framework to assist in the development of sustainable PSS business models in the South African urban informal context*

> *Sub-Objective 2.1: Reduce the number of concepts (identified in Objective 1) by integrating and grouping the different concepts together*
> *Sub-Objective 2.2: Identify current tools available in literature and evaluate their adequacy in the context of this study*
> *Sub-Objective 2.3: Develop a framework (based on the evaluation findings of Sub-Objective 2.2) that adequately addresses the reduced concepts of Sub-Objective 2.1*

CFA Phase 5 instructs the reduction of concepts through integrating and grouping concepts together but provides no further guidance in this regard. A concept integration and grouping methodology followed by Yang (2015) was used as it assisted the researcher to visually illustrate how the concepts discovered in Chapter 3 are integrated and grouped together. Yang (2015) used arrows to illustrate how the different concepts where integrated and grouped to form key concepts. The key concepts were consequently integrated and grouped to form a summary of the amalgamation of key concepts, named "rationales". The rationales make up the different parts within a single tool. This study followed the same logic; however, the amalgamation of key concepts was named "consolidated key concepts". Each represents a different module (that could be used as tools) within a larger framework (that could also be used as a tool). This integration and grouping methodology addressed sub-objective 2.1 and illustrated how the modules formed the foundation of the developed framework – moving in the realm of CFA Phase 6.

Sub-objective 2.2 considers the identification and evaluation of tools existing in literature. Similar to Emili (2017), the strengths and weaknesses of the various tools were considered within the context of this study. The iterative synthesis of concepts within CFA Phase 6 continues as the strengths within the evaluated tools provide design inspiration for the different modules of the framework. Sub-objective 2.3 is consequently achieved by evaluating the adequacy of each module to address the assigned concepts and arranging the modules together in a larger framework.

### 2.3.3 Part 3

This part of the research study aims to address all the sub-objectives of research objective 3:

*Research Objective 3: Verify and validate the developed framework in the context of a specific case study*

> *Sub-Objective 3.1: Determine the energy supply mix realities and desires of households within urban informal settlements, using a specific case study*
> *Sub-Objective 3.2: Validate the developed framework with experts in industry, using a specific case study and formulate an adapted framework*

#### 2.3.3.1 Case Study Overview

The framework created in this study allows an energy provision enterprise to develop a sustainable PSS business model while taking multi-stakeholders' perception of value into consideration. This is done by

visually mapping out the PSS business model of the enterprise and the multiple trade-offs existing in the urban informal context. End-user desirability is considered to ensure success in the informal context by visualising the energy needs and desires of the community within a specific module of the framework (see Energy Value Proposition Canvas). It is advised that the energy provision enterprise engages with the community itself to discover their true energy needs and desires to reduce misconceptions. If community engagement were not possible before using the Framework, the energy provision enterprise would have to make assumptions about the community's energy- and other, related needs and desires and validate with the community at a later stage.

Rogers (2012) states that the consideration of a case study allows a complex phenomenon to be investigated in its natural context. The Enkanini urban informal settlement was chosen as a case study to allow the evaluation of the Framework within a real-world context.

Enkanini was established in 2006 through an illegal occupation of municipal land (CORC, 2012). The settlement has grown to a population of about 8000 people whose occupation today is still considered illegal by the State (Kovacic *et al.*, 2019). According to the different informal settlement types discussed in section 1.1, Enkanini is regarding as having started as a squatter camp (Category C: Informal, Illegal, Unplanned, Illegitimate) and progressed to a site and service informal settlement (Category D: Informal, Legal, Planned; Legitimate) as they households have limited access to basic services (70 public toilets and 32 water taps and no grid electricity) (CORC, 2012; Smit *et al.*, 2017).

The north of the Enkanini settlement borders to a formal, legal informal settlement, Kayamandi. Some of the dwellings situated close enough to Kayamandi obtain electricity from their Kayamandi neighbours through informal connections – commonly known as indirect electricity. Indirect electricity users pay for electricity with prepaid vouchers that are given to the owner of the formal connection in Kayamandi. As there is no record of the amount of electricity used by the indirect electricity users, these arrangements are open to exploitation and therefore rely heavily on trust.

An energy provision enterprise, iShack, also operates within the Enkanini settlement. The enterprise was established in 2012 by Stellenbosch University and Sustainability Institute researchers. The Bill and Melinda Gates Foundation and the South African Green Fund provided funds to roll out Solar Home Systems (SHS) to 1500 households. These SHS systems are predominantly sold with three lightbulbs and have a USB port that can be used for mobile charging (Keller, 2012)[1]. Since 2015, iShack has been receiving a monthly subsidy from the Stellenbosch local government after changing their indigent policy to regard all households within Enkanini as indigent and therefore eligible for the Free Basic Electricity subsidy.

The Enkanini settlement was chosen as a case study for two reasons. Firstly, the settlement does not just provide the means of collecting data from end-users (Enkanini residents) to visualise their energy needs and desires but also allows the opportunity to use an energy provision enterprise (iShack) operating within the settlement as an example to demonstrate the logic of the Framework. Secondly, as discussed in Section 2.3.1,

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[1] For more information see https://www.ishackproject.co.za/

the settlement is a convenient choice as it nearby, and the researcher has access to the settlement using the Enkanini Research Centre.

The Enkanini case study can be regarded as an intrinsic case study as it was primarily undertaken to provide insight into the particularities of a single situation, community, rather than generic issues (Stake, 1995). The researcher engaged with the Enkanini case study through means of conducting a survey with the end-users (Enkanini residents) and visualised the survey findings, along with the iShack business model in a focus group context for validating the Framework. The community survey, focus group and post-focus group survey used for the purposes of evaluating the Framework is discussed in the remainder of the section.

### 2.3.3.2 Enkanini Community Survey

A survey was conducted in November 2016 within the Enkanini settlements and thus represented a snapshot of the community at that time. Zikmund, Babin, Carr and Griffin (2013) regard surveys as an efficient, accurate, inexpensive and flexible method of collecting information from a sample.

The survey formed part of a larger research initiative that utilises system dynamics to investigate the monetary and energy flows within urban informal communities. The questionnaire consisted of four sections, and a copy of the questionnaire can be found in Appendix B.2. A brief overview of each section is provided below.

**General Information** - allowed the documentation of the details relating to the survey and dwelling. The questions can be summarised as:

- Field researcher identification
- Location of the dwelling in the settlement
- Type or structure

**Household Details** - considered household composition and financial circumstances. The questions can be summarised as:

- Preferred language
- Gender of participant
- Gender of household head
- Age of household head
- Ownership of the dwelling
- Household composition and number of people per household
- Number of household members employed and income from paid work
- Other forms of household income
- Household expenses (beyond expenditure on energy services)
- Savings

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**Energy Services** - determined what appliances are used by the household as well as their current energy realities and desires. The questions can be summarised as:

- Household appliances

- Energy supply mix and underlying reasons

- Reason for the different energy supply sources within the energy supply mix

- Possibility of the household running out of energy supply for energy services and underlying reasons

- Preferred energy supply sources and underlying reasons

**Fuels** - considered fuel expenses as well as how and where fuels are obtained by the household. Questions can be summarised as:

- Fuel expenses - Informing ability to pay

- Location where fuels are obtained

- Energy supply consumption

- Unit cost of energy supply

- Household energy supply expenditure

As the Framework requires the end-user data for visualising energy needs and desires, the Energy Services section will be of focus for this study. This section provides insight regarding the households' current energy realities (through means of investigating their current energy supply mix) and desires, along with their underlying reason - echoing Sub-objective 3.1. Key results of the other sections are displayed within the Appendices of this document.

### i. Questionnaire Validity and Sampling

The Enkanini Research Centre (ERC) is located in the settlement. The centre was established to be used as a platform for researchers and the community to connect with each other. The drafted questionnaire was first discussed with the representatives of the ERC and adapted where needed. The goal was to ensure minimal non-responses from participants due to a lack of understanding or cultural sensitivity.

The ERC offered the services of three field researchers, from the Enkanini community, who would be able to distribute the questionnaire within the community. Using the field researchers reduces the internal validity of the survey, but they are be critical in carrying out the survey, as these community members are welcomed by the community and fluent in both English and in Xhosa. The questionnaire was paper-based to encourage the participation of the community, as not all residents have smartphones. As it was known that the majority of the settlement is Xhosa speaking, the questionnaire and consent form was translated by the Stellenbosch University Language Centre.

A pilot survey was conducted where 12 households were chosen using convenience sampling. The survey participants were asked to sign a consent form and complete the questionnaire on their own – asking the field researcher clarifying questions only when needed. Self-completion questionnaires were chosen as it allowed

participants answers to remain confidential, thus allowing the participant to possible share sensitive or socially undesirable information which they would not otherwise share (Zikmund *et al.*, 2013). Each questionnaire and corresponding consent form was placed in its own opaque envelope to ensure response confidentiality. Table 2 presents an overview of the number of households that participated in the pilot study along with the participation- and validity rates. It was found that the average time spent filling in the questionnaire was 1 hour and 20 minutes, and there was a 100 per cent validity rate of the completed questionnaires.

**Table 2: Pilot Questionnaire Details**

| Contacted to participate in the survey | Completed questionnaires | Participation rate | Invalid responses | Valid response | Valid response rate | Average Time Used for Completion |
|---|---|---|---|---|---|---|
| 13 | 12 | 92.3% | - | 12 | 100% | 1 hour, 20 minutes |

On reviewing the pilot test phase, it was evident that the time used to complete the survey was too long, as participants became fatigued. It was decided that the field researcher would read the questions to participants and fill in responses on behalf of the participants. Participant response confidentiality was compromised by this choice; however, it allowed the questionnaire to be administered in a shorter time, reducing possible non-responses. It was further observed by the field researchers that the participants were uncomfortable filling in their household details at the start of the questionnaire as they were unsure what exactly the questionnaire was for. They advised that the Household Details section should be moved and be used as the last section within the questionnaire, allowing participants to get a better understanding of the purpose of the survey. Finally, it was observed that the participants found it challenging to identify the difference between the different types of lightbulbs. The field researchers were consequently provided with a document displaying the different types of light bulbs (documented in Appendix B.3).

Non-probability sampling was used as due to the time and resource constraints of this study. The sample size for the final questionnaire was 100 households. This corresponds to a similar survey conducted by Kovacic, Smit, Musango, Brent and Giampietro (2016) in the Enkanini community that also targeted 100 households. Households that participated in the pilot questionnaire were excluded from the 100-household sample to avoid bias. Residents regard Enkanini as being composed of multiple sections. These sections are illustrated in Figure 8. Quota sampling was utilised based on the location of the household in the settlement, as each field researcher was assigned to specific sections (Bryman *et al.*, 2016).
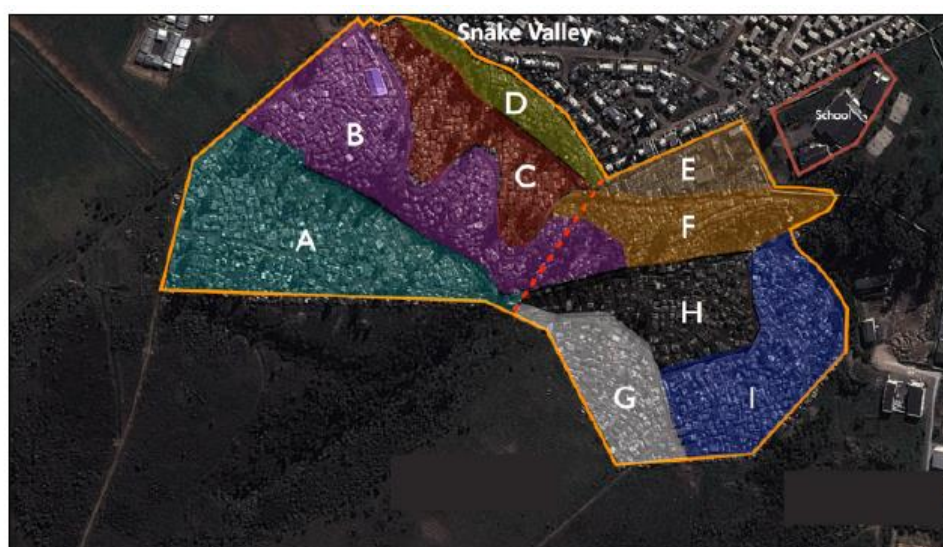
**Figure 8: Different sections of the Enkanini community** (Wessels, 2015)

The response rate and total sampled households from the population are presented in Table 3.

**Table 3: Final Questionnaire Details**

| Contacted to participate in the survey | Completed questionnaires | Participation rate | Invalid responses | Valid response | Valid response rate | Average Time Used for Completion |
|---|---|---|---|---|---|---|
| 111 | 100 | 90% | - | 100 | 100% | 1 hour |

The table demonstrates the reduced completion time due to the field researcher reading and filling in the answers on behalf of the participant.

### ii.    Question Framing and Data Analysis

The questionnaire structure and questions correspond closely to the surveys conducted by Appies (2016) and Makinde (2018) in the Enkanini and Kayamandi settlements.

Maintaining best practice in current surveys within energy provision literature (such as ESMAP (2015)), the section was constructed to individually focus on the different energy services utilised by the household. The energy services addressed in the survey were cooking, lighting, space heating, cooling, home entertainment appliances and other appliances.

As discussed, the Energy Services section allows Research Sub-Objective 3.1 to be addressed as it provides insight regarding the households' current energy realities (through means of investigating their current energy supply mix) and desires as well as their underlying reasons.

A multi-response question format was utilised to allow participants to indicate the proportion of use (in percentage) of the different energy supply sources used in their energy supply mix. The goal was to understand the energy supply mix of a household for each energy service. This would be expressed as 90 per cent indirect

electricity and 10 per cent paraffin used for the lighting energy service. The percentages provided for the different energy supply were analysed using descriptive statistics within Microsoft Excel 2016. The results of households' energy supply mix can be seen in Section 5.1.

A range of open-ended, why-probing questions was asked in the questionnaire to gain a deeper understanding of the current energy supply realities and desires of a household. The use of why-probing questions is commonly used in energy provision studies as it provides insight into the underlying reasons for household choices (Clements *et al.*, 2019; Hirmer and Guthrie, 2016). The insight into the underlying reasons is critical to understand for energy provision enterprises that aim to provide a unique value proposition that is responsive to the needs of the community.

The reasons behind the current and desired energy supply mix of a household were investigated, along with the reasons for a household running out of energy supply sources for specific energy services. Following the categories of Osterwalder, Pigneur, Bernarda and Smith (2014), the open-ended responses were categorised according to whether they inform the "gains" or "pains" of their current or desired energy supply mix. Gains are considered as positive outcomes and benefits, whereas negative outcomes and risks are regarded as pains (Osterwalder *et al.*, 2014). Silverstein, Samuel and DeCarlo (2012) distinguishes between functional requirements that are solution-specific performance criteria (such as candle burn time) and outcomes that reside on a higher level and are solution neutral (such as duration of illumination). The various qualitative reasons offered by the participants are therefore analysed by means of content analysis and translated in a manner as to be solution neutral. Phrasing gains and pains in this manner allows the consideration of any energy supply sources to be a possible energy supply alternative to current energy supply options (or the lack thereof) – corresponding to the aim of the study, to develop a technology-neutral framework.

On the one hand, the advantages of content analysis are its flexibility that which allows it to be applied to a wide variety of structured and unstructured information (Bryman *et al.*, 2016). On the other hand, this flexibility allows for a large amount of subjectivity to possibly arise within the analysis due to the researcher's interpretation (Bryman *et al.*, 2016). For this reason, participants' direct responses were used as far possible. The gains and pains were listed according to the frequency in which they appeared in the responses with the most frequently mentioned response placed first. A direct quote or phrase best representing a specific reason was chosen.

Surveys allow data collection from a broad audience with greater ease of administration and reliability of the gathered information as compared to focus groups. Surveys, however, are limited in provided in-depth perspectives as compared to focus groups. Smit, Musango and Brent (2019) conducted a three-day focus group, focusing on energy, with the residents of the Enkanini community. The focus group participants were divided into three different groups according to their energy profile: indirect electricity users, solar electricity users and divergent energy users (those who do not use indirect electricity or SHSs). Ten people represented each of these user groups. Similar to the survey of this study, the workshop participants were asked why they use a particular energy supply source within their energy supply mix. The focus group format allowed the

participants to elaborate as to the reason for their current energy supply mix. In addition, workshop participants were directly asked what they felt were the benefits and disadvantages of that particular energy supply source. This was not present in the survey of this study. The responses in the Smit *et al.* (2019) study can be used as complementary responses to provide additional gains and pains for this study.

To ensure consistency between the responses within this study's survey and those within the focus group of Smit *et al.* (2019), the population of the survey were also be divided into the same, three energy user groups: indirect electricity users, solar electricity users and divergent energy users. Limited research has been conducted regarding the reasons for urban informal households' energy supply mix and the resulting positive and negatively outcomes (Makinde, 2018). By aligning the responses of this study with that of Smit *et al.* (2019), a nuanced contribution is made to the body of knowledge, as it illustrates the energy realities experienced by the different energy user groups. The gains and pains for the three different energy user groups are documented within Appendix B.1.

Beyond adding to the body of knowledge of the energy realities and desires of urban informal households, the primary aim of the gains and pains responses are to inform the Framework from the bottom-up with end-user data. To decrease the complexity for new users of the framework, the Enkanini community is considered a single market segment. This, therefore, leads to the gains and pains responses within the three different energy to be combined to represent the Enkanini community as a single market. Considering the entire population as one market corresponds to the real-world reality of Enkanini, as the Stellenbosch Municipality utilises a blanket policy that classifies all residents as indigent with no further differentiation within the population. The gains and pains results of the survey that considers the Enkanini community as one market segment is documented in section 5.1.

### 2.3.3.3 Focus Group

This section provides an overview of the focus group that was conducted with experts (researchers and practitioners) in the energy sector. Corresponding to CFA phase 7, the purpose of the focus group was to validate the developed Framework when applied within the context of a real-world case study. The use of the focus group method to validate a developed tool has been established by various studies. Studies specific to PSS business model tools such as Emili (2017) Yang (2015) have also made use of this method.

#### i. Pilot workshop

Prior to the focus group with experts in industry, a pilot workshop was conducted in August 2019. The pilot focus group took place in Stellenbosch and aimed to determine how intuitive the Framework was through considering its ease of use and clarity to participants. Three postgraduate students with limited exposure to the energy sector and urban informal settlements were consequently chosen (through means of convenience sampling). The students obtained their respective degrees in the fields of visual communication, marketing and entrepreneurship.

The focus group consisted of a five-hour session (including breaks) as this was the maximum amount of time that the participants could allocate within their schedules. Similar to the studies of Yang (2015) and Emili (2017), the researcher acted as a facilitator for the focus group.

The logic of the Framework was explained through presenting the Framework overview figure (as was seen in section 4.4) on a laptop screen and systematically going through each of the modules by individually placing them on a large table. As to ease understanding, the energy provision enterprise operating in Enkanini, iShack was used as an example. iShack was chosen as an example as it is fitting for the context of Enkanini, and it makes use of a PSS business model (Pay-to-lease). The participants were not familiar with the iShack case study, and therefore the researcher had to provide sufficient background information. Following the use of iShack as an example in the Framework, the researcher tasked the participants to design solutions for the Enkanini community as a hypothetical energy provision enterprise.

Keeping to the sequence of the Framework (discussed in 4.1.3), the hypothetical solution design process commenced with populated (through means of Sticky Notes) the module dedicated to considering the multiple trade-offs existing within the different sustainable development dimensions - the Sustainable Development Indicators Table (Section 4.3.1). Subsequently, as per the suggestion discussed in Section 2.3.3.3, the bottom-up approach was utilised through considering the module of the Framework that visualises the energy needs and desires of the community. The End-User Profile of Energy Value Proposition Canvas allows the visualisation of the prioritised energy services of the community. As the community survey data did not focus on determining the energy services were prioritised by the community, the researcher allowed the participants to decide what energy services they desired to target as a hypothetical energy provision enterprise. The energy services of cooking and lighting were chosen, and due to time constraints, a limited number of Gains and Pains (five each) from the community questionnaire were populated for the cooking and lighting energy services. With facilitation from the author, the participants completed the End-User Profile of the Energy Value Proposition Canvas.

Next, the other part of the Energy Value Proposition Canvas, the Energy Value Map (Section 4.3.3.3) was considered. The Energy Value Map is dedicated to designing energy solutions and their corresponding PSS offers. The guiding cards of the author and those developed by Emili *et al.* (2016) (Section 4.3.3.1) were handed out to participants to familiarise themselves with the concept of PSS business models. After populating the Energy Value Map, the rest of the Framework modules were populated on a high level due to time constraints. Through focus group observations, it was found that the Framework allowed them to successfully design a sustainable PSS business model for a hypothetical enterprise.

After the Framework was populated, a discussion was held to allow participant feedback. Participants verbalised that they found the different relationships between the modules to be unclear at the beginning of the workshop. It was established that it would be helpful to place the different modules on the walls of the room during the explanation phase of the focus group as to allow participants to see all the modules at once, rather than displaying them individually on a table. During the design phase of the focus group, the specific module

that needs to be populated should be removed from wall and placed on the table to allow participants to add Sticky Notes. It was further found that the participants ran out of space when populating the Partner Interaction Canvas (Section 4.3.4). The module was consequently adapted from an A1 paper size design to an A0 paper size design.

## ii. **Workshop with Experts**

Following the pilot focus group, a focus group was held with experts in September 2019 in Stellenbosch, South Africa. The focus group consisted of five participants whom are researchers and practitioners in the energy sector. Details of these participants are presented in Table 4. The participants were chosen by means of convenience sampling.

**Table 4: Details of Focus Group Participants**

| Sector | Area of expertise/ experience | Job Title |
|---|---|---|
| Academia | Renewable energy technologies, energy policy | PhD Researcher |
| For-profit Energy Provision Enterprise | Energy Provision in urban informal settlements | Project Manager |
| NPO – Start-up Incubator | Start-up incubator dedicated to renewable energy entrepreneurs | Implementation Manager |
| NPO – Consultancy | Financing of energy access initiatives, multi-stakeholder engagement and collaboration | Consultant |
| NPO – Consultancy | Community engagement | Consultant |

The focus group was limited to a four-hour session (including breaks) as this was the maximum amount of time that the participants could allocate within their schedules. The researcher also acted as a facilitator for this focus group.

Figure 9 demonstrates how the logic of the Framework was explained through digitally projecting the Framework overview figure (as was seen in section 4.4) to the participants and systematically going through each of the modules on the walls of the room in which the focus took place. The projector allowed visualisation of the logic of the Framework throughout the focus group. The room had limited space; it was therefore decided to keep the different modules up on the walls of the room, and the researcher to put the various Sticky Notes of the participants on the modules.

**Figure 9: Framework logic explanation in focus group**

iShack was once again used as an example to explain how an enterprise's PSS business model would be visualised on the Framework. It was discovered that all the participants were familiar with the iShack enterprise, which decreased the time spent on explanation. The same sequence of design was followed as in the pilot workshop.

Participants were once again tasked to design solutions for the Enkanini community as a hypothetical energy provision enterprise and the same design sequence and activities as in the pilot study were followed. Participants also chose to focus on cooking and lighting as energy services which their hypothetical energy provision enterprise would target. It was also evident (through focus group observations) that the Framework allowed them to design a sustainable PSS business model for a hypothetical enterprise successfully. The use of systematic thinking was apparent to the participants as they observed how one change in a module would have a ripple effect on the other modules of the Framework.

After the Framework was populated, a link to an electronic survey was emailed to the participants to allow them to evaluate the Framework. The post-focus group survey will be discussed in detail below.

### 2.3.3.4 Framework Evaluation Survey

A self-administered electronic survey (developed within Qualtrics Survey Software[2]) was used to allow the focus group participants to evaluate the Framework formally. An electronic self-administered questionnaire was chosen as the preferred research method for three reasons. Firstly, the digital nature of the survey could

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[2] https://www.qualtrics.com

offer visual appeal to the participants that could assist in increasing their cooperation and willingness to spend time answering the questionnaire (Zikmund *et al.*, 2013). Secondly, the self-administered nature of the survey allowed participants' responses to remain anonymous – allowing them to evaluate the Framework more freely (Bryman *et al.*, 2016). Lastly, the survey allowed for convenience as the participants could complete the questionnaire at their desired speed and location (Zikmund *et al.*, 2013).

Four of the five participants filled in the questionnaire in the focus group setting. One participant filled in the questionnaire within a week after the workshop. The short time between the explanation and use of the Framework and the filling in of the electronic questionnaire allows for results that are true to the participants' understanding and impression of the Framework. By filling in the questionnaire within the focus group setting, participants also had the opportunity to ask clarifying questions from the researcher if needed. As per the Qualtrics analytics, it took an average of 25 minutes to complete the survey.

The questionnaire uses the same question structure as that of Geissdoerfer, Bocken and Hultink (2016). The different components of the Framework (the modules) were evaluated separately to determine to what extent they address their intended aim (the assigned group of consolidated key concepts). In the cases where the extent to which the modules addressed their assigned group of consolidated key concepts could not be worded within a single question, more than one evaluation question was used. The reason for possibly splitting a single question into multiple questions is to ensure that only a single variable is considered for evaluation at a time. The tables used within see section 5.2 demonstrate the rating responses of the participants to questions as well as what specific concepts are addressed by that specific question.

As present in the tool evaluation surveys of Bocken, Short, Rana & Evans (2013), Geissdoerfer *et al.* (2016) and Emili, Ceschin and Harrison (2016), a five-point Likert scale was used to evaluate the Framework. A rating scale ranging from 1 to 5 was used in the Framework evaluation survey. The rating scale signifies: Strongly Disagree = 1; Somewhat Disagree = 2; Neither Agree nor Disagree = 3; Somewhat Agree = 4; Strongly Agree = 5. In contrast to Bocken *et al.* (2013), Geissdoerfer *et al.* (2016) and Emili *et al.* (2016), the questionnaire additionally asked participants to explain the reason for each Likert scale rating. These open-ended questions allow a narrative to emerge of the participants' opinions beyond their rating. As per CFA phase 8, the alterations made to the Framework from the participants' feedback will also be discussed in section 5.2.

The closed-ended Likert scale responses were analysed using descriptive statistics in Microsoft Excel 2016 to determine the average rating provided by the participants. The open-ended responses were analysed through means of content analysis to determine the reason behind a participant's rating.

## 2.4   Chapter 2 Conclusion

In this chapter, the combination of research methods used to conduct the study was described. The research was conducted in three parts to reach the three formulated objectives of the study. In Part 1, the iterative methodology of the CFA approach, consisting of eight phases was used to identify the main concepts. A focus group with industry experts were also conducted. For Part 2 and the second objective, phases 5 and 6 of the

CFA approach were used. For objective 3, phases 7 and 8 were conducted. A paper-based field resarcher-administered survey was conducted on 100 households in an informal urban settlement. A focus group was also conducted to validate the framework.

In the next chapter, the narrative literature review conducted to identify the main concepts of the study, is presented.

# CHAPTER 3:    LITERATURE REVIEW

## 3.1  Introduction

In the previous chapter, it was established that because theory would be the outcome and not the basis of this research study, it would have been problematic to determine the theoretical and conceptual terms before data collection, that is, the literature review. For this reason, the narrative literature review is conducted in this chapter in order to identify the main concepts of the study. To ensure that this study aligns with sustainability and consequently, the sustainable development goals (SDGs), specifically SDG7 on universal access to energy by 2030, a high-level overview of sustainability is provided. Following the overview, four different bodies of the literature are analysed: energy access, BOP, business models and PSS. Specific concepts correlating to sustainability are identified in each of these bodies of literature (see Figure 10). The focus of the literature review is illustrated in Figure 10 below. In the following section, the concept sustainability will be described.
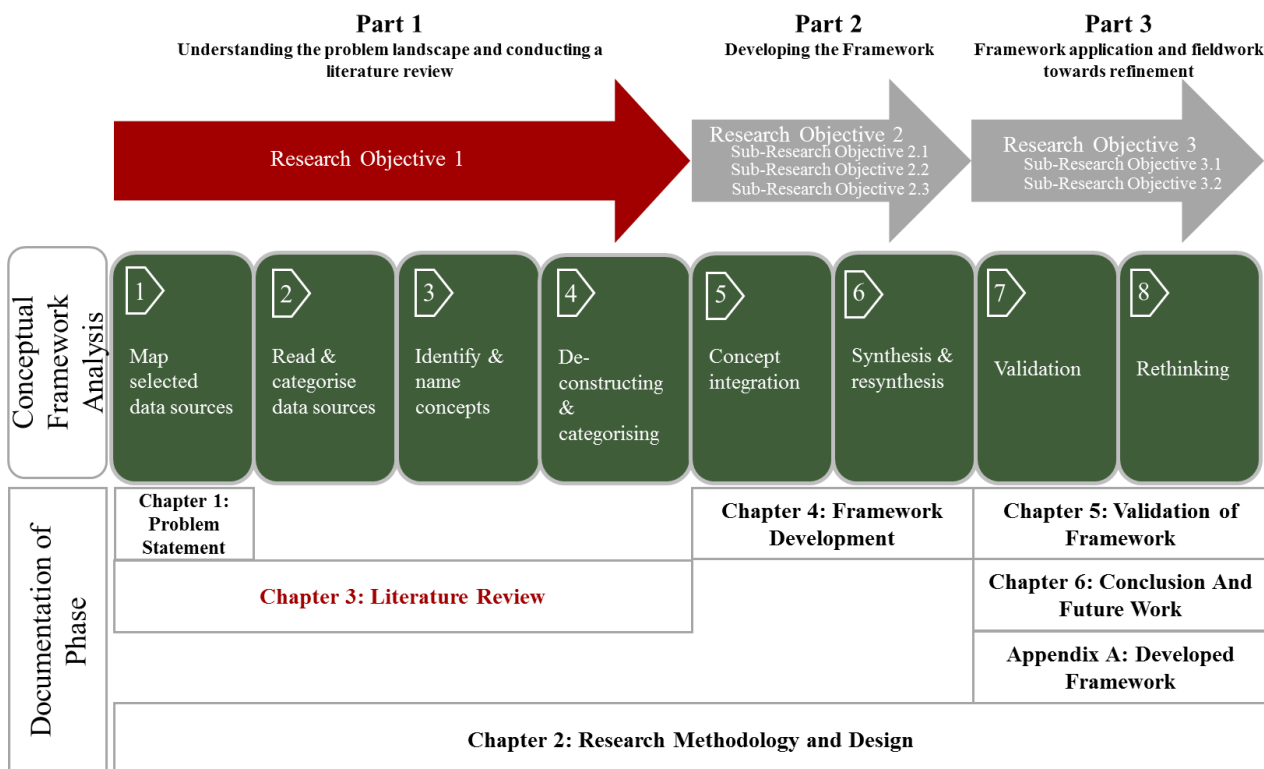


**Figure 10: Document context diagram - Chapter 3**

To ensure that this study aligns with sustainability and consequently, the SDGs, a high-level overview of sustainability is provided. Following the overview, four different bodies of the literature are analysed: energy access, BOP, business models and PSS. Specific concepts correlating to sustainability are identified in each of these bodies of literature (see Figure 11).
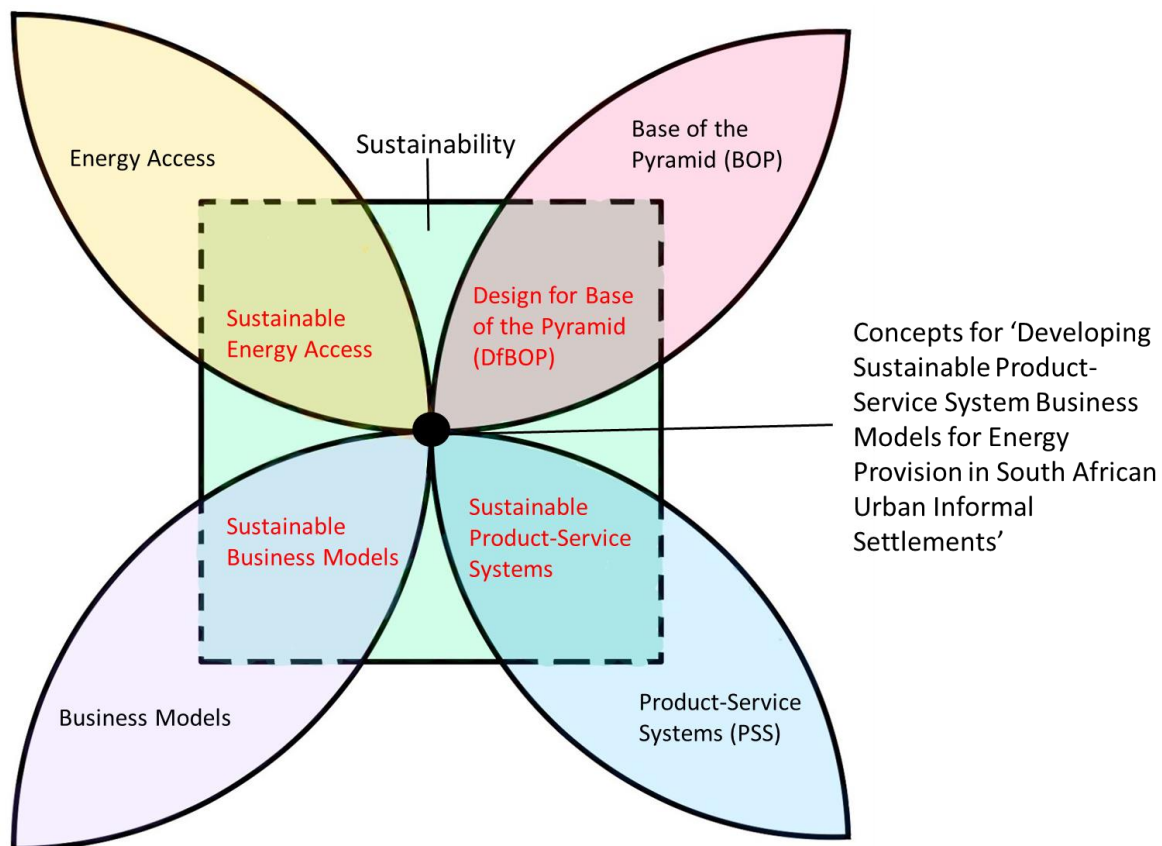
**Figure 11: Focus of the literature review**

'Sustainability' or 'sustainable development' is used interchangeably in academic literature. A high-level overview of the two terms is provided below.

## 3.2 Sustainability

References to sustainability date back to 1713. It was first mentioned by Von Carlowitz in the publication *Sylvicultura Oeconomica*, preceding the stronger focus on environmental issues by 250 years (Charter & Tischner, 2001). More recently, the term sustainable development was coined by the World Conservation Strategy in 1980 to highlight the linkages between the economy and the environment. Further refining by the World Commission for Environment and Development led to the most commonly cited definition as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987). A broader spectrum of considerations is implied by this definition such as poverty, employment and population growth, in addition to the economy and the environment.

Similarly, the most notable description of the term in a South African context is defined by the National Environmental Management Act (NEMA) as "the integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations" (Republic of South Africa, 1998). Within this definition, the dimensions of social, economic and environmental are noted. This is what Elkington (1998) called the triple bottom line (TBL). The TBL is also popularly referred to as people, profit, planet. This concept provides the pillars on which a sustainable

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enterprise should be built (Elkington, 1998), and is of specific interest in this study. In the following section, the concepts for sustainable energy access will be identified

## 3.3 Concepts for Sustainable Energy Access

### 3.3.1 Energy Access

The primary reason for providing energy to households is their socio-economic development. Energy is not consumed for itself, but for the activities (that is, energy services) it enables (ESMAP, 2015; Practical Action, 2016a; Runsten, Fuso Nerini & Tait, 2018). Energy services indicate the manner in which energy supply is used in a household. Multiple authors (Nussbaumer, Bazilian & Modi, 2011; Practical Action, 2010; Practical Action, 2012; UN Energy, 2005) have created different groupings of energy services for households. Excluding energy services that are used for productive/income generating purposes, the most commonly used household energy services are lighting, cooking, space heating and cooling, communication, entertainment and refrigeration (Bhatia & Angelou, 2014). It can be deduced that socio-economic benefits are enabled through energy services.

Access to energy, however, does not necessarily allow users the ability to make use of the various energy services they desire. The energy supply should have the right attributes to be usable by the end-users. The attributes of energy supply (that is, supply attributes) are indicators that communicate the usability of an energy supply. The usability of energy can be defined as the potential to use energy supply (when required) for the use of desired energy services (ESMAP, 2015).

There is no consensus in the literature about what number and combination of energy services would represent a basic bundle of energy services enabling the necessary socio-economic benefits. There is also no clear agreement of what the standards for the different supply attributes should be to allow for the energy service to be usable (Bhattacharyya, 2012). It is therefore, up to the energy provision enterprise and the community to agree on what bundle of energy services would be suitable. Alternatively, energy provision enterprises looking to possibly receive a governmental subsidy would try to align with national policy standards that define "basic" access to energy and choose a bundle of energy services accordingly. These policy standards are mostly specific to access a particular technology, rather than specific energy services and thus alignment may be challenging without further engagement with the state.

Multiple authors recommend energy provision enterprises to make use of a bottom-up approach for developing a basic bundle of enabling energy services in low-income contexts. This is done by engaging with communities to understand the settlement context, the socio-cultural context, and the communities' broader developmental needs (Garside & Wykes, 2017). Within these broader developmental needs, communities need to voice their energy needs and desires. As stated in section 1.5, this study does not consider the provision of energy for productive activities related to enterprises and energy services for community facilities. As such, the energy needs and desires are limited to those used within the household. Bellanca and Wilson (2012), Clements *et al*. (2019) and Practical Action (2016a) all demonstrate that a practical way of voicing community energy needs

and desires are allowing communities to prioritise the energy services they wish to use. A select number of energy services are chosen from the prioritised energy services to make up a desirable bundle of energy services. Figure 12 illustrates a workshop held by Clements *et al*. (2019), whereby community representatives voted (through different dots), for their most desirable energy services. The energy services were represented by pictures familiar to the community. The bottom-up methodology is in line with incremental upgrading policies that call for community involvement. It has also commonly been found that such an end-user centred approach leads to increased adoption of the technologies and acceptance of the energy provision enterprise (Bernal *et al*., 2009; Byrne, Kirumba, Ely, Becker & Gollwitzer, 2014; Schäfer, Kebir & Neumann, 2011; Zalengera, Blanchard & Eames, 2015). In the cases where community engagement is not possible, assumptions have to be made about the bundle of energy services that would be most desirable and beneficial for the target community.



**Figure 12: Community energy services before (Designated by A) and after (Designated by B) voting (Clements *et al.* (2019)**

There is no agreed-upon, universal definition for energy access. Multiple definitions of energy access have been presented. The Sustainable Development Goal 7 phrases universal energy access as "... affordable, reliable and modern energy services" (United Nations, 2016). The exact meaning of "modern energy services" has been debated in academic literature (Bhanot and Jha, 2012; Serwaa Mensah, Kemausuor and Brew-Hammond, 2014). It is evident that the definition is independent of the form in which energy is supplied. What *is*, however, present in the definition (and other commonly used definitions), is the focus on energy services and the desired attributes that energy supply should convey (Tait, 2016).

Energy supply can take multiple forms. Table 5 demonstrates the solid, liquid, gas, direct conversion and electricity supply forms with examples.

**Table 5: Different energy supply forms** (Practical Action 2016b)

| Energy Supply Form Names | Examples |
|---|---|
| Solid | Wood, charcoal, coal, peat, grasses, animal dung, husks/shells, sawdust, stalks/leaves, municipal solid waste and gel fuels |
| Liquid | Fossil oils such as diesel, petrol and paraffin as well as plant-based fuels including bioethanol and biodiesel |
| Gas | Natural gas, gas synthesised from fossil fuels and gas derived from plant material or animal matter including biogas |
| Direct Conversion | Energy supply that is converted directly from a natural energy source such as light, or potential or kinetic energy of water, into the energy service required, such as hot or pumped water |
| Electricity | Altering and direct current supply generated or converted from any renewable or non-renewable energy source, used either directly or via storage media such as batteries. |

Energy access statistics worldwide is predominantly focused on whether households have access to grid electrification or not (Clements *et al.,* 2019). Beyond not presenting the statistics for the households with access to other forms of supply, this binary view of energy access equates all grid connections as equally usable to end-users (ESMAP, 2015). Furthermore, the focus on a grid connection does not allow the underlying technologies (which supply the electricity) to be considered. This leads to off-grid technologies such as solar mini-kits, solar home systems (SHS) and mini-grids being placed on par with a grid connection or being ignored as part of the energy access statistics.

As discussed above, the usability of energy supply is indicated through supply attributes. Similar to the definition of energy access, there is consensus in literature to evaluate an energy supply option by using supply attributes as evaluation criteria.

Bhatia and Angelou (2014) developed different supply attributes demonstrating the multi-dimensional nature of energy. The attributes are capacity, availability, reliability, quality, affordability, formality, health, safety and convenience.

The energy services grouping of "communication and entertainment" energy services can only be delivered through energy supply in the form of electricity. The other energy services can be delivered through multiple forms of energy supply. Each of the energy supply forms (and their underlying technologies) has certain strengths and weaknesses in delivering different energy services. As a result, a bundle of energy supply forms (and their underlying technologies) may be used to deliver the basic bundle of enabling energy services.

An energy supply evaluation that uses attributes as evaluation criteria is energy supply form (and their underlying technologies) agnostic. It ensures that technology biases are removed and that no energy supply form is disqualified from the evaluation (Tait, 2015). Different energy supply forms (and their underlying

technologies) can be evaluated for a specific community to determine what would be the best supply option. This allows, for example, normal coping mechanisms, such as paraffin and indirect electricity connections, to be fairly evaluated against a grid connection to see what energy services are enabled through them.

The move away from a binary view of energy access further allows all types of energy interventions to be considered as contributors to improved access (ESMAP, 2015). An example could be diesel generators that are provided to households with grid connections. The generators, acting as back-up supply, would increase the reliability and/or duration attributes of the bundle of energy supply forms. This is very much in line with incremental upgrading as it measures energy access on a continuum of improved usability.

### 3.3.2 Sustainable Energy Access

Stretching from technical (capacity, availability, reliability and quality) to economic (affordability), to institutional (formality), to environmental and social (health & safety and convenience), the supply attributes of electricity supply as found by Bhatia and Angelou (2014) act as indicators for the multidimensional nature of energy.

Indicators beyond those communicating the usability of the energy supply should be considered to measure the sustainability of an energy provision enterprise as a whole. Indicators are commonly used in the literature on sustainable development as it depicts data in a comprehensive form. Endorsing the use of indicators as a means of evaluation is apparent in the Agenda 21 action plan of the United Nations (Stevens, 2005). Indicators of sustainable development are suggested to be used as a foundation for decision-making at all levels (Stevens, 2005).

As demonstrated through section 3.3, sustainable development is traditionally considered within the social, environmental and economic dimensions of sustainability (TBL). The TBL dimensions have been used by multiple authors in the energy sector to conduct sustainability evaluations for energy enterprises. Davidson, Winkler, Kenny, Prasad, Jabavu, Sparks, Howells & Alfstad (2006) used the TBL dimensions in the South African context and developed indicators accordingly. Bhatia and Angelou (2014), however, affirm the different dimensions of energy as demonstrated in the supply attributes of Ilskog (2008) and therefore also considers the technical and institutional dimensions when developing indicators for evaluating an energy provision enterprise. The use of technical and institutional dimensions along with the dimensions of the TBL for sustainability evaluation has been used by several other authors in recent studies in the energy provision literature (Bhattacharyya, 2012; Fuso Nerini, Howells, Bazilian & Gomez, 2014; Mainali & Silveira, 2015; Runsten *et al.* 2018).

As energy has such a multidimensional nature, energy provision enterprises experience multiple and diverse challenges. Miller, Nigel, Carlo, Nafeesa, Saurabh and Carl (2018) depict the ecosystem of actors and actor interactions required to ensure successful, sustainable delivery of energy for an energy provision enterprise in low-income contexts. The illustration can be seen in Figure 13. It should be noted that the work of Miller *et al.* (2018) is specific to energy provision enterprises (named "energy suppliers" in the illustration) that provide

off-grid solutions, therefore excluding those that provide grid solutions. It should further be noted that the end-users listed are not limited to households (named "residential" in the illustration), as it is in this study.
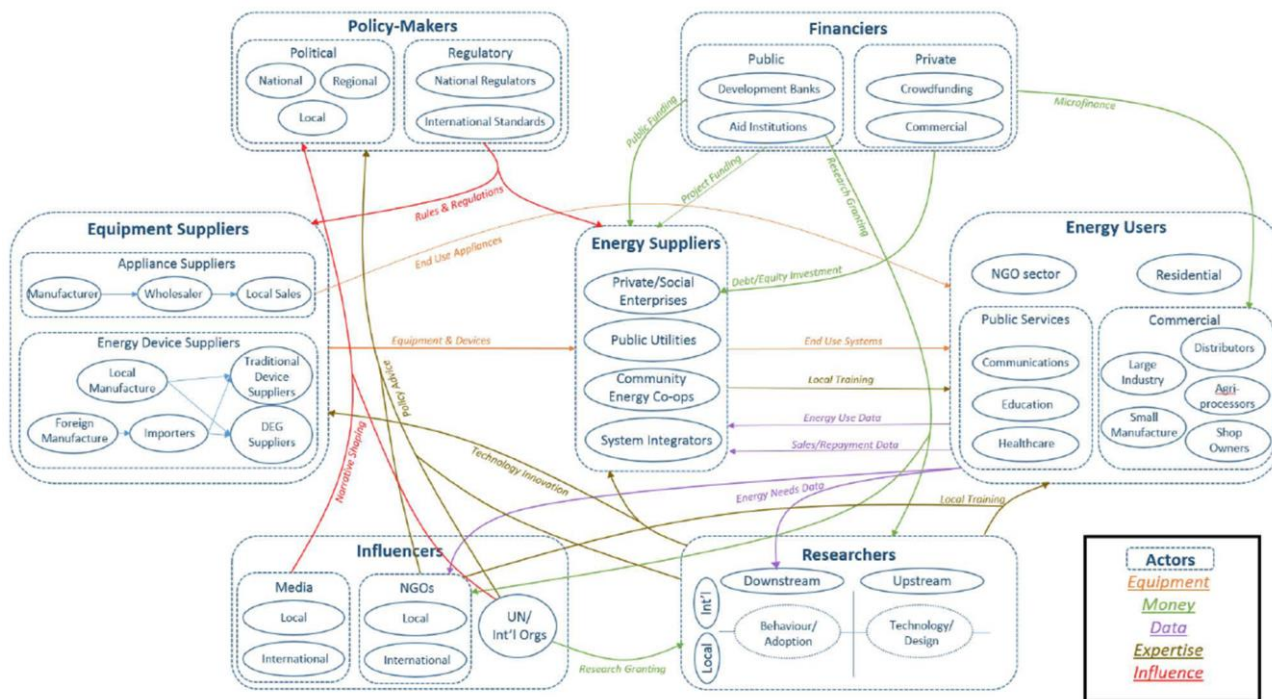


**Figure 13: Multi-actor energy access ecosystem (Miller *et al*., 2018)**

Multiple barriers exist for an energy provision enterprise that wants to operate in the urban informal market. Active collaboration is required to ensure sustainable energy provision and long-term success. Bellanca, Bloomffield and Rai (2013) and Practical Action (2015) consider the multiple supporting interventions that other actors could provide for an energy provision enterprise. They consider interventions such as project design, technical design, policy, advocacy, awareness-raising and training support. The typical financial support interventions provided could be grant, loan and equity financing. In this study, the actors who contribute directly to ensure the creation and delivery of the value proposition of the energy provision enterprise (such as providing supporting interventions) are considered partners.

The concepts of sustainable energy access that have been discussed are summarised in Table 6.

**Table 6: Concepts of sustainable energy access**

| Concepts | Description | Source(s) |
|---|---|---|
| Sustainable energy development | Considering sustainable development across the social, economic, environmental, institutional and technological dimensions | Bhattacharyya (2012); Ilskog (2008); Fuso Nerini *et al.* (2014); Runsten *et al.* (2018) |
| Development measurement criteria | Indicators of sustainable development as enterprise development evaluation criteria | Bellanca & Wilson (2012); Bellanca *et al.* (2014); Practical Action (2016); UN Energy (2005) |
| Bottom-up planning | End-user engagement to understand needs and desires | Practical Action (2016) |
| Usability of energy | Potential to use energy supply for the use of desired energy services | ESMAP (2015) |
| Multi-stakeholder engagement | Consideration of multiple stakeholders' roles and responsibilities in delivering sustainable energy to end-users | Jiang & Kandachar (2009); Miller *et al.* (2018) |

## 3.4 Concepts of Design for the Base of the Pyramid (DfBOP)

### 3.4.1 The Base of the Pyramid (BOP) Market

The base of the pyramid (BOP) concept was introduced by Prahalad & Hart (1999). BOP refers to the "largest but poorest socio-economic groups in the global income pyramid working in predominantly informal markets and living on a few dollars a day" (Prahalad and Hart, 2002). In particular, the BOP market is not bound to specific ethnicities, cultures, capabilities or needs, but is a heterogenic market composed of "... over four billion people who live on less than \$2/day..." which "... can be segmented in multiple ways" (Prahalad, 2011). In the South African context, this can be translated to those who live on less than ZAR20 (Eighty20, 2011), which represents over 25 per cent of the South African population (SAARF, 2014). Beyond the low income received by this market segment, the BOP is also characterised by lack of access to basic services such as education, sanitation, energy provision and public health (Ceschin & Gaziulusoy, 2016; London, Davidson & Ross, 2007). The BOP market is used synonymously with the informal settlements market in the literature and therefore used interchangeably in this study.

The BOP market has unique challenges to that of higher-income markets. Some of the biggest challenges for enterprises operating in the BOP market are (Ceschin & Gaziulusoy, 2016; Jagtap & Kandachar, 2010; Jagtap, Larsson & Kandachar, 2013; London and Hart, 2010; Narayan, Patel, Schafft, Rademacher & Koch-Schulte, 2000; UNDP, 2008):

- Low purchasing power of customers
- Lack of education and skills
- Lack of market information about end-user needs
- Underdeveloped regulatory environment and governance
- Cultural, lifestyle and language barriers
- Lack of physical infrastructure

A BOP-specific design approach is necessary to overcome the challenges listed above.

### 3.4.2   Design for the BOP (DfBOP)

Vezzoli, Ceschin, Osanjo, M'Rithaa, Moalosi, Nakazimbwe and Diehl (2018) observe that humankind's reaction to environmental degradation has evolved, particularly in the last fifty years. Previously, interventions were conducted *after* damage of the environment had taken place. At present, the focus has shifted to *prevention*, which requires a holistic analysis of the life cycle of an enterprise. A spill-over effect of conducting life cycle analyses was the consideration of sustainability in the social dimension. The design for sustainability (DfS) discipline emerged out of this context.

Over time, several approaches emerged out of the DfS disciple. The most widely known approaches are design for eco-innovations (DfEI), biomimicry (BM) design and cradle-to-cradle (CTC) (Idil Gaziulusoy, 2015). The unique challenge of the BOP market segment necessitated a new design methodology. The DfBOP approach was added and is also viewed as one of the commonly used approaches, being used in global organisations such as the United Nations Development Program (UNDP, 2008).

After conducting a literature review of various theoretical frameworks and enterprises implemented in the BOP context, Castillo, Diehl and Brezet (2012) identified the design requirements integral to success in the BOP market as desirability, feasibility, viability and sustainability. The critical design requirements for the BOP market are illustrated in Figure 14 below.
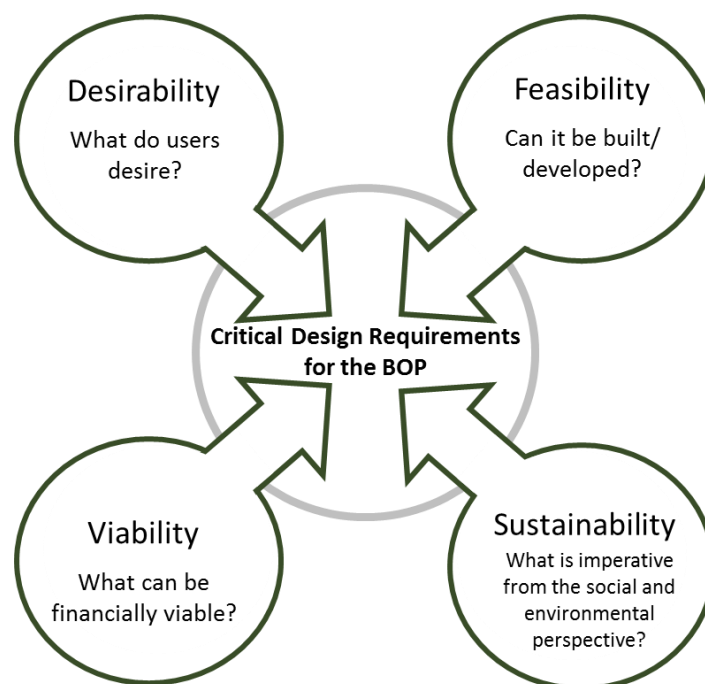
**Figure 14: Critical design requirements for the BOP market (Adapted from** Castillo, Diehl and Brezet (2012)**)**

Castillo *et al.* (2012) advised enterprises operating in the BOP market to start by developing an in-depth understanding of the end-users. Enterprises must engage with the community to understand what needs they desire to be satisfied and how. The socio-cultural factors (values, beliefs and aspirations) and the context in which the end-users live (economic, social, political, surrounding infrastructure and access to public services) must be considered (Clements *et al.,* 2019). As end-users not only see grid electrification as a technical solution but a symbol of legitimacy from the state, any alternative will be considered critically. Solutions that are desirable to end-users have an increased chance of adoption. Rejected solutions may face vandalism through service delivery protests. When engaging with end-users, Castillo *et al.* (2012) advise involving the end-users as allies in co-creating solutions to their articulated needs (Jiang & Kandachar, 2009). Designing solutions in an end-user centred manner leads to solutions that are truly impactful and responsive to end-users' lives.

Following, the investigation of end-users' desirability, design ideas are transformed into tangible solutions. The feasibility of the enterprise is determined by considering the various technical and organisation requirements. Technical and organisation requirements such as reliance on local resources, ease of installation and use, as well as operations and maintenance needs, demand attention (Prahalad, 2010). With the high demand for energy poverty relief, an extended implementation period may possibly rule out some solutions. Furthermore, modularity and portability of solutions could be considered in communities that are provided interim services. The modularity allows end-users to increase their energy supply if they have the financial means to pay for it.

Viability considers the enterprise from a financial point of view. The analysis of the feasibility of an enterprise would assist in understanding the capital and operational costs involved in the proposed solution. Financial risk can also be considered such as the technical solution's vulnerability to theft, manipulation or damage

through fire. It should be determined what the end-users are willing to pay as well as their actual ability to pay (Bellanca & Garside, 2013; Smith, 2007). Funds from third parties, whether it be through donations, subsidies or other customer segments outside the BOP market, should be considered to cover the expenses possibly not covered by end-user income. Possible income-generating opportunities created through the intervention can also be considered (Larsen & Flensborg, 2011). These income-generating opportunities provide end-user empowerment and assist them to be active citizens within their own community (as intended through incremental upgrading).

As energy provision falls within the public services sector, enterprises are often implemented on a large scale, and therefore the sustainability considerations are essential in initiative development. Castillo *et al.* (2012) consider sustainability as the underpinning requirement in enterprises in the BOP context and emphasise the need to evaluate the impact on the social and environmental dimensions of sustainability. As discussed in section 3.3.2, energy provision in the urban informal context requires not only the sustainability evaluation of the TBL but also the technical and institutional dimensions of sustainability.

To overcome the barriers in the BOP market, the collaboration of multiple stakeholders such as end-users, enterprises, governments and NGOs are needed (Jiang & Kandachar, 2009). In terms of considering different stakeholders' value perceptions and balance concerns, Jiang and Kandachar (2009) recommend a "team-effort" when designing for BOP enterprises.

Table 7 provides a summary of the critical concepts in sustainable DfBOP.

**Table 7: Concepts of design for the base of the pyramid (DfBOP)**

| Concepts | Description | Source(s) |
|---|---|---|
| Desirability | Maintaining a user-centred approach and designing desirable solutions that would satisfy their needs that users would find attractive | Castillo *et al.* (2012); Jagtap & Kandachar, (2010) |
| Feasibility | Consideration of whether a solution can be developed/built from a technical and organisational perspective | Castillo *et al.* (2012) |
| Viability | Considering a solution from a financial perspective to determine whether the enterprise income will outweigh the enterprise expenses | Castillo *et al.* (2012) |
| Consideration of sustainability | Design products and services that contributes to sustainable development to ensure scalability to millions of people | Castillo *et al.* (2012) |
| Multi-stakeholder collaboration | Collaboration of multiple stakeholders to overcome barriers in the BOP market | Jagtap & Kandachar (2010) |

## 3.5 Concepts for Developing Sustainable Business Models

### 3.5.1 Business Models

Multiple authors in the energy provision literature take the lens of business models when studying how energy can be provided to low-income communities (Bellanca and Garside, 2013; Gabriel & Kirkwood, 2016; Hiteva & Sovacool, 2017; Knuckles, 2016; Wilson, Godfrey Wood & Garside, 2012). The president of South Africa also made use of the term business model when addressing the restructuring of Eskom on 7 February 2019 in his State of the Nation Address. President Ramaphosa said, to "… avoid a similar financial crisis in a few years' time, Eskom will need to develop a new *business model*" (South African Government, 2019)

The term business model first appeared in academic literature in 1957 (Wirtz, Pistoia, Ullrich & Ottel, 2015), but research and practice have only become prominent the past 15 years (Lüdeke-Freund & Dembek, 2017). Most authors contribute this increased interest due to the dot-com boom/era of the late 1990s (Zott, Amit & Massa, 2011). In simple terms, a business model describes "how a firm does business" (Magretta, 2002). The concept originated out of a need to more efficiently facilitate the explanation of complex business ideas and has matured to be used as a common analytical and classification tool by researchers and practitioners (Baden-Fuller & Morgan, 2010; Nosratabadi, Mosavi & Shamshirband, 2019). Although the term has commonly been used in the literature, scholars have not agreed on a single definition (Osterwalder, 2004; Zott, Amit & Massa, 2011). The most commonly used definition in the literature is that of Osterwalder and Pigneur (2010:14) describing a business model as *"... the rationale of how an organisation creates, delivers, and captures value"*. This description of the business model concept is adopted in this research study.

### 3.5.2 Sustainable Business Models

The literature on business models predominantly takes an economic perspective of businesses by considering their financial profit and growth (Rana, Short, Evans & Granados, 2017). The challenges posed by sustainable development, however, necessitate a new way of thinking that also considers the social and environmental dimensions. This new way of thinking has been deemed "sustainable business thinking" (Bocken, Rana & Short, 2015). It views business as a positive force, which contributes to the environment and society while maintaining financial profitability (Bocken *et al.,* 2015). Strategic and operational changes to businesses are required for the consideration of the social and environmental dimensions (Rana *et al.*, 2017).

Semples and Hoffmann (2013) argue that the requirement to integrate sustainable development into a business successfully is to link it to the strategy of the company. Stubbs and Cocklin (2008) recommend the use of TBL indicators as measurement criteria to determine to what extent this strategy be implemented.

Casadesus-Masanell and Ricart (2010) argue that the concepts of a business strategy and its business model(s) are closely related. They are typically a reflection of each other. It is therefore a difficult task to differentiate between these two terms on a conceptual level. Osterwalder (2004) assert however that a business strategy and its business model consider the same challenges (for example, how to create long-term profits), but at different business layers (as seen in Figure 15).

| planning level | strategic layer | vision, goals & objectives |
| architectural level | business model layer | money earning logic |
| implementation level | process layer | organisation & workflow |
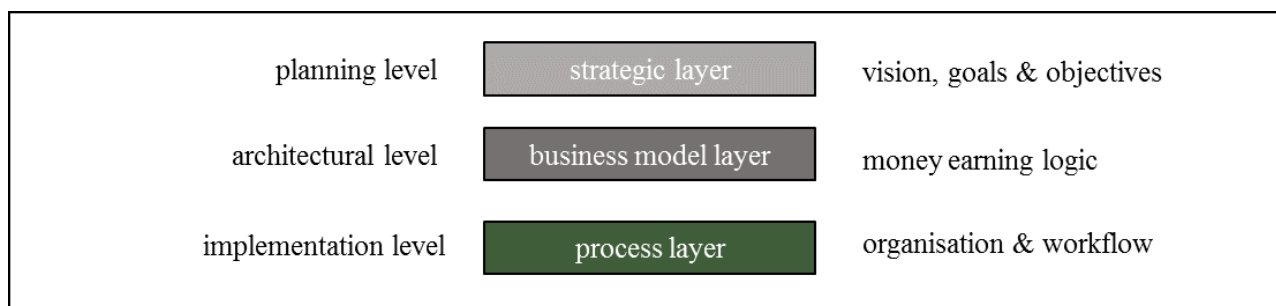
**Figure 15: Different business layers and corresponding levels (Adapted from** Osterwalder (2004)**)**

It can therefore be deduced that a business model, as a unit of analysis, serves as a conceptual tool to create a link between business strategy and implementation (Osterwalder, 2004; Semples & Hoffmann, 2013). It provides a way to put a strategy into practice as it translates the business strategy into a blueprint of how it creates, delivers, and captures value (Casadesus-Masanell & Ricart, 2010; Osterwalder, 2004; Osterwalder & Pigneur, 2010). Consequently, it becomes clear that a businesses' strategy can be embodied by multiple business models.

It has been described how sustainable business models should consider the economic dimension of sustainability and its impact on society and the environment. Some authors further argue that sustainable business models should not limit its focus on creating value for the customers and the business, but for all stakeholders (Magretta, 2002; Seddon *et al.*, 2004; Zott, Amit & Massa, 2011). The stakeholders of a business are defined by Freeman (1984) as "any group or individual who can affect or is affected" by the business. Commonly listed stakeholders in sustainable business model literature are employees, suppliers and partners, investors and shareholders, academia, media and the government (Bocken, Short, Rana & Evans, 2013; Bocken *et al.,* 2015; Rana 2016; Stark, Seliger & Bonvoisin, 2017). All these authors also include society and environment in the list of stakeholders to consider. The business model, as a conceptual tool, provides a system-level perspective to discuss value creation for all stakeholders (Zott & Amit, 2010). This is accomplished by considering the multiple relationships and exchanges (both financial and non-financial/intangible) that the different stakeholders have with the business and the activities performed by the business and the relevant stakeholders (as part of the businesses' business model) (Zott & Amit, 2010). A business model can therefore be used as a unit of analysis to provide researchers and practitioners a common language for discussing trade-offs for sustainability and multi-stakeholder value creation, resulting in creative design to ensure win-win solutions (Zott & Amit, 2010).

Bocken *et al*. (2013) found that one way of understanding value exchange between different stakeholders (leading to new business model opportunities) is by mapping various forms of value. This process is called value mapping, and the rationale is displayed in Figure 16. The value proposition of the enterprise forms the core of the value mapping logic, as it represents the benefits delivered to the multiple stakeholders. Value may be destroyed by individual stakeholders or the network as a whole whilst delivering the value proposition. This is represented by value destroyed and can manifest itself in many forms such as a market opportunity that has been disrupted for an individual stakeholder, pollution and so forth. Value Missed represents the scenarios in

which value for a stakeholder exists but not exploited. Reasons for value missed could vary from one stakeholder not being persuaded to pay for a benefit, to poorly designed value creation, and so forth. Those making use of the value mapping methods should attempt to reconceptualise destroyed value as missed value to capitalise on exploiting possible value. Lastly, new opportunities for value creation should be considered. This can be done by considering the current value proposition, attempting to generate solutions for value destroyed or capitalising on possible value missed, as illustrated in Figure 16 below.
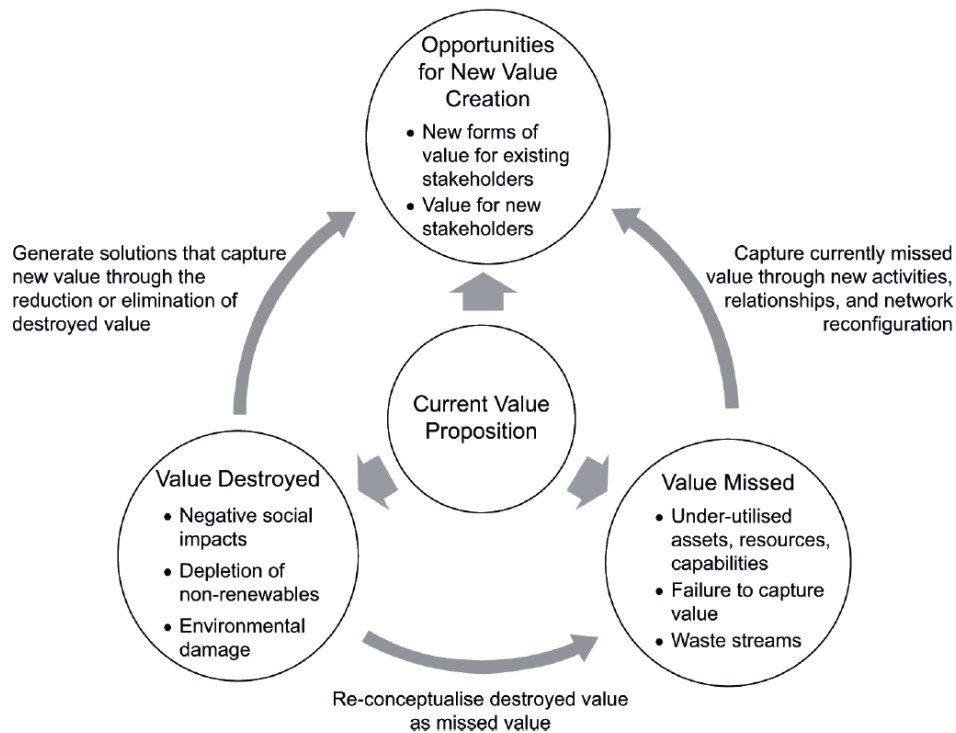
**Figure 16: Value Mapping Tool Rationale (Bocken *et al.,* 2013)**

As demonstrated in Figure 16, Bocken *et al.* (2013) used Value Destroyed and Value Missed to represent the negative aspects of the current business model. Yang, Vladimirova and Evans (2017:5) built on these concepts and further introduced two new concepts – Value Absence and Value Surplus. Value Absence refers to "value which is required, but does not exist" whereas Value Surplus refers to "value which exists, but is not required". These concepts will be discussed further in section 4.3.6.

Table 8 provides a description of the important concepts discussed when developing sustainable business models.

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**Table 8: Concepts for developing sustainable business models**

| Concepts | Description | Source(s) |
|---|---|---|
| Sustainable development strategy | Sustainable development (that is, TBL) incorporated into the strategy of the business | Semples & Hoffmann (2013) |
| TBL measurement criteria | TBL indicators as evaluation criteria for sustainability | Stubbs & Cocklin (2008) |
| Multi-stakeholder engagement | Considering multi-stakeholder collaboration and the value created for all to ensure win-win solutions | Bocken *et al.* (2013); Bocken *et al.* (2015); Dembek, York and Singh (2018); Hart (1997); Stubbs & Cocklin (2008); Yang *et al.* (2017) |
| Systems thinking | Understanding a system as a whole, along with its interrelated relationships between elements to consider multiple options (trade-offs) | Madrazo & Senge (2011); Meadows (2009) |
| Multiple forms of value | Considering different forms of value as from the perspective of stakeholders | Bocken *et al.* (2013) |

## 3.6  Concepts for Sustainable Product-Service Systems (PSS)

### 3.6.1  Product-Service Systems (PSS)

Multiple authors consider PSSs as one of the most promising alternatives to the challenges experienced by traditional production/consumption systems (Vezzoli *et al.,* 2018). PSS was first proposed by Goedkoop, Van Halen, Te Riele & Rommens, (1999) and similarly to the business model concept, has no agreed definition (Boehm & Thomas, 2013). The concept of PSSs can be clarified by describing a PSS as "*a mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customer needs*" (Tukker & Tischner, 2006:1552). Through this definition, it is evident that a PSS is a specific type of value proposition that is not limited to products *or* services but offers a combination of *both* products and services. PSSs focuses less on product sales and customer ownership, and more on delivering the service-value embedded in that product to fulfil customer needs (Tukker, 2004). This focus on offering functionality/performance to customers links closely to the concept of jobs-to-be-done of Christensen & Raynor (2003). The jobs-to-be-done theory considers a customer need/job from a customer point of view, as it asks what is needed to get that job done. An example could be a customer who wants to travel from point A to point B in a city requiring mobility to get their job done. As the functional customer need is "mobility",

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other solutions beyond selling a car (and the need for customer ownership) are possible, such as public transport.

A commonly used definition of PSS is: *"a system of products, service, supporting networks and infrastructure that is designed to be competitive, satisfy customers' needs, and have a lower environmental impact than traditional business models"* (Mont, 2002:240). This description of a PSS illustrates the relationship between PSSs and sustainability. It achieves this by firstly stressing that a PSS is a "system" that consists of not only products and services, but a network of partners that assists in creating and delivering the PSS value proposition by using infrastructure (all physical and IT infrastructure) (Mont, 2004). In a low-profit margin market such as urban informal settlements, this network of partners could assist in the profitability of a business, addressing the economic dimension of sustainability. Secondly, the definition emphasises competitiveness, highlighting that a PSS allows for creating added value as compared to traditional offerings for customers. The social dimension of sustainability is addressed through this as it speaks to enhanced social equity and technology justice to low-income communities. Lastly, "environmental impact" is present in the definition, demonstrating the ability of a PSS to decrease the impact on the environment – addressing the environmental dimension of sustainability.

The PSS classification most frequently cited in the literature is the classification of Tukker (2004), categorising PSSs into product-oriented, use-oriented and result-oriented PSSs. Tukker (2004) further classifies these PSSs into eight PSS types, as depicted in Figure 17.
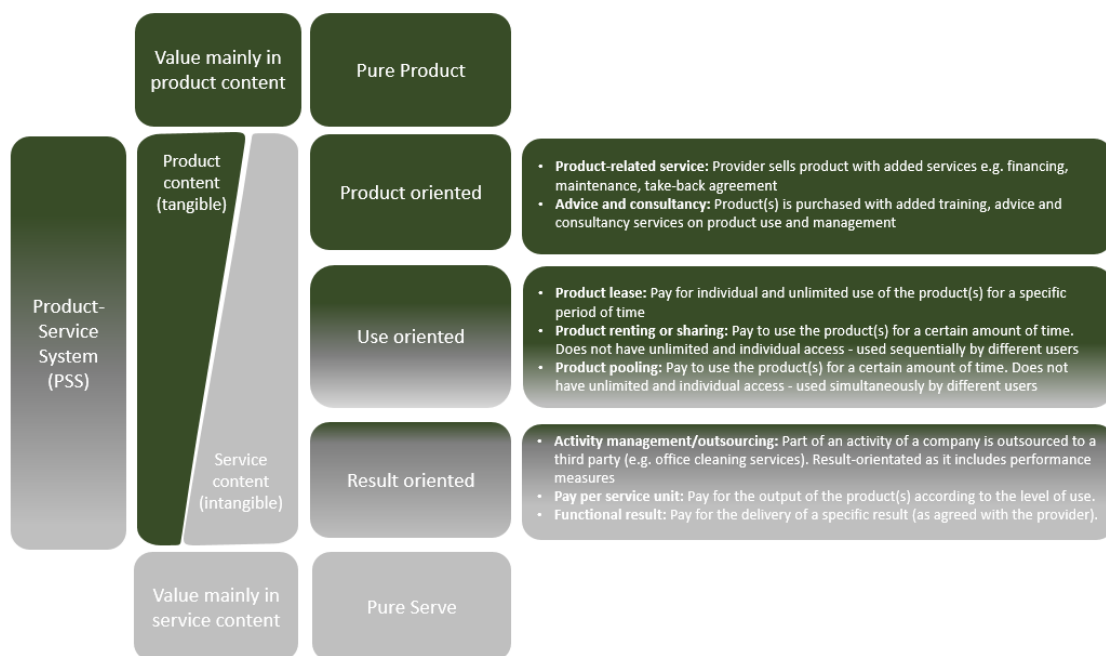


**Figure 17: Classification of PSS types**

PSSs have been studied in the context of energy provision in low-income contexts. Emili, Ceschin and Harrison (2016) developed a classification for the different PSS types relevant to distributed renewable energy (DRE) technologies that supply energy in the form of electricity. Practical Action Consulting's PISCES Project also

considered different PSS types in the low-income energy provision sector (Practical Action, 2016b). They developed a less-detailed classification of different PSS types. It is however not limited to a specific form of energy such as electricity. For this study, Emili's (2017) and Practical Action's (2016b) classification of different PSS types were combined to form a classification appropriate for multiple forms of energy. The classification is depicted in Figure 18.
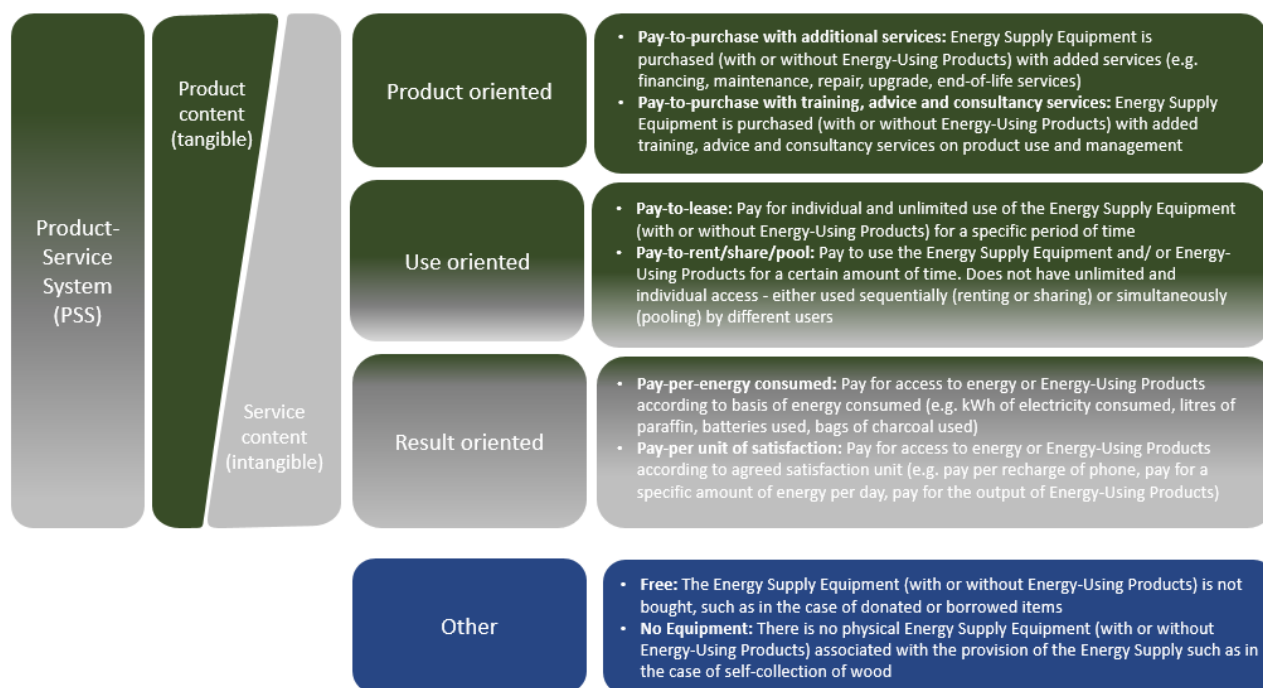


**Figure 18: Classification of PSS types in the energy provision sector**

It is evident that the PSS classification is similar to that of Tukker (2004). As this study is focused on the provision of PSS offers, pure product and pure service are not considered in the classification of the different PSS types. The terminology of energy supply equipment and energy-using products are used. The terminology will be discussed in detail in Section 4.3.3.2. Energy supply equipment refers to equipment used to convert energy from an energy source into a usable energy form of energy supply. Energy-using products refer to the equipment used to convert a form of energy supply into energy services. Within the developing classification of different PSS types, the renting/sharing and pooling types of Tukker (2004) are combined to allow for simplicity, as they are applied similarly in the energy provision context. The activity management PSS type is also not present as it is not relevant to enterprises providing energy to households. Lastly, other PSS types were added - the free and no equipment types. These PSS types are present in the work of Practical Action (2016b) and demonstrate the reality of donation and charity in the low-income context.

As demonstrated, there are multiple PSS types. The different PSS types communicate the ownership of the product(s) and for what the customer pays. The business model concept will be used (where applicable) for the remainder of the study, as it goes beyond product ownership and customer payment and considers the logic of how value from the PSS offer is created, delivered and captured, as per the definition of Osterwalder and Pigneur (2010).

### 3.6.2 Sustainable PSS

Tukker and Tischner (2006) describe sustainable PSS as *"a PSS causing minimum negative environmental and social impact while maximising social well-being and maximising economic added value"* Although PSS has the potential to create sustainable alternatives, sustainability is unfortunately not inherent in their delivery (Tukker & Tischner, 2006; Vezzoli *et al.*, 2018). An example of this could be increased fuel use and air pollution resulting from transportation in PSS types where products are borrowed and returned. Another example could be careless consumer behaviour resulting from PSS types where customers have no ownership – resulting in a greater demand for resources.

The design stage significantly influences the long-term PSS business model that will be followed, affecting the resources and activities required to create and deliver the business model. It is therefore critical that sustainability is considered in the design stage. This necessitates the consideration of the sustainability of the whole "… system of products, service, supporting networks and infrastructure…" as per the definition of PSS provided earlier (Mont, 2002). The life cycle thinking method allows a holistic perspective and is thus seen as an essential concept to assist researchers and practitioners in developing sustainable PSS (Mario, Cedeño & Hannola, 2019; Sundin, 2009;  Umeda, Takata, Kimura, Tomiyama, Sutherland, Karak Herrmann & Duflou, 2012).

Life cycle thinking is defined by Orellano *et al.* (2018:293) as "… *the ability to decouple the life cycle of any offer into sub-processes…"*. A PSS life cycle can be seen in Figure 19. Following the example of other authors in the literature, the life cycle phases are grouped into beginning of life (BOL), middle of life (MOL) and end of life (EOL) to ease life cycle thinking (Aurich, Fuchs and Wagenknecht, 2006; Cedeño and Hannola, 2019; Orellano *et al.*, 2018).
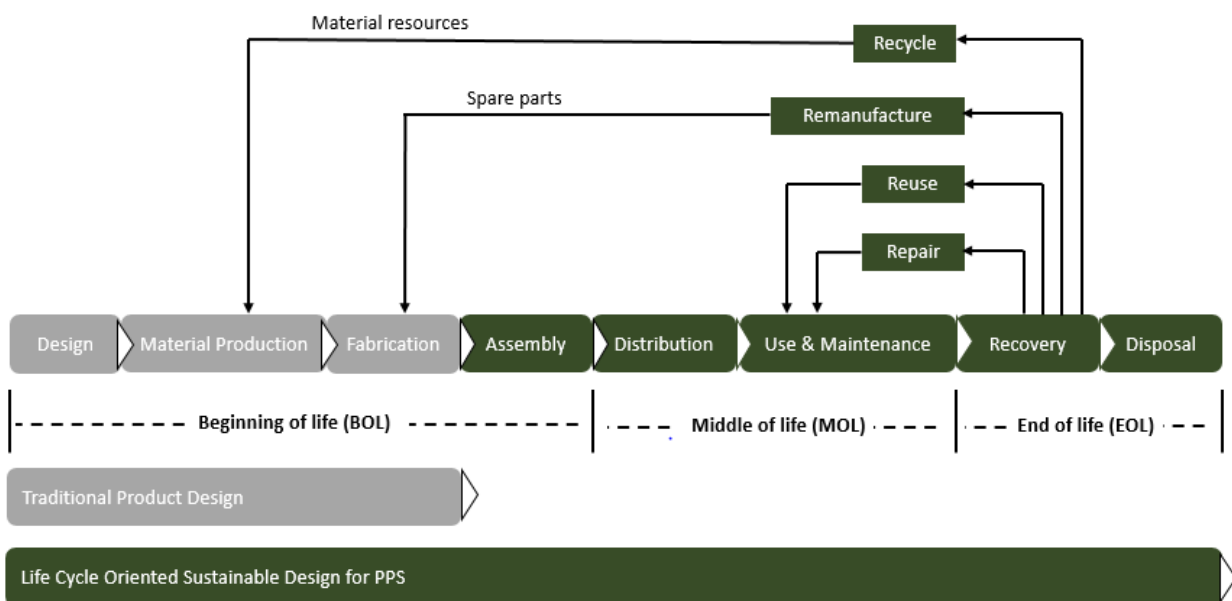


**Figure 19: PSS Life Cycle (Adapted from** Yang (2015*))*

In traditional business models that offer products without added service, the involvement of the product provider does not stretch beyond just-before or at the point of purchase by the customer. The involvement of the provider in PSS business models, however, can stretch along the entire PSS offering's life cycle (as illustrated in green in Figure 19). As the provider is involved in more life cycle phases, researchers and practitioners need to design the necessary resources and activities required (throughout the life cycle) and what actors could possibly be partnered with in providing and performing these resources and activities, respectively, in a sustainable manner. As discussed, multi-stakeholder engagement is necessary for sustainable business models. In sustainable PSS business models, an even wider range of stakeholders is required to create and deliver the mix of products and services, possibly resulting in win-win solutions for all (UNEP, 2009; Vezzoli *et al.*, 2018). In the context of this study, possible partners could be members of the urban informal settlements – thus creating job opportunities. The economic dimension of sustainable development is further addressed, as third party financers can be considered throughout the PSS life cycle to ensure financial viability. In use- and result-orientated PSS types, capital costs are high as the provider retains ownership of the products, which could have a long payback period (Barquet *et al.*, 2013; Tukker, 2004). This is especially true in the urban informal energy provision sector where infrastructure is expensive, and profit margins are low.

The provider/customer relationship is also affected as it is no longer limited to a single transaction but is characterised by a longer-term relationship (Adrodegari, Saccani & Kowalkowski, 2016). The multiple customer interactions create opportunities for customer involvement/co-creation, leading to trust, empathy and offerings that are responsive to their needs (Aurich, Fuchs & Wagenknecht, 2006; Davidson & Winkler, 2003). As the relationships with the customers are critical to long-term success, partners such as NGOs can be considered to assist in improving relationships – addressing the social dimension of sustainable development (Costa Junior & Diehl, 2013). Lastly, the environmental dimension of sustainable development can, for example, be considered either through focusing on the EOL phases or through considering how customer education, with regard to energy efficiency and renewable energy sources, can be offered (Costa Junior & Diehl, 2013).

The prominent concepts of sustainable PSS are described in Table 9.

**Table 9: Concepts for sustainable product-service systems (PSS)**

| Concepts | Description | Source(s) |
|---|---|---|
| Product and service combinations | Offering a mix of tangible products and intangible services | Tukker & Tischner (2006) |
| Jobs-to-be-done | Considering the tasks/"jobs" that need to be completed from a customer perspective | Christensen & Raynor (2003) |
| New modes of ownership | Considering product ownership and timelines of ownership transfer | Emili, Ceschin & Harrison (2016); Yang & Evans (2019) |
| Consideration of sustainability | Consider the impacts on the TBL dimensions of sustainability | Yang *et al.* (2013) |
| Life cycle thinking | Holistic analyses of an offer's entire life cycle and its corresponding sub processes | Cedeno (2019); Orellano *et al.* (2018) |
| Multi-stakeholder engagement | Consideration of multiple stakeholders' contributions that assist in creating and delivering PSS offerings | UNEP (2009) Vezzoli *et al.* (2018) |
| Customer co-creation | Involving customers in multiple phases of the PSS life cycle | Aurich, Fuchs & Wagenknecht (2006); Da Costa Junior (2013) |

## 3.7 Conclusion

The literature review provided established definitions of the main concepts of the study. Concepts correlating to sustainability within the four bodies of literature (energy access, BOP, business models and PSS) were identified. The literature overview provided a firm theoretical framework for this study.

In the next chapter, the Framework development is presented.

# CHAPTER 4: FRAMEWORK DEVELOPMENT

## 4.1 Introduction

As seen in Figure 20 below, this chapter considers the development of the conceptual framework which will address research objective 2.
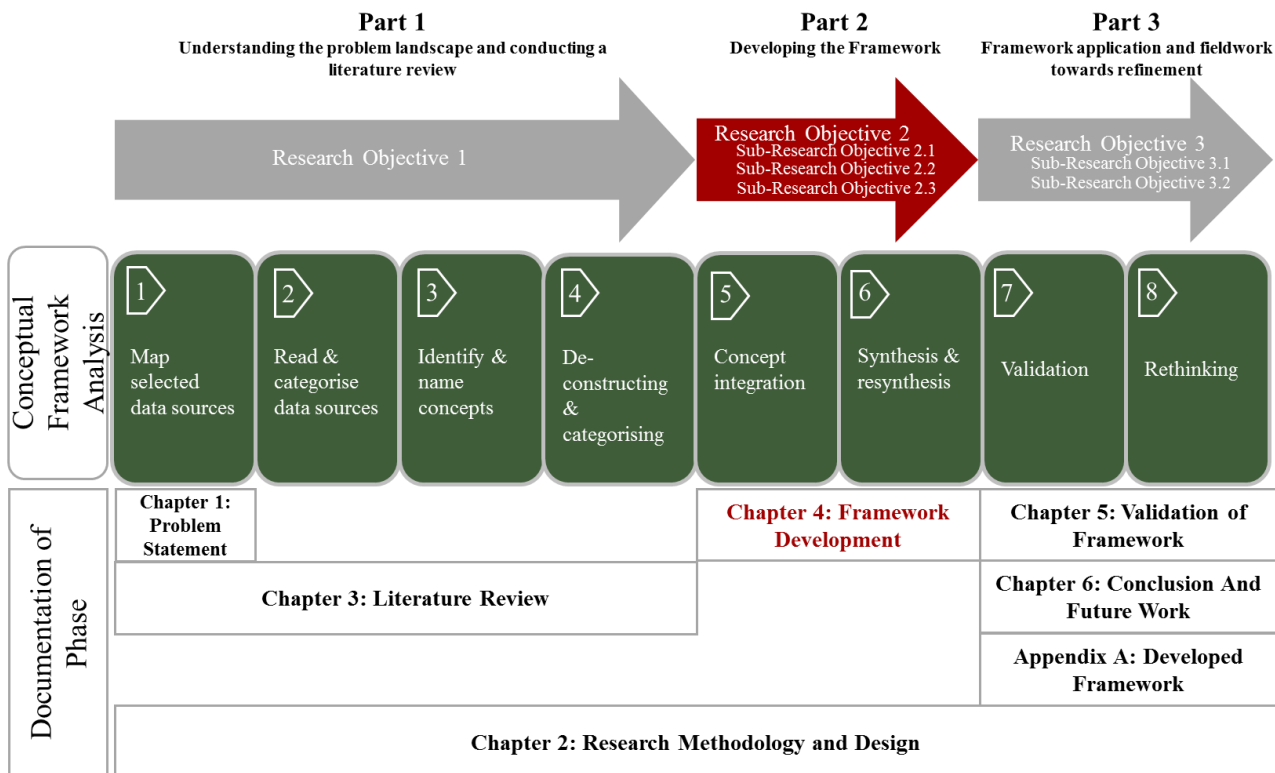


**Figure 20: Document Context Diagram – Chapter 4**

The framework consists of six different modules. Together, the sum of these modules forms an appropriate whole, namely a sustainable product-service systems (PSS) business model development framework that is fitting to the context of this study.

## 4.2 Integration of Concepts

Figure 21 demonstrates how the concepts identified in Chapter 3 are synthesised into a conceptual framework consisting of different modules. It can be seen how the concepts are integrated to form the key concepts. These key concepts are further merged into consolidated key concepts – a concise phrase that summarises the rationale for the framework modules. The different modules of the conceptual framework are designed through the critical review of tools existing in the literature in terms of the extent to which they address the key concepts previously defined.
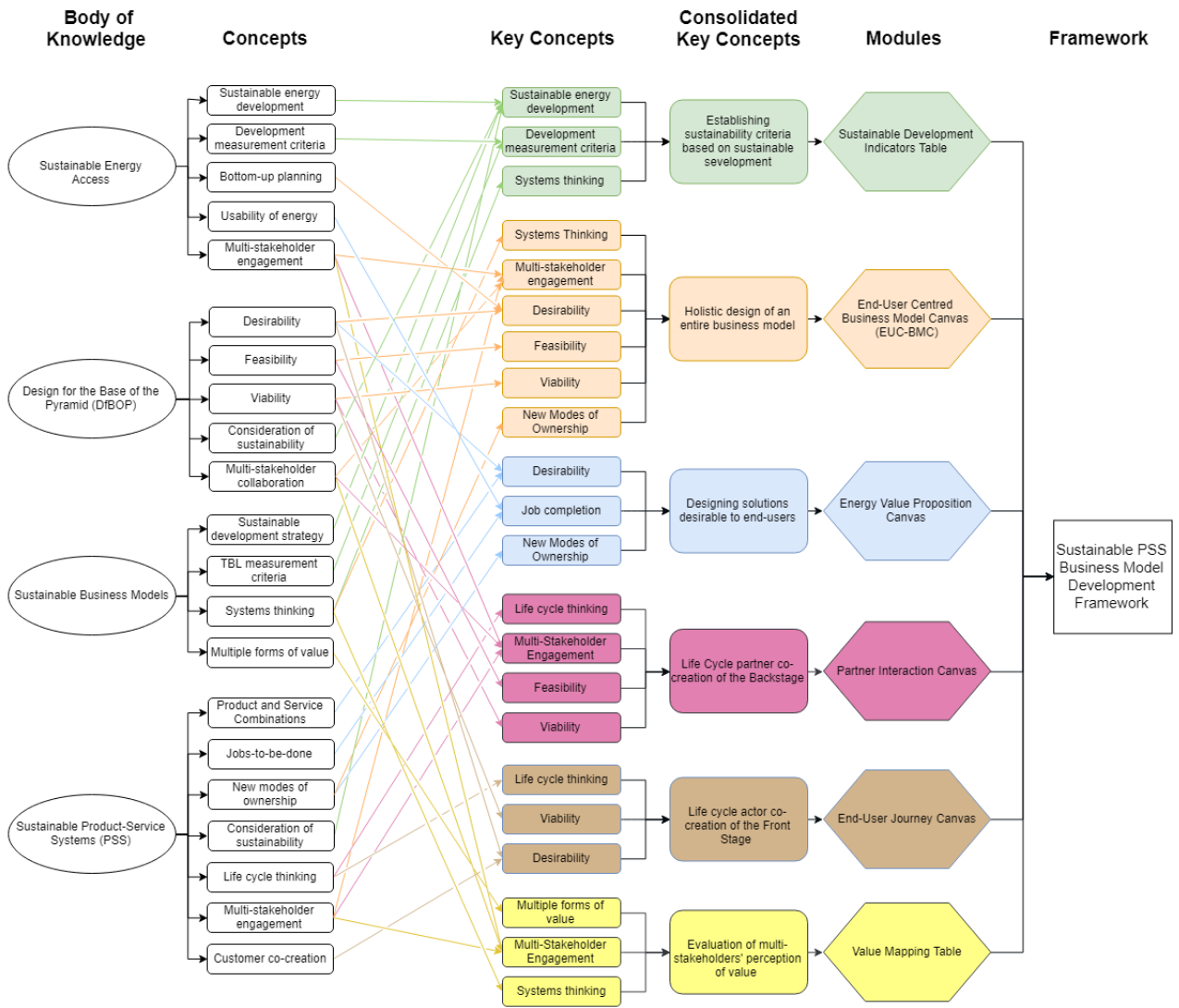
**Figure 21: Conceptual framework development**

Table 10 provides descriptions of the different key concepts.

**Table 10: Key Concept Descriptions**

| Key Concept in Module | Description | Consolidated key concepts | Framework module |
|---|---|---|---|
| Sustainable energy development | Considering sustainable development across the social, economic, environmental, institutional and technological dimensions | Establishing enterprise evaluation criteria based on sustainable development | Sustainable development evaluation criteria |
| Development measurement criteria | Indicators of sustainable development as enterprise development evaluation criteria | | |
| Systems thinking | Understanding a system as a whole, along with its interrelated relationships between elements, as to consider multiple options (trade-offs) | | |
| Systems thinking | Understanding a system as a whole, along with its interrelated relationships between elements, as to consider multiple options (trade-offs) | Holistic design of an entire business model | Holistic design of entire business model |
| Multi-stakeholder engagement | Consideration of multiple stakeholders' roles and responsibilities in delivering sustainable energy to end-users through PSS offers | | |
| Desirability | Maintaining a user-centred approach and designing desirable solutions that would satisfy their needs that users would find attractive | | |
| Feasibility | Consideration of whether a solution can be developed/ built from a technical and organisational perspective | | |
| Viability | Considering a solution from a financial perspective to determine whether the enterprise income will outweigh the enterprise expenses | | |
| New modes of ownership | Considering product ownership and timelines of ownership transfer | | |
| Desirability | Maintaining a user-centred approach and designing desirable solutions that would satisfy their needs that users would find attractive | Designing solutions desirable to end-users | Energy value proposition canvas |
| Job completion | Considering the energy-specific and other tasks/ "jobs" that need to be completed from a customer perspective | | |
| New modes of ownership | Considering product ownership and timelines of ownership transfer | | |
| Life cycle thinking | Holistic analyses of an offer's entire life cycle and its corresponding sub-processes | Life Cycle partner co-creation of the Backstage | Partner Interaction Canvas |
| Multi-stakeholder engagement | Consideration of multiple stakeholders' roles and responsibilities in delivering sustainable energy to end-users through PSS offers | | |
| Feasibility | Consideration of whether a solution can be developed/ built from a technical and organisational perspective | | |
| Viability | Considering a solution from a financial perspective to determine whether the enterprise income will outweigh the enterprise expenses | | |
| Life cycle thinking | Holistic analyses of an offer's entire life cycle and its corresponding sub-processes | Life cycle actor co-creation of the Front Stage | End-User Journey Canvas |
| Viability | Considering a solution from a financial perspective to determine whether the enterprise income will outweigh the enterprise expenses | | |
| Desirability | Maintaining a user-centred approach and designing desirable solutions that would satisfy their needs that users would find attractive | | |
| Multiple forms of value | Considering different forms of value as from the perspective of stakeholders | Evaluation of multi-stakeholders' perception of value | Value-mapping table |
| Multi-stakeholder engagement | Consideration of multiple stakeholders' roles and responsibilities in delivering sustainable energy to end-users through PSS offers and the value created for all | | |
| Systems thinking | Understanding a system as a whole, along with its interrelated relationships between elements, as to consider multiple options (trade-offs) | | |

The conceptual framework (referred to as the "Framework" in the remainder of the document) is made up of six modules. Each module manifests itself as a tool to be used by users in an idea generation phase to map out trade-offs visually. The Framework has a modular design, as each module can be used on its own. However, when used in its entirety, the modules work together to display all relevant trade-offs that exist in the context of this study in a single framework.

The different Framework modules will be discussed in detail below.

## 4.3   Development of Different Framework Modules

The following sections provide an overview of the developed modules where the consolidated key concepts summarise the aim of each module. Each section is concluded through a discussion of how each module attempted to address the relevant key concepts determined in Section 4.2.

Each of the developed modules undertakes a critical review of relevant tools in literature to evaluate to what extent they address the key concepts existing in the context of this study. The strengths and weaknesses of the tools are determined, documented in a table, and the strengths provide design inspiration for the modules of the Framework.

### 4.3.1   Establishing Sustainability Criteria Based on Sustainable Development

The aim of the module is to establish enterprise evaluation criteria based on sustainable development. The evaluation criteria serve as strategic guidance to the business model of an energy provision enterprise, as it creates constraints that inform design choices.

The multi-criteria decision analysis (MCDA) methodology has been used by several studies in the energy provision literature to assist in decision making between multiple energy technology alternatives (Mainali & Silveira, 2015; Wang *et al.*, 2009). The MCDA assists decision-makers as it provides a structured approach to analyse multiple trade-offs (Runsten *et al.* 2018). Runsten *et al.* (2018) used the MCDA methodology in the context of energy provision in the South African urban informal context – demonstrating the appropriateness of this methodology for the context of this study.

As discussed in section 3.4.2, the success of an enterprise/initiative should be determined through the sustainable development benefits it leads to. Strantzali and Aravossis (2016) claim that the evaluation of sustainability in the energy provision sector is "extremely perplex". Mainali and Silveira (2015), however, reassure that MCDA is suitable for sustainability assessments in the energy provision space. Studies such as Bhattacharyya (2012), Fuso Nerini, Howells, Bazilian and Gomez (2014) and Runsten *et al.* (2018) used the MCDA to compare multiple technology alternatives for the provision of energy to low-income communities. Following the recommendation of the United Nations (UN Energy, 2005), the criteria in which these technology alternatives are evaluated is according to sustainability indicators. In line with what was discussed in section 3.4.2, these studies also did not only consider the traditional TBL dimensions (social, environmental

and economic) but developed sustainability indicators for the technological and institutional dimensions as well.

Inspired by the structure of the five sustainable development dimensions and the use of indicators as evaluation criteria, the sustainable development indicator table was developed (see Figure 22). A full-page version of the module can be seen in Appendix A (Figure A.2). The module is divided into the five dimensions of sustainable development, deriving its name from its table-like layout. Within each dimension, users are instructed to list the appropriate indicators in the first row. As with other modules in the framework, users populate the rows of the sustainable development indicators table with Sticky Notes. Allowing a 'clean' design and maximum space for populating the module with sticky notes, the researcher decided not to include instructions on the module itself, but instead communicate it through the Framework facilitator. It is assumed that the logic of the module would be easy to understand for most users and therefore this method of instruction communication would be sufficient.

| Sustainable Development Indicators | | | | | |
|---|---|---|---|---|---|
| Institutional | | | | | |
| Indicator Specifications | | | | | |
| Indicator Compliance/ Non-compliance | | | | | |

**Figure[3] 22: Sustainable development indicators table**

A guiding card (Figure 23) was created to assist users in considering the relevant indicators within each sustainable development dimension. Runsten *et al.* (2018) previously developed indicators for the urban informal context of South Africa. However, after a critical literature review of indicators used in multiple MCDAs in energy provision enterprises in low-income contexts, an updated set of indicators were created. As with the indicators developed by Runsten *et al.* (2018), the suggested indicators are not meant to be an exhaustive list but aim to assist users in identifying the critical trade-offs that may arise in the context of energy provision for urban informal households.

The sustainable development indicator table goes beyond the work of Bhattacharyya (2012), Fuso Nerini *et al.* (2014) and Runsten *et al.* (2018) by adding a "Specifications" row to each sustainable development dimension. This row allows users to specify requirements to set evaluation standards. No guiding card was developed to assist users in setting up requirements for the different specifications. Future work to develop specifications for all indicators can be conducted in this regard.

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[3] Although the module is called the sustainable development indicators *table*, this illustration is classified as a figure as it depicts the module. The table caption is assigned to those components of the framework that are displayed through a table within Microsoft Word

| Sustainable Development Indicators | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sustainable Development Dimensions** | **Institutional** | Institutional Barriers | Availability of supply chains | | | | | | | |
| | **Environmental** | GHG Emissions | Noise Pollution | Land Used | Land Degradation | Waste Disposal (Infrastructure) | Community Environmental Awareness | | | |
| | **Technical** | Capacity | Reliability | Availability | Quality | Operations & Maintenance Need | Modularity | Portability | Reliance on local resources | Implementation Period |
| | **Economic** | Contribution to income generating opportunities | Capital Cost | Operations & Maintenance Cost | Access to Subsidies | Vulnerability to manipulation or theft | Vulnerability to fire | | | |
| | **Social** | Health & Safety | Cultural Justice | Community Connectedness/ Ubuntu | Women's time availability | | | | | |

**Figure 23: Guiding card for SD indicators**

As stated, the studies of Bhattacharyya (2012), Fuso Nerini et al. (2014) and Runsten *et al.* (2018) used different technologies as the unit of analysis in the MCDA to determine the best technology alternative for serving low-income communities. As with the other modules in the framework, the sustainable development indicator table takes a firm-centric perspective, as it allows a single technology/offer or a business model as a whole to be the unit of analysis. Users are instructed to comment briefly in the compliance/non-compliance rows to what extent the offer/business model meets the indicator specifications. An energy provision enterprise can provide multiple products (and their corresponding services). Users are therefore encouraged to use the appropriate product/service sticky note colour as was used in other modules of the Framework to demonstrate what products/services resulted in the compliance/non-compliance evaluation.

Within the MCDA methodology, some authors apply the value measurement models or weighted score systems methods as a means of evaluation. These means of evaluation derives a quantitative score for each alternative evaluated by assigning weights to the evaluation criteria, that is, indicators. The methodology is evident in the work of Fuso Nerini *et al*. (2014). Runsten *et al.* (2018) argued that the weighted score systems model of Fuso Nerini *et al.* (2014) would not be appropriate to the South African urban informal context, as the dynamic social and political factors cannot accurately be quantified. It was therefore not used in the Sustainable Development Indicator Table. Bhattacharyya (2012) uses a simplistic 1 (*poorest*) to 7 (*highest*) scale when evaluating alternatives. Future work can be conducted to determine how this scale can be incorporate in the Specifications row.

**Framework logic:**

The MCDA was used as a stand-alone tool in each of the three highlighted studies of Bhattacharyya (2012), Fuso Nerini *et al*. (2014) and Runsten *et al.* (2018). Similarly, the sustainable development indicators table can be used on its own. In addition, the developed module can be used in conjunction with the rest of the modules of the Framework to allow a business model-wide perspective on sustainability and to incorporate the multi-stakeholder perception of value. Runsten *et al.* (2018) observed that a business model lens on sustainability evaluation would be beneficial in the complex urban informal context. The business model perspective is achieved by considering the end-user centred business model canvas (Section 4.3.2.4) and its corresponding detail-design modules (collectively referred to as 'cluster of canvas modules'). The multi-

stakeholder perception of value can be gained by using the value-mapping table. The different modules of the Framework will be discussed in the sections below.

As with the other modules in the framework, Sticky Notes are used to populate the module. Users can use specific Sticky Note colours in the compliance/non-compliance rows to indicate which products/services they are referring to in the cluster of canvas modules.

**Sustainable Energy Development:**

The module does not only consider the dimensions of the TBL (social, environmental and economic) that are typically used in sustainability evaluations. The institutional and technical dimensions are added to demonstrate the multidimensional nature of energy appropriately.

**Development measurement criteria:**

Unlike the supply attributes developed by Bhatia and Angelou (2014), the indicators developed for the Sustainable Development Indicators Table allows for the evaluation of an enterprise. A critical review of the literature was conducted to update the indicators developed by Runsten *et al.* (2018) for the urban informal context of South Africa.

**Systems Thinking:**

The module allows the visualisation of all five dimensions of sustainability and the evaluation of an energy access enterprise according to the indicators of sustainability and their specifications. The generic module allows users to customise their evaluation as they please and consequently identify the different trade-offs emerging between the different sustainability dimensions.

### 4.3.2  Holistic Design of an Entire Business Model

#### 4.3.2.1  Introduction

The aim of the module is to facilitate the holistic design of an entire business model on a high level. The Business Model Canvas (BMC) of Osterwalder and Pigneur (2010), along with other authors' adaptions of the BMC, will be explained and critiqued according to the needs posed by the context of this study and a new adaption of the BMC will be created by the author.

#### 4.3.2.2  Business Model Canvas Overview

The Business Model Canvas is an ideation tool that facilitates the visualisation of any enterprise's business model. Osterwalder and Pigneur (2010) formally introduced the BMC to the world through the book *Business Model Generation*. The book has been translated into over 30 different languages, and more than one million copies have been sold worldwide (Strategyzer, 2015). Over 250 universities in the United States of America use the book in at least one course, and the canvas itself has received over five million downloads online

(Strategyzer, 2015). Some deem the BMC as the standard for start-up presentations and workshops and one of the (if not *the*) most widely used tools for start-up management (Blank & Dorf, 2012).

The PhD thesis of Alex Osterwalder (2004) developed the Business Model Ontology (BMO), which forms the theoretical foundation of the BMC. Osterwalder (2004:15) defines a business model as follows: "A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams". The BMO initially consisted of 20 concepts. A few years later, Osterwalder and Pigneur (2010) reduced the BMC to nine concepts – also deemed the "building blocks". Furthermore, Osterwalder and Pigneur (2010:14) simplified the definition of the business model to "… the rationale of how an organisation creates, delivers, and captures value". The BMC with its nine building blocks is depicted in Figure 24 on the next page.

Each building block of the BMC contains trigger questions and examples to assist users in populating each building block. The different trigger questions and examples of the BMC are depicted in Figure 24. For more information about the examples of each building block, see Osterwalder and Pigneur (2010). Users are encouraged to print out the BMC and use Sticky Notes to populate the different building blocks through their ideas. A brief overview of each building block is provided in Table 11.

**Table 11: BMC Building Blocks Overview**

| Building Block Name | Description |
|---|---|
| Customer segments | Different groups of people that an enterprise aims to reach and serve |
| Value proposition | The combination (aggregation or bundle) of products and services that create value for a specific customer segment |
| Channels | How an enterprise reaches and communicates with its different customer segments to deliver a value proposition |
| Customer relationships | The types of relationships that are established between an enterprise and a specific customer segment |
| Revenue streams | The income an enterprise receives from each customer segment |
| Key resources | Critical assets required to ensure that a business model works |
| Key activities | Critical things an enterprise must do to ensure that a business model works |
| Key partners | Main partners and suppliers involved to ensure that a business model works |
| Cost structure | All the costs incurred to operate a specific business model |
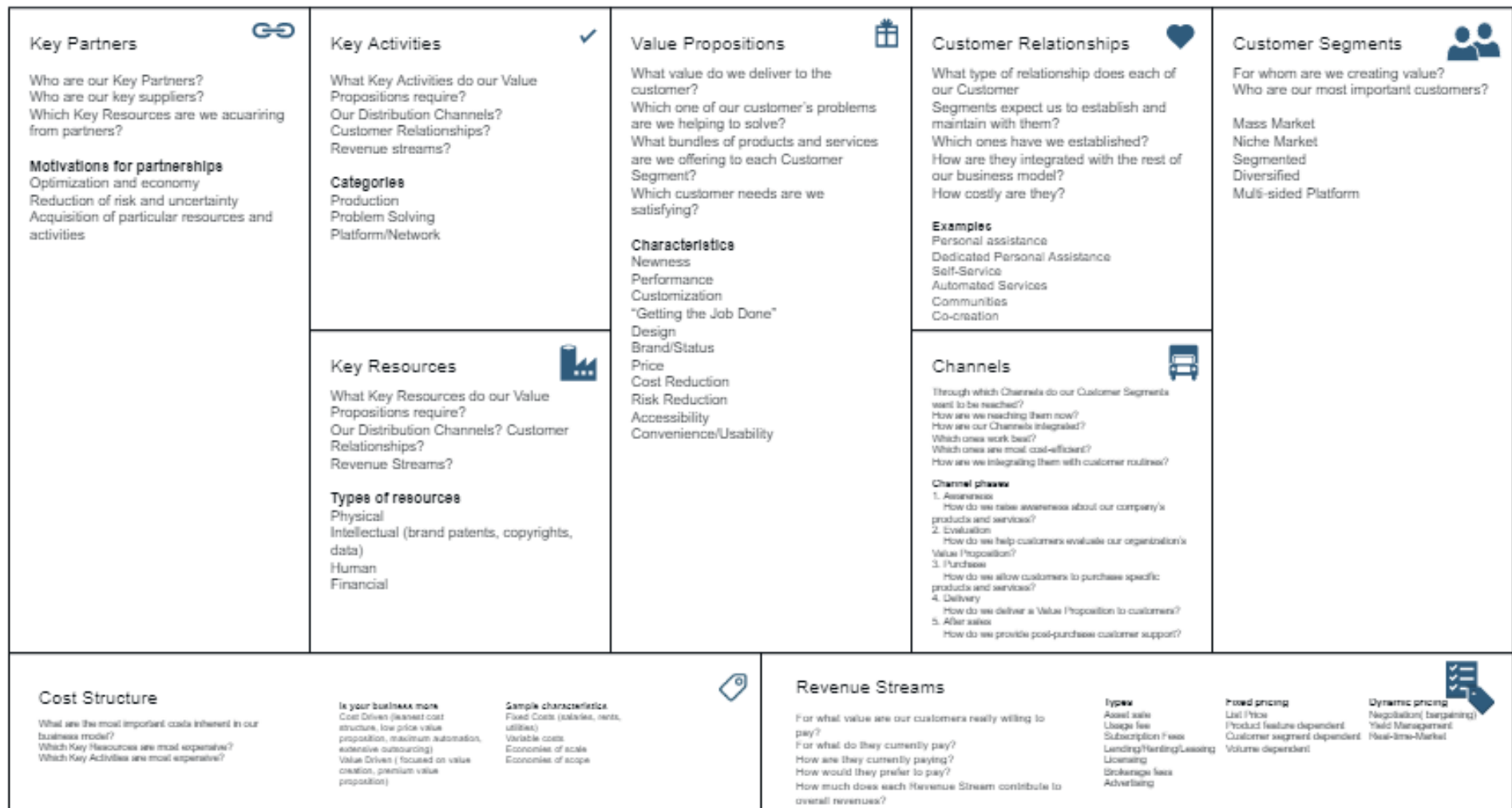
**Figure 24: Business Model Canvas (BMC) (Draw.io[4] template adapted from** Osterwalder & Pigneur (2010)**)**

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The BMC does not only visualise the necessary building blocks to design an entire business model, but the layout of the canvas is also configured in a specific way. The building blocks of the canvas have different relationships with others. These building block relationships have been plotted using the meta-models by Hauksson and Johannesson (2013) and Iacob (2012). Meta-models are used in software development and are a type of descriptive language (Baroni & Abreu, 2002). A meta-model can be defined as "… a semantic construct that rigorously defines a collection of elemental building blocks and the rules that tie their interplay together" (Longstreet & Cooper, 2012:2). Figure 25 contains a meta-model that depicts the different building block relationships existing in the BMC. The meta-model is an adaption of work done by Hauksson and Johannesson (2013) and Iacob (2012).
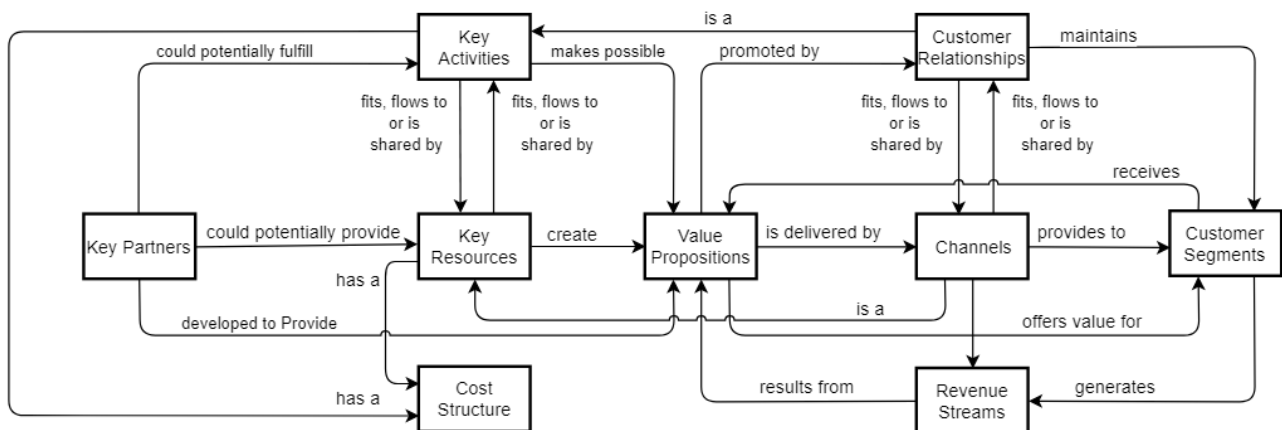


**Figure 25: BMC meta-model (Adapted from** Iacob (2012); Hauksson & Johannesson (2013)**)**

The meta-model illustrates how the BMC assists users in considering systems thinking. An idea can be visualised in a building block, and it would most probably have a ripple effect and influence other building blocks. This allows users to consider different trade-offs. An example could be a new digital channel (channels building block) to reach end-users is desired to be added. As per the meta-model, channels are a key resource. Users are required to consider the necessary resources (key resources) needed to create and maintain this new channel. Resources such as equipment (computers, servers), software and staff can be considered; however, the activities (key activities) required also need to be listed, for example, programming and customer support. If new resources and activities are required, the costs will be visualised in the cost structure building block. An option that can be explored is to consider collaborating (key partners) with another organisation to create and/or operate and/or maintain this new digital channel – therefore providing key resources and/or key activities. Finally, as a new channel has been created, users can define the type of relationship (customer relationships) desired with the customer segment.

### 4.3.2.3   Business Model Canvas Critique

The BMC has been praised for its simplicity and its ability to bring participating users on the same page (Spanz, 2013). There is, however, the other side of the coin of simplicity. The BMC has been criticised by some for placing too much emphasis on innovation and not considering other aspects of organisational management such as competitor analysis, strategy management, performance measurements and formulation of business

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objectives (Joyce, Paquin & Pigneur, 2016). Others such as Upward (2013) have argued that the BMC is built on a profit-first philosophy and does not consider the social and ecologic dimensions of the triple bottom line. This is evident in the aim of the BMC to quantify the different building blocks and attempt to ensure that the revenues outweigh the costs in purely financial terms.

Competitor analysis falls outside the scope of what the framework of this study will address; however, the sustainable development indicators table aims to provide functionality outside that of the BMC that considers strategy management, performance measurements and formulation of business objectives. The Sustainable Development Indicators Table (Section 4.3.1) further considers sustainability across, not only for the TBL but also for the technical and institutional dimensions of sustainability.

As discussed in section 3.5.1, the urban informal market is a different market and thus necessitates a dedicated focus on the end-users to ensure success. The urban informal market has limited ability to pay, and their willingness to pay for alternative solutions is negatively influenced by their desire for access to grid electrification.

Osterwalder and Pigneur (2010) maintain the third-party funded business model is one way of ensuring affordability to the end-users in a low-income context such as the urban informal context. This business model entails receiving funds from third parties, which are primarily interested in the "mission" an enterprise is fulfilling. This mission could be of public service and/or social and/or ecological nature. Funds are typically received through governmental subsidies, donor donations, investments from impact investors and so forth. Each of these third parties can see value in a specific part of the fulfilled mission. In the energy provision context, this could be, for example, the humanitarian relief provided, the use of renewable technologies or combining the two outcomes. If the enterprise serves the community (that is, the end-users) well (based on criteria such as affordability and desirability to the end-user as well as other sustainable development indicators), these third parties will provide the necessary funds.

A second way in which affordability is created for the end-users is through cross-subsidising profits made with a third-party segment *outside* the urban informal market. This business model is more market-based, as third parties do not provide funds because of the fulfilled mission/positive impact made on the community, but for products and/or services that the enterprise provides directly to them. An example of this business model could be investments from investors (not impact investors) predominantly interested in the profits that can be made by providing energy to an urban informal community. Another example could be the selling of solar panels for a premium price to high-income communities.

It should be noted that cross-subsidisation could also be used *within* the urban informal market. As variation in the income of urban informal communities exists, a more profitable end-user segments' revenue can be used to subsidise the revenue of another less-profitable segment. To decrease complexity for new users of the framework, this study did not consider multiple customer/end-user segments. The entire urban informal market will be used as a single customer/end-user segment in the idea generation workshop in Chapter 5.

Although warning against the risks of mission drift, Osterwalder and Pigneur (2010) demonstrated that the BMC could be applied in an unaltered state when visualising third-party funded business models in low-income contexts. This unadapted BMC design led to Osterwalder and Pigneur (2010) placing these third parties in the customer segment building block and considering 'mission' in the value proposition building block. Osterwalder and Pigneur (2010) are not the only authors who put both the end-users (also deemed as beneficiaries/recipients by some) and the third parties in the customer segment. Other adapters of the BMC in the BOP context such as Bellanca and Garside (2013), Tandemic (2013), Qastharin (2016) and Yeoman and Moskovitz (2013) followed suit. Figure 26 illustrates this common method in the literature of placing both third parties (blue) and end-users (yellow) in the customer segments block and how it affects other BMC building blocks.
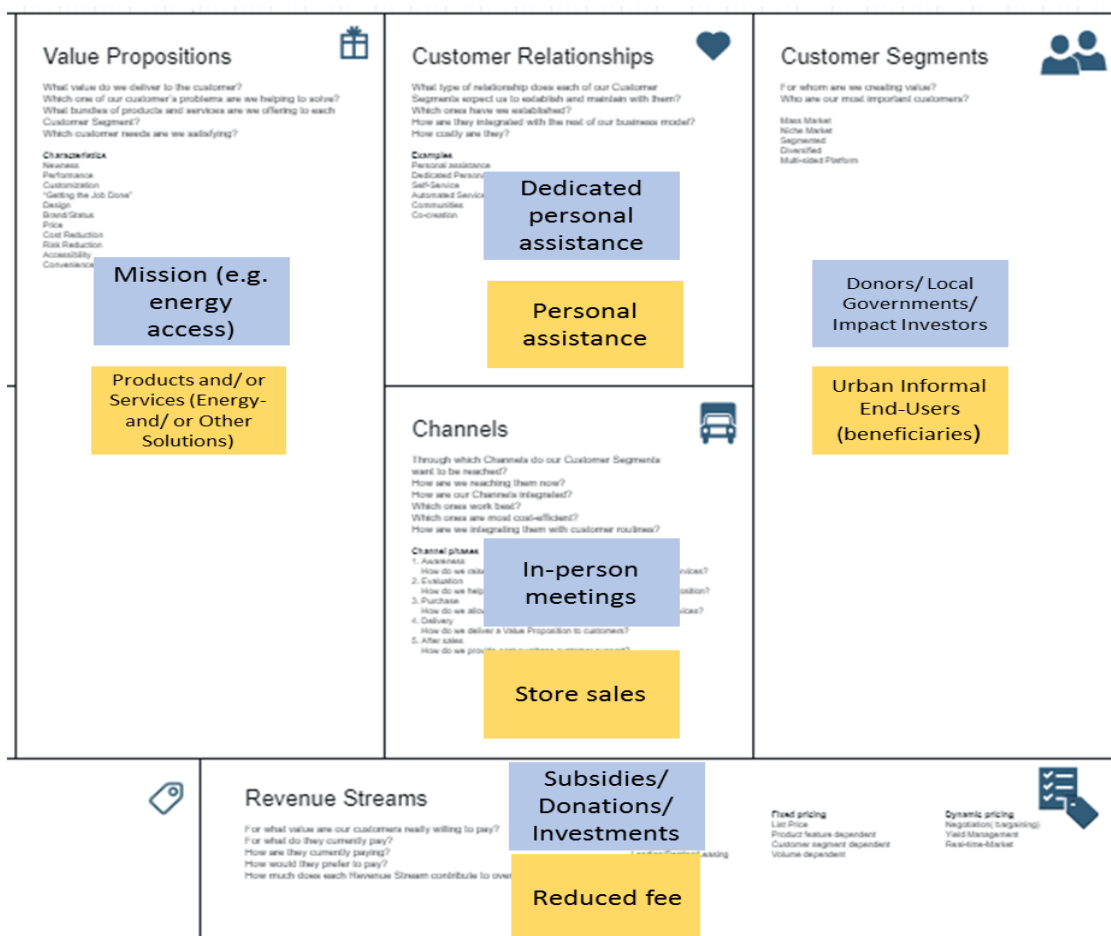


**Figure 26: Common method of considering both third parties and end-users**

As was demonstrated by the BMC meta-model in Figure 25, by placing the third party in the customer segment block, the funds received from the third party can consequently be indicated in the revenue streams building block. By considering both third parties and end-users in the value proposition, customer segment and revenue streams, these building blocks create the risk of mission drift. This is especially true for the energy sector as infrastructure for energy provision is expensive, and thus the capital funds from third parties are often of great need. To ensure that funding is secured, enterprises may alter their "mission" and hence the products and/or services offered to end-users, leading to mission drift.

As per the logic of the meta-model in Figure 25, not only is the revenue streams building block populated but consequently, the rest of the canvas also has to be populated. This leads to Sticky Notes such as "dedicated personal assistance" in customer relationships and "in-person meetings" in channels (as depicted in Figure 26 above). These Sticky Notes take up space in the canvas, consume idea generation time and allow focus to be taken off the end-user. The space on the canvas and brainstorming time can be better used when considering the third parties as *enablers* (partners) to the offer provided to the end-users and maintaining the focus on the end-users.

The logic of seeing third parties as enablers (partners) is also applicable to the more market-based business model of cross-subsidising profits made with a third-party segment outside the urban informal market.

#### 4.3.2.4 End-User Centred Business Model Canvas (EUC-BMC) Design

A change to the design of the BMC is necessary if end-users are to be the focus of the business model while visualising the third-party funds that enable the business model to be financially viable. An adaption of the BMC was made for this purpose. As the purpose of the canvas adaption is to maintain focus on the end-users, the name is the End-User-Centred Business Model Canvas (EUC-BMC).

Figure 27 depicts the meta-model for the EUC-BMC. Changes to the BMC are depicted in red. Similar to the work of Bellanca and Garside (2013), the customer segments building block was renamed to end-user segments as the context of the study is providing energy and related value-adds to *end-users* in urban informal settlements. As per the logic of the canvas, if the end-user segments building block is exclusive to end-users, then the value proposition building block is exclusive to end-users. This follows that the rest of the canvas is end-user focused as the canvas "… describes the rationale of how an organisation creates, delivers and captures value" (Osterwalder & Pigneur, 2010:2) for the end-user segment. The customer relationships building block was also renamed to the end-user relationships building block.
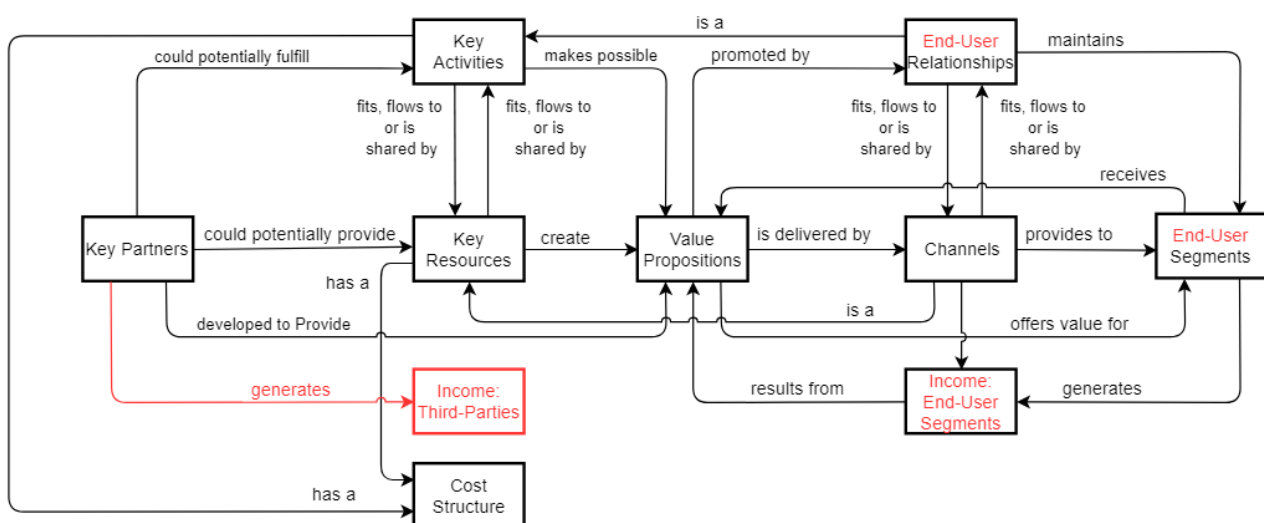


**Figure 27: EUC-BMC meta-model**

The revenue streams building block was renamed to "Income: End-user segments" to establish that only the financial contributions of the end-users can be visualised here. This block, exclusive to end-users, clearly illustrates the financial strain the offering will place on the end-users. A new building block, Income: Third Parties, was created to demonstrate the funds received from third parties. The third parties are seen as enablers as they allow the business model to work. They are therefore regarded as key partners in the business model. Symmetrical to the relationship that the end-user segment building block has with the Income: End-user segments building block, the key partners building block has with the newly created "Income: Third-Parties" building block as key partners "generate" third-party income. Unlike the Income: End-User Segments building block, there is no relationship between the Income: Third Parties and value propositions building blocks. As stated earlier, this is due to the value proposition building block being specific to the offering provided to end-users and not third parties.

Figure 28 exhibits an alternative BMC illustration by Osterwalder and Pigneur (2010). Inspired by how the puzzle- and arrow shapes of the building blocks inform users of some of the relationships, which exist between the blocks, the building blocks of the EUC-BMC were adapted.



**Figure 28: Alternative BMC illustration** (HBEC, 2019)

The EUC-BMC with its adaptions to the BMC is shown in Figure 29. A full-page, colour figure of the module can be found in Appendix A (Figure A.3)

## Key Partners

[Using the most appropriate Product/Service Sticky Note colour]

Who are our Key Partners?
Which Key Resources are we acquiring from partners?
What Key Activities do they perform?

**Motivations for partnerships**
Optimisation and economy
Reduction of risk and uncertainty
Acquisition of particular resources and activities

## Key Activities

[Using the most appropriate Product/Service Sticky Note colour]

What Key Activities do our Value Propositions require?
Our Distribution Channels? End-User Relationships?
End-User Income? Third-Party Income?

**Categories**
Production
Problem Solving
Platform/Network

## Key Resources

[Using the most appropriate Product/Service Sticky Note colour]

What Key Resources do our Value Propositions require?
Our Distribution Channels? End-User Relationships?
End-User Income? Third-Party Income?

**Types of resources**
Physical
Intellectual (brand patents, copyrights, data)
Human
Financial

## Value Propositions

[Ideally, use a distinct Sticky Note colour for each product]

What value do we deliver to the End-User?
Which one of our End-User's problems are we helping to solve?
What bundles of products and services are we offering to each End-User Segment in our Energy Solutions?
What bundles of products and services are we offering to each End-User Segment in our Other Solutions?
Which End-User needs are we satisfying?
Through what type of payment offering (PSS type) are the Energy Solutions provided?
Who is the owner of the Energy Solutions and what is the timeline(s) for onwnership transfer?

**Characteristics**
Newness
Performance
Customization
"Getting the Job Done"
Design
Brand/Status
Price
Cost Reduction
Risk Reduction
Accessibility
Convenience/Usability

**PSS Types**
Product-Orientated
Use-Orientated
Result-Orientated
Free
No Equipment

## End-User Relationships

[Using the most appropriate Product/Service Sticky Note colour]

What type of relationship does each of our End-User Segments expect us to establish and maintain with them?
Which ones have we established?
How are they integrated with the rest of our business model?
How costly are they?

**Examples**
Personal Assistance
Dedicated Personal Assistance
Self-Service
Automated Services
Communities
Co-creation

## Channels

[Using the most appropriate Product/Service Sticky Note colour]

Through which Channels do our End-User Segments want to be reached?
How are we reaching them now?
How are our Channels integrated?
Which ones work best?
Which ones are most cost-efficient?
How are we integrating them with End-User routines?

**Channel phases**
1. Awareness
   How do we raise awareness about our company's products and services?
2. Evaluation
   How do we help End-Users evaluate our organization's Value Proposition?
3. Purchase
   How do we allow customers to purchase specific products and services?
4. Delivery
   How do we deliver a Value Proposition to End-Users?
5. After sales
   How do we provide post-purchase End-User support?

## End-User Segments

[Using the most appropriate Product/Service Sticky Note colour]

For whom are we creating value?
Who are our most important end-users?

Mass Market
Niche Market
Segmented
Diversified
Multi-sided Platform

## Income: Third-Parties

[Using the most appropriate Product/Service Sticky Note colour]

Are any subsidies available?
Are any donations available?
Are any grants available?
Are there market-based opportunities available?

**Types**
Product-Orientated
Use-Orientated
Result-Orientated
Subscription Fees
Licensing
Brokerage fees
Advertising

**Fixed pricing**
List Price
Product feature dependent
Customer segment dependent
Volume dependent

**Dynamic pricing**
Negotiation( bargaining)
Yield Management
Real-time-Market

## Income: End-User Segments

[Using the most appropriate Product/Service Sticky Note colour]

For what value are our End-Users really willing to pay?
For what do they currently pay?
How are they currently paying?
How would they prefer to pay?
How much does each End-User Income contribute to overall Income?

**Types**
Product-Orientated
Use-Orientated
Result-Orientated
Subscription Fees
Licensing
Brokerage fees
Advertising

**Fixed pricing**
List Price
Product feature dependent
Customer segment dependent
Volume dependent

**Dynamic pricing**
Negotiation( bargaining)
Yield Management
Real-time-Market

## Cost Structure

[Using the most appropriate Product/Service Sticky Note colour]

What are the most important costs inherent in our business model?
Which Key Resources are most expensive?
Which Key Activities are most expensive?

Is your business more
Cost Driven (leanest cost structure, low price value proposition, maximum automation, extensive outsourcing)
Value Driven ( focused on value creation, premium value proposition)

**Sample characteristics**
Fixed Costs (salaries, rents, utilities)
Variable costs
Economies of scale
Economies of scope

**Figure 29: End-user-centred business model canvas (EUC-BMC)**

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The puzzle shape between the key partners and both the key activities and key resources were kept. This relationship informs users that the key partners are involved in supplying/ providing the key activities and key resources of the business model. Although adapted to keep the building block design of the BMC, the arrow shapes at the end-user relationships and channels blocks were kept to demonstrate the appropriate building block relationships. Key activities and key resources are the building blocks that represent the necessary activities and resources for the production and delivery of the value proposition to the end-user segment. Gear shapes were introduced to communicate both the production and delivery functions of these two building blocks. The cost structure building block is located "beneath" the Income: Third Parties building block. It would be difficult to demonstrate how this block (along with the Income: Third Parties and Income: End-User Segments blocks) form the financial foundation of the business model without disrupting the logic of the canvas or inferring a relationship between the cost structure- and the Income: Third Parties building blocks. It was therefore decided to not alter the shapes of these blocks - similar to the alternative BMC illustration in Figure 28.

Adaptions beyond the structure design of the BMC blocks were made. The trigger questions and examples within the building blocks were adapted for the context of this study. The adaptions are indicated in red in Figure 29. Following the new relationships created by the addition of the Income: Third Parties building block, the "Third Party Income" was added to the trigger questions of key activities and key resources. As the wording of customer segments was changed to end-user segments, all examples of "customer" in trigger questions were changed to "end-user".

As the context of the study is the provision of energy to end-users, the trigger questions of the value propositions block were adapted. As discussed, in Section 1.1, end-users see grid-electrification from the state as a preferred energy provision solution as it brings further legitimacy to the end-users' dwellings. Users are encouraged to list products and services for energy solutions and other solutions. Energy solutions refer to any products and its corresponding services that would assist in alleviating the energy poverty experienced by the end-users in urban informal settlements. Other solutions refer to related value-adds that could be offered to ensure further desirability and therefore, adoption of the energy solutions. As to not diverge drastically from the energy solutions offering, an energy provision enterprise could offer products and or services that are enabled through the provision of energy such as discounted rates on Wi-Fi data where the Wi-Fi router is one of the products provided. Also, the enterprise could provide a discounted subscription fee to an online educational programme for adults as they could utilise the data provided through the WiFi router. These other solutions/related value-adds could be produced and delivered by the energy provision enterprise, or through a third-party partner.

Multiple products could typically be offered to fulfil the bundle of energy services used by end-users. There could additionally be multiple products offered in related value-adds to end-users. As indicated through the square brackets, users are encouraged to use different sticky note colours for each product (and its

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corresponding services and offer). This allows for clarity in visualising the different parts of the energy and other solutions, minimising confusion.

Inspired by the work of Emili *et al.* (2016), the trigger question: "Through what type of payment offering (PSS type) are the energy solutions provided?" was added. This trigger question encourages users to consider the different PSS types through which a combination of products and services can be offered to end-users. The different types of PSS offers (as discussed in section 3.7.1) are listed as examples within the value propositions building block. In addition to the work of Emili *et al.* (2016), users are also encouraged to consider the timelines for when ownership transfer of energy solution(s) product(s) takes place. Explicitly stating the ownership timelines allows users to visualise the multitude of ways that ownership transfer take place in PSS.

As the different PSS types refer to how end-users pay for the offering, these types were also included in the examples of the Income: End-User Segments building block. "Asset sale" was replaced by "product-orientated" as they both refer to the purchasing of assets; however, product-orientated is the more appropriate wording to be used in the context of this study. Similarly, "lending/renting/leasing" was replaced with "use-orientated". Finally, "usage fee" refers to the cost for the usage of a specific product/service, for example, a Telecom operator charging customers for the number of minutes spent on a phone call. This term is synonymous with the "result-orientated" PSS type and therefore appropriately replaced.

The types of income listed within the Income: End-User Segments building block is also appropriate for the Income: Third Parties building block and therefore populated appropriately. The trigger questions were however adapted to be specific to third parties and therefore consider questions regarding subsidies, donations, market-based opportunities and so forth.

The BMC facilitates the design of any enterprise's business model. Similarly, the EUC-BMC facilitates the PSS business model design of any energy provision enterprise (governmental or non-governmental) that trades directly with end-users in the urban informal context. Similar to the BMC, the EUC-BMC can be used to design a business model for a new energy provision enterprise or redesigning an existing business model, that is, business model innovation.

#### 4.3.2.5  Relationship of the EUC-BMC to Other Modules

The EUC-BMC allows for the holistic design of an entire business model. The module takes a high-level design perspective on the different building blocks that make up an entire business model. The EUC-BMC is a slight adaption of the BMC of Osterwalder and Pigneur (2010). As mentioned, the BMC was formally introduced to the world through their book *Business Model Generation*. Acknowledging that a more-detailed perspective is necessary to design solution that is desirable to end-user, Osterwalder *et al.* (2014) released their follow-up work, *Value Proposition Design* introducing the Value Proposition Canvas. The Value Proposition Canvas is an idea generation tool, which represents a zoomed-in version of the Value Propositions and End-User Segments building blocks. Osterwalder *et al.* (2014:152) go on to suggest that the remaining BMC blocks can be divided into the "Backstage" and "Front Stage"; however, no tools were designed for these purposes.

This study adds to the work of Osterwalder *et al.* (2014:152) by adapting the value proposition canvas to the context of the study and by designing modules (manifesting themselves as tools) that would allow a detailed design perspective for the "Backstage" and "Frontstage". The "Backstage" refers to the various interactions within the enterprise and with its partners in producing and delivering an offer to the End-User Segment (Vezzoli *et al.*, 2018). The "Front Stage" refers to the various interaction of the End-User Segment with the enterprise in the delivery of the offer (Vezzoli *et al.*, 2018). Figure 30 depicts how the different building blocks are divided into the developed detail-design modules and where these developed modules are documented in this study. For the remainder of the study, different coloured outlines that correspond to the colour of the EUC-BMC building blocks are used to indicate where these blocks are represented in the three modules that are focused on detail that is more significant.
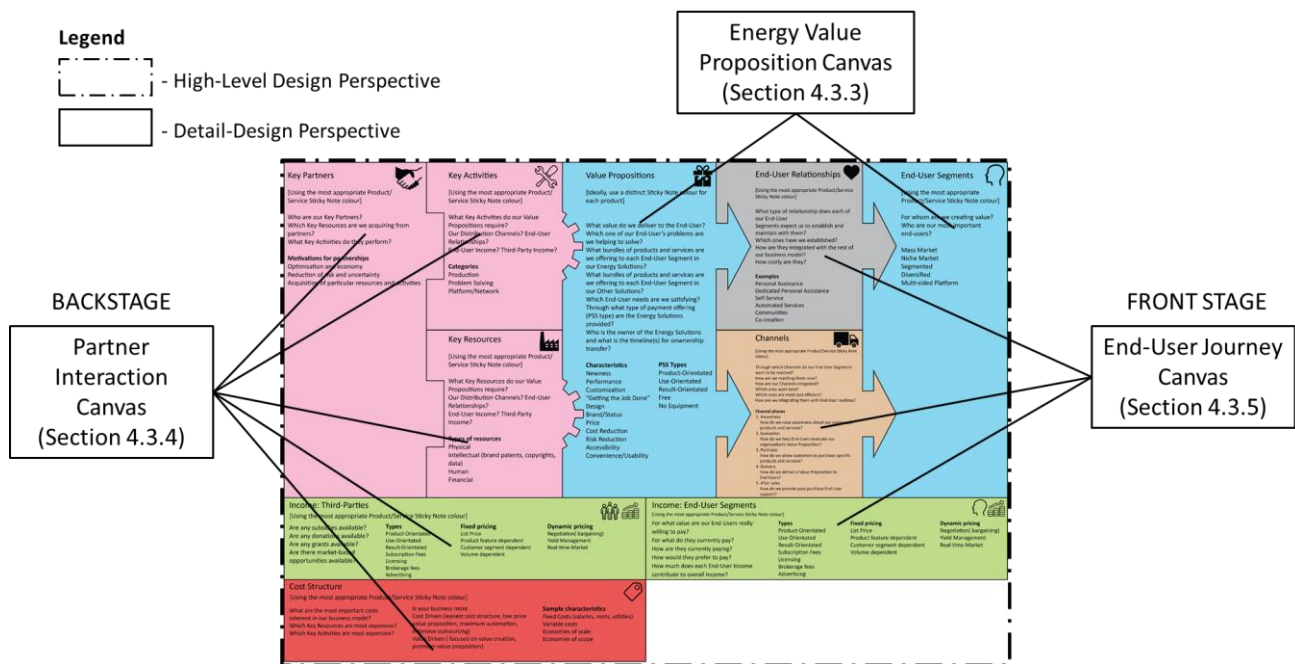


**Figure 30: Relation of the EUC-BMC building blocks and the other detail-design modules**

As all nine building blocks are contained in these three modules, duplication of Sticky Notes will occur if *both* the EUC-BMC and any of these three modules are utilised. The Framework is furthermore modular and, therefore, users have the choice to:

- Maintain a high-level design perspective and use the EUC-BMC without using the other detailed-design modules.

- Maintain a detail-design perspective and use the other detail-design modules without using the EUC-BMC. The EUC-BMC can be used as an overview diagram to relate the detail-design modules to one another such as the partner interaction table and the end-user journey canvas to determine financial viability (this will be discussed below in section 4.3.2.6).

- Make use of a combined high-level- and detail design perspective. It should, however, be noted that duplication of Sticky Notes will occur.

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#### 4.3.2.6   Addressing the Key Concepts

Gabriel (2016) observes that the BMC is built on the foundation of the three constraints of Design Thinking: desirability, feasibility and viability. The top left of Figure 31 demonstrates where in the BMC these constraints are applicable. The applicability of the concepts is also plotted on the (larger) EUC-BMC.
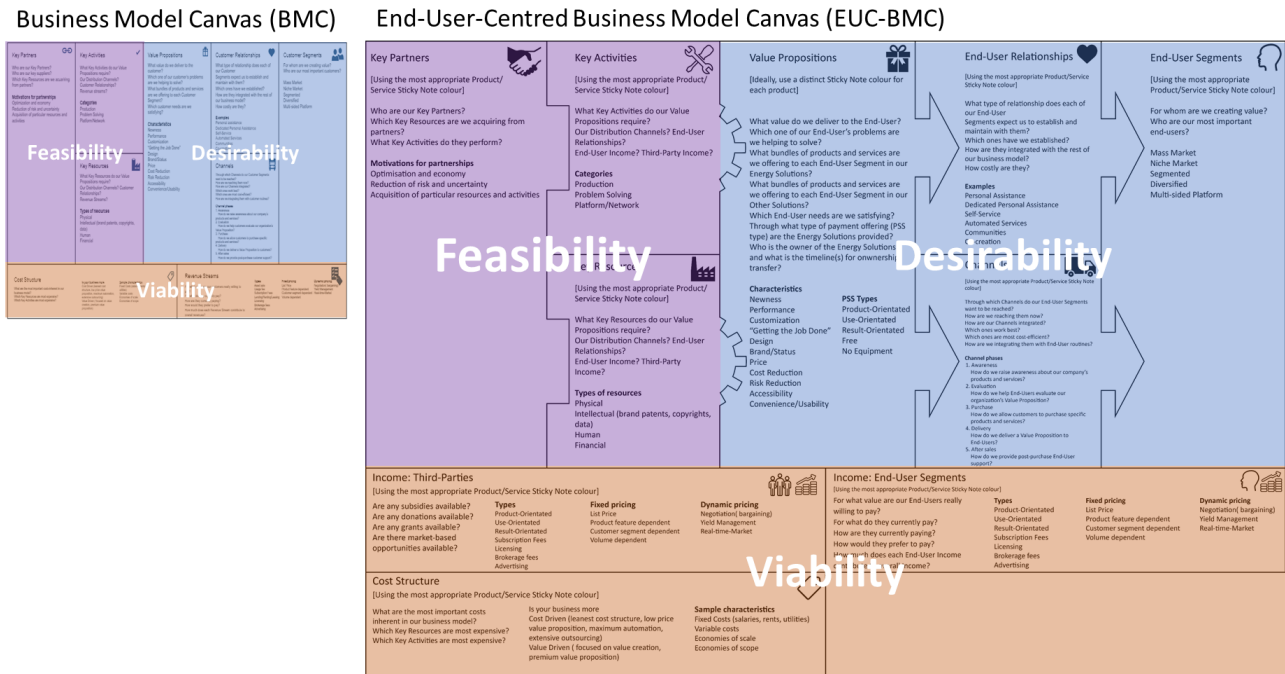


**Figure 31: Constraints Plotted on the BMC and EUC-BMC**

As discussed in section 3.5.2, desirability considers what end-users desire. This constraint is applied to the building blocks of Value Propositions, End-User Relationships, Channels and End-User Segments. Desirability is applicable in these building blocks as it describes what (Value Propositions) is wanted by who (End-User Segments), through what channel (Channels), whilst maintaining what type of relationship (End-User Relationships) with them. Feasibility considers whether the offer of the business model is technically possible, that is, whether it can be built/developed. The feasibility constraint can be considered by investigating the different resources (key resources) and activities (key activities) required to produce and deliver the value proposition to the end-user segment and what parties (key partners) will be partnered with in providing these resources and activities. Finally, the viability constraint considers whether the business model is financially sustainable. The BMC compares the revenue streams building block and the cost structure building block to determine profitability. The EUC-BMC is different in this regard, as it considers both the Income: End-User Segments and Income: Third-Parties building blocks to determine total income. The cost structure building block is then compared with these blocks to determine viability.

**Framework Logic:**

As with other modules in the Framework, the UEC-BMC makes use of the terminology of Energy- and Other Solutions. It further instructs users to make use of different Sticky Notes colours for the different products (and

their corresponding services) as to minimise user confusion. The building blocks were also shaped in specific ways to assist users in user standing the different relationships within the canvas

Similar to the BMC, the EUC-BMC can be used on its own. It can, however, be used in combination with other modules. Specific colours were used for the different building blocks to illustrate how the EUC-BMC connects to other modules.

### Systems Thinking:

As evident through the EUC-BMC meta-model, the building blocks do not just provide the necessary parts to design an entire business model – the blocks are laid out according to specific relationships they have to one another. The canvas, therefore, allows users the ability to visually map out ideas and consider different trade-offs, as one change in building blocks will most probably have a ripple effect and impact other building blocks.

### Multi-stakeholder Engagement:

The key partner building block considers what other parties can form part of the production and delivery of the Energy- and/ or Other Solutions in the key activities and key resources building blocks. Those providing third-party funds can also be visualised in both the key partners and Income: Third Parties building blocks.

### Desirability:

As is demonstrated in Figure 31, desirability is determined through considering the building blocks of Value Propositions, End-User Relationships, Channels and End-User Segments. By making the End-User Segments building block exclusive to end-users, the logic of the canvas ensures that the Value Proposition, End-User Segments and Channels building blocks are all focused on the end-users. It can, therefore, be concluded that EUC-BMC is correctly structured to consider the desirability of the end-users. This end-user centricity minimises mission drift.

Unlike the traditional business models in the DRE energy provision space that only offer the sale of products, the EUC-BMC prompts users to consider different types of PSS types for the Energy Solution. In the desirability to end-users is increased by not only offering products but also a combination of products and services.

The EUC-BMC further encourages users to consider not just offering Energy Solutions to slum dwellers, but Other Solutions as well. The related value-adds could assist with the attractiveness of the alternative energy provision solution in urban informal contexts.

### Feasibility:

As was demonstrated in Figure 31, feasibility is determined through considering the building blocks of key resources, key activities and key partners. It allows users to consider whether it is technically possible to develop and deliver the offer to the end-users.

**Viability:**

Creating the Income: End-User Segments and Income: Third Parties building blocks allow users to visualise end-user income and third-party income separately. This separation illustrates the financial strain the offering will place on the end-users and the assistance of the third parties in this regard.

As is demonstrated in Figure 31, viability is determined through considering the building blocks of Income: Third Parties, Income: End-User Segments and Cost Structure.

**New Modes of Ownership:**

Users are prompted to consider the different PSS types through which offers can be provided. Users are encouraged to not only state who would be the owners of the products of the Energy Solutions, but also the specific timelines involved for ownership transfer. This the multiple variations of PSS offers (as observed by Yang *et al.* (2017)) to be considered and visualised.

The first module that allows a detail-design perspective, allowing for the design of a desirable solution to the end-users will now be discussed.

### 4.3.3 Designing Solutions Desirable to End-users

#### 4.3.3.1 Introduction

In the EUC-BMC, users were asked to list the Products, Services and Offers of the Energy Solutions and Other Solutions in the blue Value Proposition building block. As to design solutions with the main purpose of making it desirable to end-users that have a multitude of expectations for an Energy Solutions, a detailed design perspective is necessary. This can be enabled by breaking up the energy solutions into specific parts to design each part in a specific way.

#### 4.3.3.2 Energy Solutions Guiding Cards

To assist users of the framework in understanding the different parts of an Energy Solutions and its corresponding terminology, guiding cards that are compatible with the framework modules were created. The guiding card in Figure 32 provides an overview of terms for the different parts of Energy Solutions. The illustration and terminology used in the card is an adaptation of work done by Practical Action Consulting's PISCES Project (Practical Action, 2016b). Breaking up the energy solutions into these distinct parts allows for an increased understanding of the parts required to make a whole, leading to informed and focused idea-generation sessions, with shared terminology within the group of users.
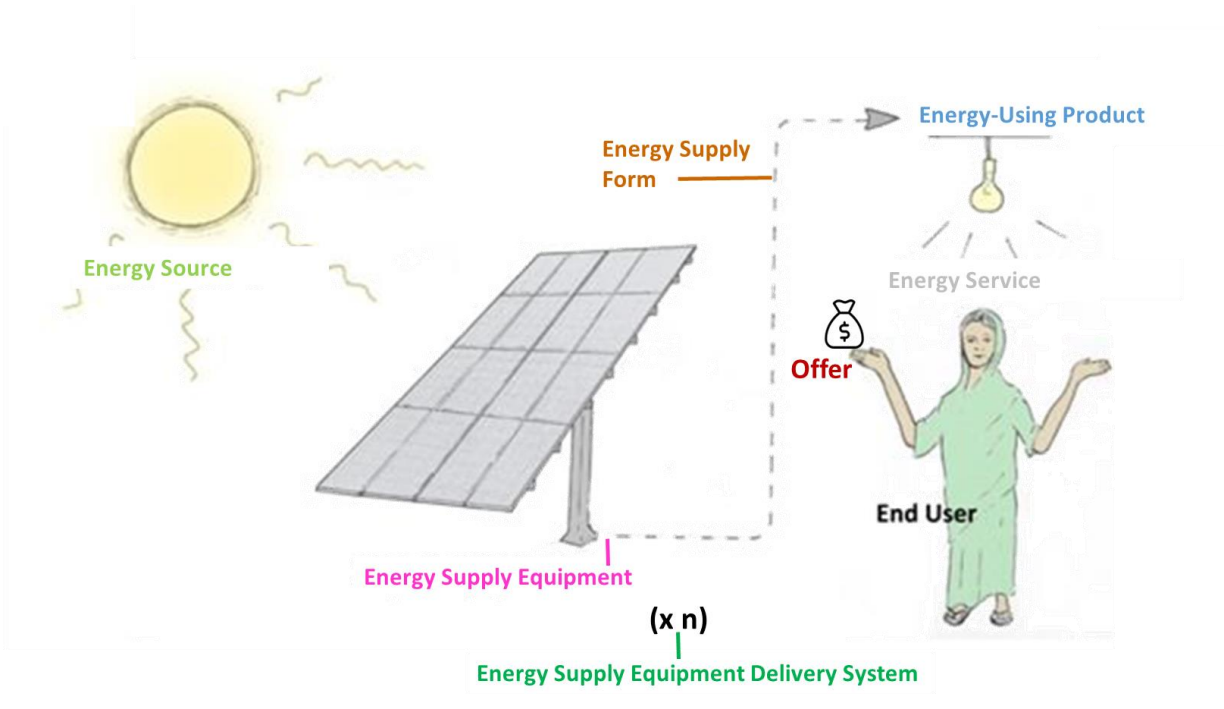
**Figure 32: 'Energy solutions terminology overview' Guiding Card (Adapted from** Practical Action (2016b)**)**

Making use of the appropriate text colours to show the connection with the terminology of the 'Energy Solutions Terminology Overview' Guiding Card in Figure 32, Figures 33–36 provide definitions and examples for the different parts of the Energy Solutions. To indicate a relationship, the border colours of the Energy Supply Form correspond to the section colours used in the Energy Value Proposition Canvas – the designed module that will be discussed later in this section. The content in the guiding card in Figure 33 is an adaption of work done by Practical Action (2012a)

| | Renewable | | | | Non-renewable |
|---|---|---|---|---|---|
| **Energy Source** (Original form in which energy is available) | e.g. the sun's rays and heat, woody biomass, biofuels, bioresidues, wind, waves, tides, running water, geothermal heat | | | | e.g. coal, crude oil, natural gas, uranium (for nuclear power) |
| | **Energy Supply Form** | | | | |
| | Solid | Liquid | Gas | Direct Conversion | Electricity |
| **Energy Supply Equipment** (Equipment used to convert energy from an Energy Source into an usable Energy Supply Form) | | | Biomass technologies: Biogas digesters, biomass gasification units | Solar technologies: Solar thermal technologies (thermal water heaters, solar cookers) Geothermal technology: Heating plants | Solar technologies: Photovoltaic (PV) solar home systems and solar lanterns, concentrated solar power (solar arrays) Biomass technologies: Biomass burning power plants Liquid fuel technologies: Crude oil, power plants and generators Mechanical energy technologies: Wind, hydro and hybrid (combination) systems, ocean power systems Geothermal technology: Geothermal power stations Energy storage technologies: Electrical energy in batteries |
| | **Energy Supply Form** | | | | |
| | Solid | Liquid | Gas | Direct Conversion | Electricity |
| **Energy-Using Product** (Equipment used to convert an Energy Supply Form into Energy Services) | Traditional stoves and improved biomass stoves (such as those fed with charcoal, dung, agricultural residues, briquettes or wood) | Liquid petroleum, pressurised and wick kerosene stoves, wick lamps, ethanol stoves | Gas stoves, mantle lamps, biogas, piped gas | N.A | Light bulbs, electric cookers, refrigerators, televisions, mobile chargers |

**Figure 33: 'Examples of Energy Solutions Parts' Guiding Card (Adapted from** Practical Action (2012a)**)**

The guiding cards illustrated in Figures 34 - 36 not only provide definitions and examples but also additionally offer insight into the extent to what certain parts of the Energy Solutions are compatible with one another. The cards encourage users to consider multiple Energy Solutions options, therefore assisting possible innovative ideas. As to assist with multi-stakeholder idea generation, the cards assist users with limited knowledge of energy technologies to also contribute to the collaborative brainstorming session.



**Figure 34: Figure 4: 'Energy Service & Energy Supply Form Compatibility' Guiding Card (Adapted from** Practical Action (2016b)**)**

Guiding cards that are used in addition to the 'Energy Supply Equipment System and Offer Compatibility' in Figure 36 are cards created by Emili *et al.* (2016). These cards illustrate a classification system for 15 common PSS business model archetypes existing in renewable distributed energy (DRE) technologies. As depicted in Figure 37, each business model archetype is demonstrated through an illustration and a case study in the guiding cards. These guiding cards are limited to the Energy Sources being renewable and the Form of Energy Supply being electricity. However, the cards offer good examples of PSS business models and assist participants to further understand PSS business models – a new type of business model for most users.

**Figure 35: 'Energy Supply Form & Energy Supply Equipment System Compatibility' Guiding Card (Adapted from** Practical Action (2016b)**)**



**Figure 36: 'Energy Supply Equipment System and Offer Compatibility' Guiding Card (Adapted from** Practical Action (2016b) and Emili *et al.* (2016))
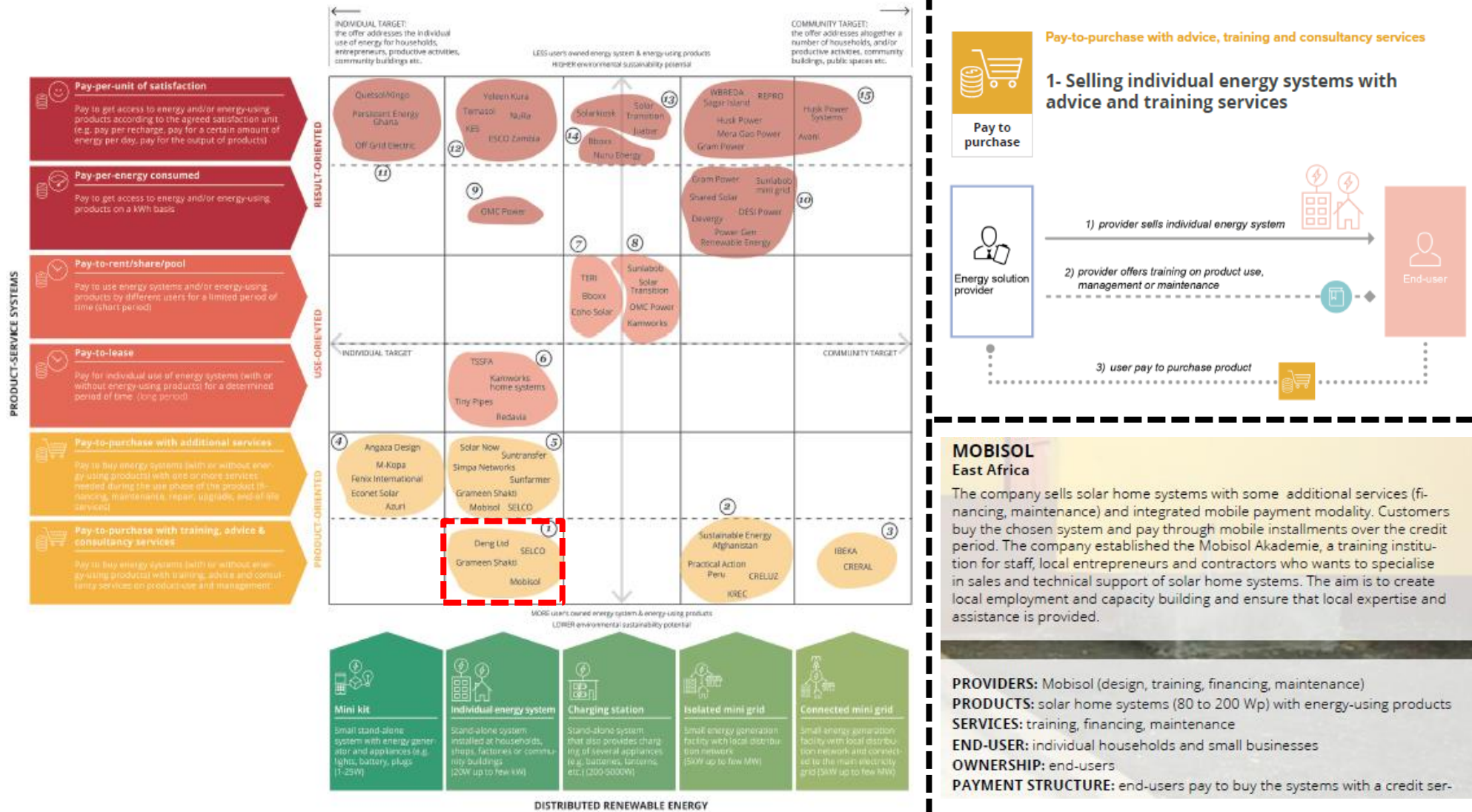
**Figure 37: Overview of 'PSS Business Model Archetypes' Guiding Cards (Adapted from** Emili *et al.* (2016))

### 4.3.3.3 Energy Value Proposition Canvas

The developed guiding cards have been discussed. They are used to support the idea generation within the developed module, the Energy Value Proposition Canvas (Figure 38).

Other tools in the literature used for the design of desirable solutions in the idea generation phase were evaluated. Some of the strengths of the tools provided design inspiration for the Energy Value Proposition Canvas. The evaluation of other tools can be seen in Table 12. The design and corresponding methodology of idea generation are predominantly inspired by the Value Proposition Canvas (Osterwalder, *et al.,* 2014) and therefore the term "Energy" was added to the front of the name of the Value Proposition Canvas as it was altered to the context of this study. The Energy Value Proposition Canvas is composed of the Energy Value Map and the End-User Profile (which are to a high degree mirrored image of each other). A full-page image of both elements can be seen in Appendix A. Both module element names are also derived from the two elements of the Value Proposition Canvas (Value Map and Customer Profile) and adapted to the context of this study (Osterwalder *et al.*, 2014).
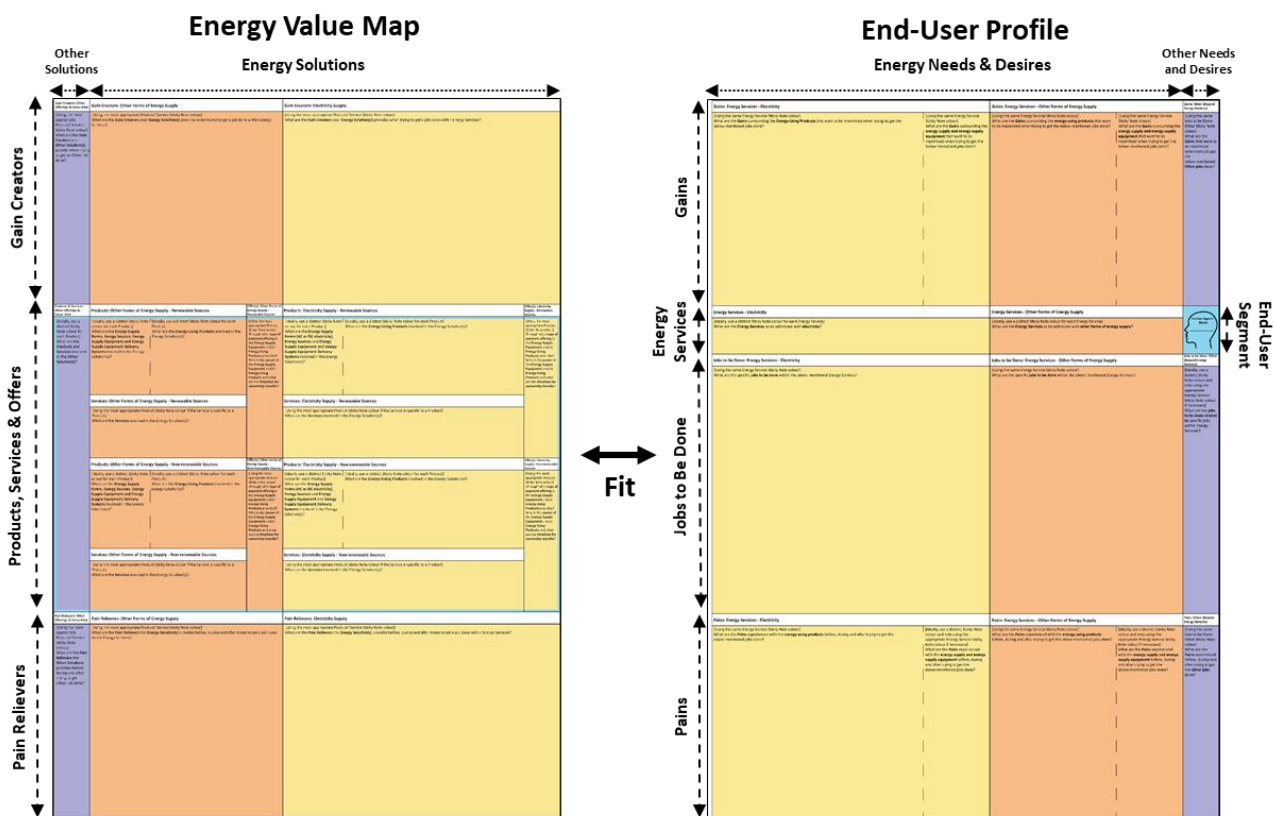


**Figure 38: Value Proposition Canvas and Additional Guiding Cards**

The Energy Value Map and the End-User Profile form the zoomed-in version of the blue Value Proposition and End-User Segments building blocks in the EUC-BMC (the blue outlines indicate this connection). It is advised that users develop an Energy Value Proposition Canvas for each End-User Segment. As mentioned in section 4.3.2.3, this study regards the entire urban informal market as a single End-User Segment, to decrease the complexity of having multiple End-User Segments for new users of the Framework.

The purpose of the tool is to achieve "fit" between the end-user profile and the energy value map. "Fit" is achieved when the needs and desires (pains and gains) of the end-users in the end-user profile are addressed by the products, services and offer features of the energy value map.

**Table 12: Critical Review of Offer Design Ideation Tools, Models and Frameworks**

| Name | Authors | Description of focus/application | Format | Strengths | Weaknesses |
|---|---|---|---|---|---|
| PSS (Product-Service System) + DRE (Distributed Renewable Energy) Design Framework | Emili *et al.* (2016) | Ideation tool facilitating the design of PSS offers for DRE technologies in the energy sector | Paper-Based | Designed for idea generation phase - makes use of Sticky Notes<br><br>Specific to the energy sector<br><br>Different PSS offers are illustrated<br><br>Contains additional guiding cards | Focus on offering - end-user needs and desires not visualised/ expressed<br><br>Design does not explicitly consider Energy Services beyond that provided by electricity<br><br>Does not consider solutions that make use of non-renewable Energy Sources<br><br>Traditional Energy-Using Products suggested – innovation is suppressed |
| Value Proposition Canvas | Osterwalder, *et, al.,* (2014) | Ideation tool that serves as a "plug-in" to the BMC (Osterwalder & Pigneur, 2010) to facilitate the detailed design of the Value Proposition and Customer Segment building blocks | Paper-Based/ Digital | Designed for idea generation phase - makes use of Sticky Notes<br><br>Integrates with the BMC<br><br>Methodology of matching the Pains and Gains experienced by end-users with the features of the offering | Criticised for being unstructured<br><br>Not specific to the energy sector<br><br>Not specific to PSSs |

The overlap in the Energy Value Map is the blue Value Proposition building block in the End-User-Centred BMC. The EUC-BMC is used for high-level design. It lists the Products, Services and Offers of the Energy Solutions and the Other Solutions. The Energy Map goes beyond listing the different Products, Services and corresponding Offers, but have two other sections that aim to illustrate the different features of the Products, Services and corresponding Offers – the Gain Creators and Pain Relievers sections. The names and functions of these sections correspond to that of the Value Proposition Canvas (Osterwalder, *et, al.*, 2014). Gain Creators describe the intended positive outcomes and benefits that your Products, Services and Offers produces for the End-User Segment while getting a specific activity/ "job" done. Users investigate what Gain Creators match with what Gains from the End-User Profile. Pain Relievers describe the intended negative experiences and risks before, during and after getting a specific activity/ "job" done that your Products, Services and Offers

will reduce or eliminate. Similarly, users investigate what Pain Relievers match with what Pains from the End-User Profile.

The Energy Value Map makes use of the same terminology used in EUC-BMC as it is broken up into two sections: Other Solutions and the Energy Solutions. The Other Solutions section is indicated through the purple section in the Energy Value Map. Acknowledging both the importance and limitations of electricity in providing a modern bundle of energy services, the Energy Solutions is made up of two parts; 'Electricity Supply' and its corresponding Products, Services and Offers (yellow section) and 'Other Forms of Energy Supply' and its corresponding Products, Services and Offers (orange section). 'Other Forms of Energy Supply' entail solid, liquid, gas and direct conversion as previously discussed and documented in the guiding cards. The division between 'Electricity Supply' and 'Other Forms of Energy Supply' is necessary as not only the Energy Supply Form is different, but consequently (in almost all cases) the Energy Supply Equipment and the corresponding Energy Supply Delivery System. As with all the other modules designed in this study's conceptual framework, Sticky Notes are used to represent ideas. Therefore, the division between 'Electricity Supply' and 'Other Forms of Energy Supply' creates greater structure and leads to an Energy Value Map that is less densely populated with Sticky Notes, which could lead to confusion.

The 'Electricity Supply' section was designed to be larger than the 'Other Forms of Energy Supply' section as electricity has the potential to offer access to multiple Energy Services and their corresponding Energy-Using Products such as entertainment and communication technologies.

Both 'Electricity Supply' and 'Other Forms of Energy Supply' is further divided into those using renewable or non-renewable Energy Sources. The importance of the choice of Energy Source is communicated through this distinct division and consequently visually illustrated. Furthermore, similar to the argument above, this further division creates greater structure, leading to an Energy Value Map that is easier to understand. This division also corresponds to the real world, as enterprises that would offer Energy Solutions (whether 'Electricity Supply' or 'Other Forms of Energy Supply') that are both renewable and non-renewable would probably make use of different Energy Supply Equipment and consequently different Sticky Notes.

As to indicate which terms in the different guiding cards would be applicable to either Energy Value Map or the End-User Profile, the 'Energy Solutions Terminology Overview' guiding card is divided accordingly in Figure 39 below.
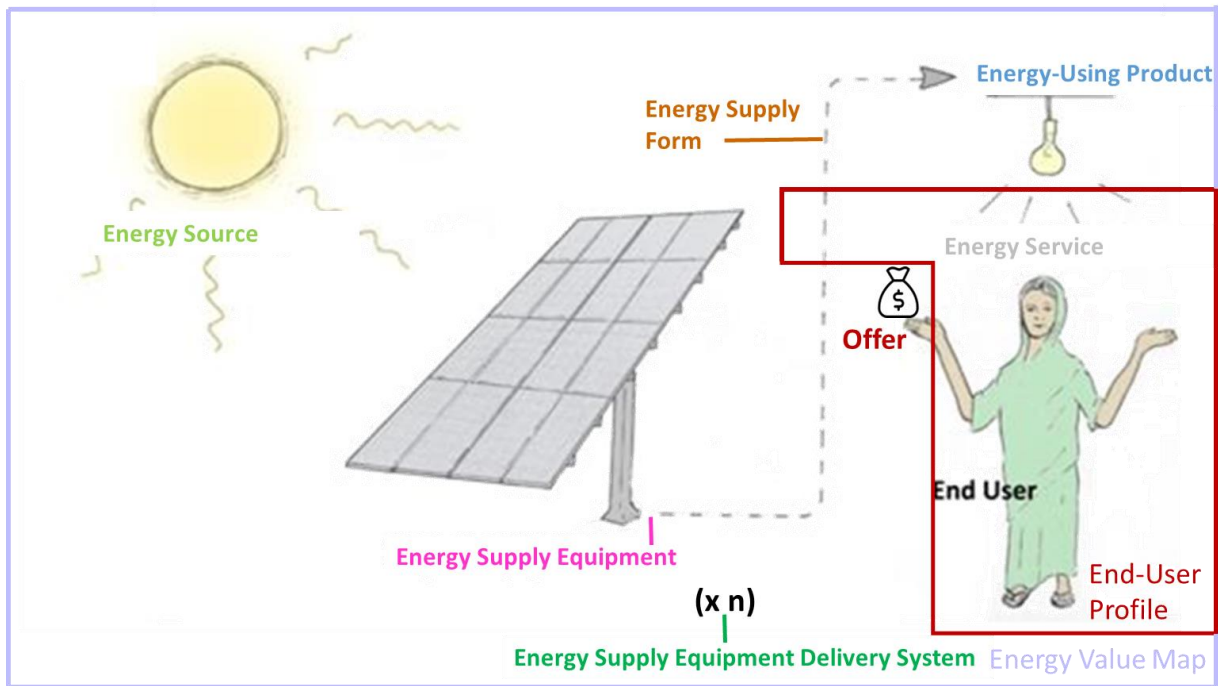
**Figure 39: Sectioned 'Energy Solution Terminology Overview' Guiding Card**

Figure 40 demonstrates a more detailed view of the Products, Services and Offers sections of the Energy Value Map. The influence of the work of Emili *et al.* (2016) can be seen through the addition of an Offer block to the traditional listing of Products and Services in business model literature (Osterwalder & Pigneur, 2010; Osterwalder *et al.,* 2014). The Offer blocks illustrate the PSS offer that is created through the combination of Products and Services.



**Figure 40: Products, Services and Offers Sections of the Energy Value Map**

The work of Emili *et al.* (2016) further influenced sectioning the Products block by keeping Energy-Using Products separately. This division allows for focused ideation surrounding the choice of Energy Source, Energy Supply Form, Energy Supply Equipment and Energy Supply Equipment Delivery System.

The Services block gives the users the opportunity to consider what services will be provided with the Products. Examples of Services are, for example, financing, maintenance and repair, installation etc. As shown above, the guiding cards assist with ideation of these Services.

The Offer block demonstrates through what type of payment offering the combination of Products and Services is provided. As can be seen in 'Energy Supply Equipment System and Offer Compatibility' Guiding Card in Figure 32, the different types of offers range from product-orientated to use-orientated, to result-orientated and include Free and No Equipment. As with the Value Proposition block of the EUC-BMC, ownership and timelines for ownership transfer of the Energy Solution(s) Products are considered. The EUC-BMC, however, does not break up the Energy Solution(s) Products into the different, detailed parts as the Energy Value Map does.

Users are encouraged to use a different colour Sticky Notes for each Product offered to the End-Users. As can be seen through the design of the products block, a product can make up a combination of Energy Supply Equipment and Energy-Using Products of each of them sold separately. In the case where the Energy Supply Equipment and the Energy-Using Products are sold together then they would all use the same colour Sticky Note.

Figure 41 'Energy Solutions Terminology Overview' Guiding Card demonstrates the parts of the Energy Solutions that are addressed in the End-User Profile are the End-User, Energy Supply Form and Energy Services.

The overlap of the EUC-BMC in the End-User Profile is the blue End-User Segment building block. In the EUC-BMC, the End-User Segment is simply named. Similarly, the End-User Segment is once again simply named as the same End-User Segment name is written in the human icon in the End-User Profile (as seen in a zoomed-in version in Figure 41 below)

As with the Energy Value Map, the End-User Profile makes use of the similar terminology to that in the EUC-BMC as it is broken up into two sections: 'Energy Needs & Desires' and 'Other Needs & Desires'. The 'Energy Needs & Desires' is also further broken up into the different Energy Supply Forms: 'Electricity Supply' and 'Other Forms of Energy Supply'.
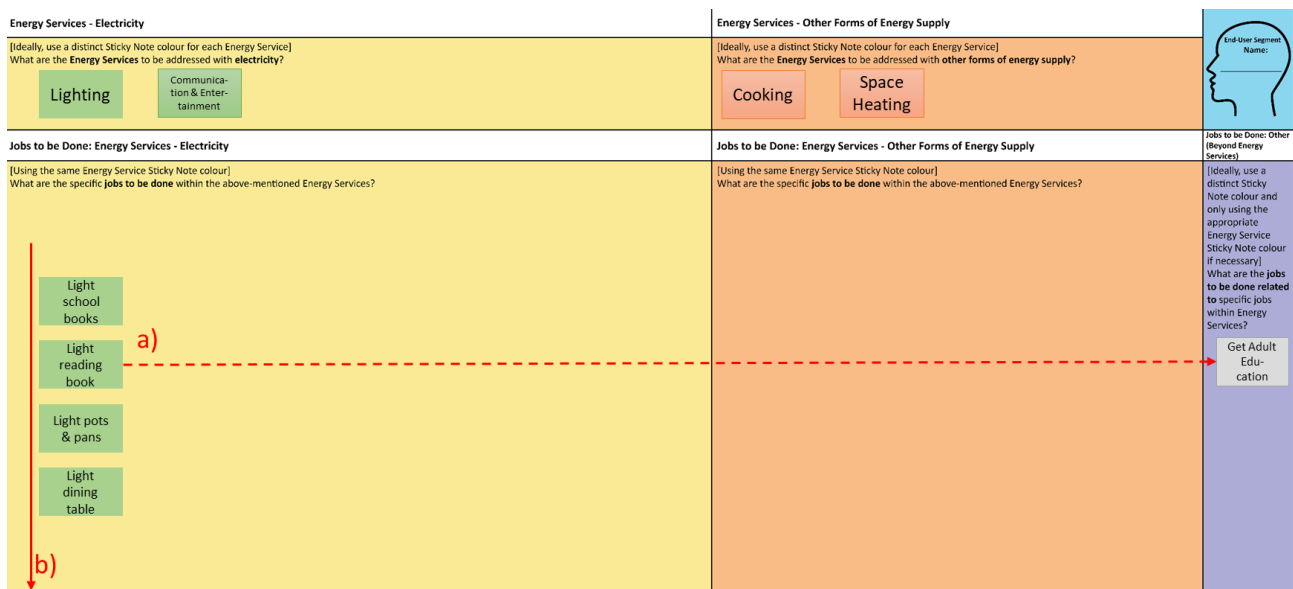
**Figure 41: Zoomed-In Version of the End-User Profile**

The last part of the 'Energy Solutions Terminology Overview' Guiding Card addressed in the End-User Profile is the Energy Services. Users are instructed to visualise the Energy Services that are to be targeted with an Energy Solutions. To ensure that valuable Energy Solutions are provided to the End-User Segment through an in-depth understanding of the Energy- and Other Needs & Desires, fieldwork should ideally be conducted prior to the idea generation session to determine what Energy Services are a priority to the End-User Segment and to address these Energy Services. Fieldwork methodologies such as that of Clements *et al.* (2019) can be utilised. If fieldwork before the idea generation workshop is not possible, then assumptions have to be made for the time being. The assumptions are verified at a later stage through contact with the end-user segment. Future work can be conducted to understand whether the End-User Segment, that is, the urban informal community could/should be part of the idea generation session. As the relationships with these communities and authorities are often complex and sometimes hostile, the end-user segment was not included in the idea generation session used for the validation of the Framework.

As discussed, energy access is often synonymous with access to grid electricity. The end-user profile addresses this by taking the focus away from energy supply form and placing it on energy services or the *usability* of energy supplied. Each energy service is indicated with a different colour Sticky Note to ensure differentiation among them and greater clarity.

The block below energy services considers the jobs-to-be-done. As discussed previously, jobs-to-be-done refer to the tasks that end-users want to complete by using a specific solution offering. Energy services are the activities that are enabled through the supply of energy. Energy Services are often divided into broad categories such as lighting, cooking, space heating. These activities need to be divided into more specific tasks to enable the tailored design of Energy-Using Products and Energy-Supply Equipment in the Energy Value Map. The Job Statement format of Silverstein (2014) is used to break these broadly stated Energy Services into specific tasks. The Value Proposition Canvas has been criticised for being too unstructured (Fernandes *et al.*, 2018),

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the Job Statement, therefore, provides the necessary structure for focused idea generation. The Job Statement format is Action Verb + Object of Action + Context Clarifier. The "Action Verb + Object of Action" combination would break the broad category of lighting into a mere specific task such as "light school books"/ "light pots and pans"/ "light dining table".

Osterwalder *et al.* (2014) demonstrate that the context in which an end-user finds themselves changes the jobs they need to complete. If a person goes to the movies with their spouse, they would like to complete the "job" of having a romantic night out. The same person going to the movies with their kids wishes to watch a movie that would entertain her kids and ideally not be too long. The additional guiding cards can be created in future work to offer suggestions for the different contexts in which these Energy Services could take place such as place, time, social setting e.g. light dining table when hosting friends. As no work has been conducted in this regard for energy provision in urban informal settlements, it lies beyond the scope of this study. The Job Statement format can then be utilised to design task and context-specific solutions.

Osterwalder *et al.* (2014) state that it is essential not to have a superficial understanding of the End-User Segment's jobs, and therefore it is important to continually ask "why" to understand their underlying motivations. This is often deemed "why-probing" and has been used in energy provision research (Clements *et al.*, 2019; Hirmer and Guthrie, 2016). Through "why-probing" jobs related to those within Energy Services can be determined and be visualised within the "Jobs-to-be-done: Other (Beyond Energy Services)" block. As stated, these jobs represent the underlying motivations for trying to get a job done within the different Energy Services. As marked with "a)" in Figure 41, it can be seen that the underlying reason why the end-users want to light a reading book is to "get adult education". Lastly, as indicated by "b)", Jobs-to-be-done are ranked from most- to least important. This allows users to consider which jobs-to-be-done are most pressing to address.

The final sections in the End-User Profile are the Gains and Pains sections. The names and functions of these sections correspond to that of the Value Proposition Canvas (Osterwalde *et al.*, 2014). Gain describe the positive outcomes and benefits that the End-User Segment wants to experience while getting a specific activity/ "job" done. Pains, on the other hand, describe the negative experiences and risks before, during and after getting a specific activity/ "job" done. Similar, to how jobs-to-be-done is ranked, Gains and Pains are also respectively ranked according to their importance and severity. Ranking the Gains and Pains assists users in considering what Gains and Pains are critical to address. As discussed, when providing an overview of the Energy Value Map, the Gains are matched with Gain Creators as to see to what extent does the Value Proposition (Products, Services and Offers) match with the needs and desires of the End-User Segment. Similarly, Pains are matched with Pains Relievers. If the Gains and Pains of the End-User Profile being sufficiently addressed in the Energy Value Map then there "fit" is achieved as the Value Proposition stands a chance of being accepted by the end-users.

It should be noted that unlike the Gain Creators and Pains Relievers of the Energy Value Map, the Gains and Pains of the End-User Profile are divided in such a way as to the Energy-Using Products separate. This division

is similar to the division seen in the Products block of the Energy Value Map. This division assists in communicating the specific Pains they would like to minimise and the Gains they would like to have maximised, for example, an individual wants the gas stove (energy-using product) to be quick in cooking their food, but they want the gas (energy supply form) that they frequently refill to be cheap and easy to collect.

### 4.3.3.4  Addressing the Key Concepts

**Logic of the Framework:**

Continuation of the terminology of Energy Solutions and Other Solutions are used. Users are encouraged to make use of different Sticky Note colours for different Products/ Services. Connection to the EUC-BMC's blue Value Proposition and End-User Segment is indicated through blue block outlines.

**Desirability:**

As discussed, the Energy Value Proposition Canvas can be filled in by either starting with the Energy Value Map or the End-User Profile. As to avoid "technology push" and improve desirability. Users are advised to start with the End-User Profile as to ensure that the Energy- and Other Solutions are designed according to actual needs and desires of the End-User Segment. As to involve end-users as "allies", users are further encouraged to first do fieldwork to understand what Energy Services are prioritised above others. If field work is not possible before the idea generation session, then assumptions have to be made, but later tested when fieldwork can be done.

Allowing the Gains and Pains of Energy-Using Products to be defined separately allows for a nuanced view of the needs and desires of the End-User Segment, allowing for informed design choices.

The process of visually matching Pain Relievers with Pains and Gain with Gain Creators minimised the creation of solutions that would be undesirable to the end-users. And the process of ranking Sticky Notes for jobs-to-be-done and the Gains and Pains furthers assists in desirability as it ensures that the most pressing matters of the End-Users are addressed.

To Energy Value Proposition Canvas goes beyond the provision of Energy Solutions by considering the underlying motivations for getting jobs done within energy services. It then allows the visualisation of Other Jobs-to-be-done as to ensure the possible design of related value-adds (named Other Solutions).

**Job Completion:**

The usability of Energy Services is considered by listing the jobs that can be completed within the different Energy Services. The use of the Job Statement format allows for detailed specifications of the jobs to be completed within the Energy Services. Each energy service is indicated with a different colour to further ensure differentiation among them. Unlike the work of Emili *et al.* (2016) that suggests traditional Energy-Using Products which could stifle innovation, the Energy-Using Products block is purposely left with minimal suggestions and users are encouraged to consider the multiple Jobs-to-be-done in the End-User Profile and

design innovative Energy-Using Products accordingly. An example could be a portable lightbulb with an attachment to the roof of a dwelling for general lighting as well as to the side of a cooking pot for more task-specific lighting.

**New Modes of Ownership:**

Through the combination of 'Energy Supply Equipment System and Offer Compatibility' Guiding Card and the guiding cards of Emili *et al.* (2016), users are assisted in understanding the concept of PSS in the energy provision sector. In the Offer block, this module goes beyond the work of Emili *et al.* (2016) and prompts users not only to consider whom the owner of the Products would be, but also what the timelines of ownership transfer would be. This allows ownership timelines and therefore the multiple variations of other PSS types (as observed by Yang and Evans (2019)) to be considered and illustrated.

### 4.3.4  Life Cycle Partner Co-creation of the Backstage

The aim of the module is to facilitate the partner co-creation of the Backstage throughout the multiple lifecycle phases. As stated in Section 4.3.2, the Backstage refers to the various interactions within the enterprise and with its partners in producing and delivering an offer to the End-User Segment (Vezzoli et al., 2018).

Table 13 demonstrates the evaluation of relevant tools existing in the literature that assist users in considering co-creation among an enterprise and its partners.

Following the review of the relevant tools in literature, the Partner Interaction Canvas was created. A full-page illustration of the module can be seen in Appendix A (Figure A.12).

Following the design of Yang *et al.* (2017), the life cycle is broken up into Beginning of Life, Middle of Life and End of Life segments, allowing greater understanding of the life cycle phases. To assist in ideation, a typical life cycle for an Energy Solutions is given. Unlike Yang *et al.* (2017), the life cycle is considered from both the (energy solutions) provider perspective and the end-user segment perspective. The life cycle phases were created by combining the work of Bacciotti, Borgianni and Rotini (2016), Geterud (2012) and Practical Action (2015) – adapting it to the context of the study where needed. As the focus of this module is designing the backstage, the "provider perspective" is emphasised through bold text. The "End-User Segment Perspective" is not written in bold text, as its purpose is purely to further assist backstage ideation through understanding what possible interactions there are with the End-User Segment in the Front Stage. The End-User Segment life cycle/touchpoints in the Front Stage are designed in detail in the end-user journey canvas module (Section 4.3.5). Similar to Yang *et al.* (2017), the Partner Interaction Canvas does not limit users to make use of the typical provider's perspective on the life cycle and gives them the opportunity to plot the actual lifecycle of the energy provision enterprise under analysis.

**Table 13: Tools Considering Partner Co-Creation**

| Name | Author | Description of focus/application | Format | Strengths | Weaknesses |
|---|---|---|---|---|---|
| Sustainable Value Analysis Tool (SVAT) | Yang *et al.* (2017) | Idea generation tool analysing the value perceptions of the different partners at each life cycle phase | Paper-Based | Designed for idea generation phase - makes use of Sticky Notes<br><br>Takes a life cycle perspective<br><br>User's actual life cycle is customisable | Not specific to the energy sector<br><br>Network-centric perspective: Does not consider how partners contribute to the enterprise, rather, how the enterprise contributes to the partners<br><br>No division lines between life cycle phases create the chance for possible confusion<br><br>Only considers the provider's perspective of the life cycle life cycle, not the End-User Segment's perspective |
| Energy Market System | Practical Action (2015) | Guidelines for developing support interventions for an energy provision enterprise to assist in overcoming common barriers | Paper-Based | Specific to the energy sector<br><br>Informs the life cycle of a product by considering its value chain<br><br>Visually illustrates at what point in a value chain certain support services are typically required | Value chain divided into segments that are too broad<br><br>Guidelines provided – challenging to use within the idea generation phase<br><br>Firm-centric view: Does not consider the interactions of the partners to one another |
| Stakeholder Motivation Matrix | Ceschin, Resta, Vezzoli and Gaiardelli (2014) | Tool in the form of a double-entry table developed as part of the MSDS (Methodology for System Design for Sustainability). Designed to visualise partner relationships to one another and to the initiative | Paper-Based | Considers what each partner contributes to the initiative, that is, energy provision enterprise in the context of this study<br><br>Illustrates the importance of considering the motivations of each partner | Not specific to the energy sector<br><br>Partial network-centric view: Visualises the interactions of the different partners |
| Partner Value Matrix | Envision (2017) | Tool developed as part of a larger self-service platform to empower SMEs in all sectors to develop and innovate their business models | Paper-Based | Considers the mutual benefits in interacting with partners, that is, what the partner contributes to the enterprise and what the enterprise contributes to the partner | Not specific to the energy sector<br><br>Does not take a life cycle perspective and therefore considers limited areas where partner interaction can take place (Resources, Sales Channel, Funding and Other) |

As discussed in the EUC-BMC module (Section 4.3.2), Key Partners are the main parties involved in ensuring the delivery of the Value Propositions to the End-User Segments. As the Partner Interaction Table take a more detail-design perspective, not only the *main* parties but also *all* parties involved are visualised.

Similar to Practical Action (2015) and unlike Ceschin *et al.* (2014) that consider the interactions of the multiple stakeholders with one another, the Partners Interaction Table takes a firm-centric view. Accordingly, a large block was designed to visualise the multiple interactions of the Partners to ensure the production and delivery of the Energy Solutions of the energy provision enterprise at each life cycle phase. Another design element that is different from other authors is the dashed division lines between the life cycle phases. These dashed, vertical lines create division between life cycle phases to create multiple columns and therefore, order and structure that minimises confusion for the multiple partners' roles and responsibilities. The block has the capacity to list 10 Sticky Notes at each life cycle phase. However, the dashed lines indicate that a life cycle phase does not have to be limited to a single column but can span multiple columns if a single column is too small.

As indicated through the pink outline, this block corresponds to the pink building blocks of the EUC-BMC (key partners, key activities and key resources). Users are instructed to answer the questions:

- Who is involved in each life cycle phase?
- What contribution will they make to the energy solutions?
- What do they expect in return for their contribution?

Inspired by the work of Ceschin *et al.* (2014) and Envision (2017), the questions not only aim to determine *who* is involved but also understanding the mutual benefits between the energy provision enterprise and the partners. Visualising this mutual benefit allows the energy provision enterprise to determine whether they will be able to fulfil in delivering the partners' expectations, resulting in sustainable collaboration.

Any contribution to the energy provision enterprise of a financial nature is further visualised in the "Income: Third Parties" block. Similarly, any financial expense for the energy provision enterprise is documented in the "Cost Structure" block. Both of these blocks correspond to the building blocks in the EUC-BMC with the same names and corresponding colours. The case can be made non-financial contributions received from or provided to partners should be indicated in these two blocks, respectively. As the BMC of (Osterwalder & Pigneur, 2010) is limited to financial income and expenses, this study is also limited in similar regard. Future work can be conducted to expand this scope.

Similar logic to that of the other modules is evident through the continual usage of the appropriate Products/Services Sticky Note colours. Another example of the Framework logic that is demonstrated is through considering not just energy solutions, but other solutions. A typical life cycle for other solutions is also provided. The "Provider Perspective" was created by adapting a few of the parts of the Energy Solutions life cycle that were specific to energy provision such as the wording of "Energy-Using Products", "Energy Supply Equipment" and the need for construction of the Energy Solutions. The "End-User Segment Perspective" is identical with the Energy Solutions life cycle.

A similar but smaller block was designed to illustrate the Partner interactions necessary to ensure the delivery of the Other Solutions. As with the Energy Solutions, any contributions to the energy provision enterprise or to the Partners are depicted in the "Income: Third Parties" and "Cost Structure" blocks, respectively.

**Logic of the Framework:**

Continuation of the terminology of Energy Solutions and Other Solutions are used. Users are encouraged to use the same colour Sticky Notes as was used for the Products/ Services in the EUC-BMC and/ or Energy Value Proposition Canvas. Colours – assists with understanding roles and responsibilities. Connection to the EUC-BMC's building blocks is evident through the same colour block outlines

**Life Cycle Thinking:**

Life cycle thinking is made more understandable to users through segmenting the life cycle phases in Beginning of Life, Middle of Life and End of Life groupings. The End-User perspective of the life cycle adds to the further understanding of an energy provision enterprise's life cycle and how End-User Segment interactions can be considered. Users are not limited to the typical life cycle provided as an example but are given the opportunity to customise the life cycle they want to visualise.

**Multi-stakeholder Engagement and Feasibility:**

Feasibility asks the question: "can it be built?" If an energy provision enterprise does not have the capabilities to build the Energy- and/ or Other Solutions, partnerships have to be formed. The Partner Interaction Table assists in determining feasibility as it visualises the entire life cycle of the solutions, who is involved in each life cycle phase and how are they involved. Feasibility is further determined by considering not just the contributions Partners make to the energy provision enterprise, but what contributions are created for the Partner. Evaluating whether the expectations of the Partner can be fulfilled by the energy provision enterprise informs the sustainability of the collaborative relationship and therefore the feasibility of the solutions offered to the End-User Segment.

Sufficient space is provided to visualise multiple partners' interactions. Dashed dividing lines allow for life cycle phases to stretch beyond a single column and creates greater structure and order for the visualisation of the multiple stakeholder's roles and responsibilities

**Financial Viability:**

Considering the Income: Third Parties and Cost Structure blocks of this module, the proportion of expenses covered by third parties, that is, the reliability of third parties can be observed.

Together, with the End-User Journey Canvas, profitability and thus financial viability can be determined.

### 4.3.5 Life Cycle End-User Co-creation of the Front Stage

As services are combined with products, PSS business models allow enterprises to go beyond the traditional transaction-based interactions with end-users and have interactions that are more continual or "relationship-based". The various interactions (also known as touchpoints) with end-users can be considered and consequently be designed by taking the perspective of an end-user "journey". The aim of the module is to facilitate the end-user co-creation of the Front Stage throughout the multiple lifecycle phases. As the Front Stage-level interactions refer to the direct interactions with the End-User Segment, the different touchpoints with the End-User Segment is considered (Vezzoli *et al.*, 2018).

**Table 14: Tools Considering End-User Co-Creation**

| Name | Author | Description of focus/application | Format | Strengths | Weaknesses |
|------|--------|-------------------------------|--------|-----------|------------|
| Customer Journey Canvas | Stickdorn & Schneider (2011) | Idea generation tool depicting the service journey from an end-user's perspective | Paper-Based | Sticky Notes are used<br><br>Considers pre- and post-service interactions | Not specific to the energy sector<br><br>Does not provide examples of typical end-user segment touchpoints |
| Storyboard | IDEO (2015) | Idea generation tool illustrating the chronological interactions experienced by the end-user | Paper-Based | Sticky Notes are used | Not specific to the energy sector<br><br>Does not consider pre- or post-service interactions |

The design of the End-User Journey Canvas is similar to that of the Customer Journey Canvas and thus the name is derived through simply changing "customer" to "end-user". A full-page illustration of the module can be seen in Appendix A (Figure A.16).

The module is divided between Pre-Service Period, Service Period and Post-Service Periods sections. As was seen in the Partner Interaction Canvas, the typical life cycle phases/ end-user touchpoints are presented. As the focus of the module is on the Front Stage, only the "End-User Perspective" is illustrated and emphasised through bold text (unlike the Partner Interaction Canvas). The life cycle phases serve as typical touchpoints experienced through the end-users and assist in idea generation.

In all three sections of the module, users can decide if they want to consider the Energy Solutions and the Other Solutions together or separately. Different colour Sticky Notes are suggested to assist in creating further clarity within the module.

The Pre-Service Period considers how end-users can become aware of the solutions offered. Users are instructed to divide each Sticky Note into three sections: End-User Relationships, Channels and Touchpoint Description/ Illustration. The End-User Relationship section is used to indicate "What type of relationship is established/maintained with the End-User Segments?". As evident through the grey outline, this section

corresponds to the grey End-User Relationships building block in the EUC-BMC. A guiding card (Table 15) was created to assist in choosing between the different types of end-user relationships. It lists the same type of end-user relationships as in the EUC-BMC but adds descriptions to assist in understanding.

**Table 15: Different Types of End-User Relationships (adapted from** Osterwalder and Pigneur (2010))

| End-User Relationship Type | Description |
|---|---|
| Personal Assistance | Human interaction forms the foundation of this relationship. A customer representative interacts with the customer during or after the sales process e.g. at the point of sales, via e-mail, through a call centre etc. |
| Dedicated Personal Assistance | In this type of relationship there is a customer representative specifically assigned to a client. This can be seen as the most intimate kind of customer relationship. Examples of this are dedicated private bankers serving high net worth individuals, key account managers that nurture a personal relationship with valuable customers etc. |
| Self-Service | In this relationship the company ensures the customer is set up with all the tools to help themselves and has no direct relationship with the customer. |
| Automated Services | This relationship combines a more advanced model of customer self-service and automated processes. These automated services have the ability to identify individual customers and their attributes and based on those patterns will offer relevant information regarding transactions and orders. If well designed these automated services can replicate a personal relationship to an extent. |
| Communities | Companies are busy expanding their engagement in customer communities and the facilitation of connections between community members. Some organizations have built online communities that enable idea exchange, advise and connections between community members – sharing knowledge, expertise and experience. These communities also give companies better insight into their consumer base. |
| Co-creation | This relationship crosses the conventional boundaries of customer-vendor relationships and brings the customer in as a co-creator. This really allows the consumer to add value to the product/service by making suggestions and coming up with innovative ideas. |

The second section is the brown Channels section and corresponds to the brown Channels building block in the EUC-BMC. Here users need to identify "Through what Channels are the End-User Segments reached?" Similar to this End-User Journey Canvas module, the EUC-BMC suggests different life cycle phases and encourages users to consider how users will be reached in this life cycle phase. The EUC-BMC does, however, not provide specific suggestions. The possible channels to reach users within the different life cycle phases are also not a topic that has not been covered in the energy provision literature, specifically in an urban informal context. As to not suggest different types of channels without substantiated research, a guiding card for this Framework element lies beyond the scope of this study and can be considered for future work. At present, participants are encouraged to suggest both physical and digital channels that are common in the energy sector to reach end-users. The last section users are instructed to describe or draw "… the touchpoints that End-User Segments experience…"

The Pre-Service Period section refers to the period when end-users become aware of the Energy- and/or Other Solutions. End-users can become aware through multiple ways such as word-of-mouth from others, educational campaigns from NGOs, advertising (physical or digital) from the energy provision company, product co-creation sessions with the energy provision enterprise etc. As stated, a guiding card with more specific suggestions for the urban informal context can be created. In this section of the module, users list the different manifestation in which end-users become aware of the Energy- and/ or Other Solutions. By listing the various examples of how the Solutions become known to the end-users, allow the energy provision enterprise to consider whether they want to/can design interventions that would improve the perception of the Solutions. At the bottom of each section, the End-User Journey Canvas considers the expectations that end-users have for the service. This is not included in the design of the End-User Journey Canvas as expectations in the form of Gains and Pains are documented in the End-User Profile of the Energy Value Proposition Canvas (Section 4.3.3) and would thus lead to duplication and possible confusion for the users.

The Service Period section is depicted through the chronological touchpoints experienced by the end-users. As with all customer journey canvases/maps in the literature, no specific structure/methodology is suggested to users other than placing Sticky Notes in chronological order. As stated earlier, the user can decide whether they want to present the Energy Solutions and the Other Solutions together as one journey or separately. There is sufficient space for multiple journeys.

At the bottom of the service period section is a block with a green outline that corresponds to the green "Income: End-User Segments" building block in the EUC-BMC. This block depicts "…the income received from End-User Segments at the touchpoints in the Service Journey…"

Finally, the Post-Service section visualises the touchpoints with the end-users after all services have been provided.

**Logic of the Framework:**

The framework logic is present as the terminology of Energy Solutions and Other Solutions are used once again, along with the use of Sticky Notes. Connection to the EUC-BMC's building blocks is evident through the same colour block outlines

**Life Cycle Thinking:**

Life cycle thinking is present through the End-User perspective of the life cycle that is presented to the users in the form of touchpoints.

**Financial Viability:**

The Income: End-User Segments block allows all income received from the End-User segment at the touchpoints to be noted. Along with the Partner Interaction Canvas, profitability and thus financial viability can be determined.

**Desirability:**

The possible contributions of the end-users can more clearly be considered through the illustration of a typical end-user life cycle. Desirability is considered by taking an end-user perspective and understanding the service journey that they experience. The End-User Journey goes beyond the current tools in literature by considering through what channels end-users are reached and the type of relationship to the end-user at that touchpoint. These considerations lead to purposeful design, leading to a better end-user journey and consequently, greater end-user desirability.

### 4.3.6   Value Perception of Multiple Stakeholders

The developed module is the value-mapping table. Section 4.3.4 considered the Partner Interaction Canvas. The Partner Interaction Canvas lists the parties that are partners, that is, the parties involved in the delivery of the Energy and Other Solutions to the End-user Segment. The value-mapping table does not only consider the Partners listed in the Partner Interaction Canvas but also visualises the parties that are stakeholders, that is, any party that would have an interest or have an influence on the Energy- and Other Solutions delivered to the end-users.

The aim of the developed module is to visualise the value perceptions of the multiple stakeholders. These are the perceptions of the multiple stakeholders for the Energy and/ or Other Solutions that are provided to the End-User Segment across multiple forms of value. Other tools in literature were evaluated so as to determine to what extent they would be suited to the context of this study – this evaluation can be seen in Table 16.

**Table 16: Tools Evaluating Multi-Stakeholder Value Perceptions**

| Name | Author | Description of focus/application | Format | Strengths | Weaknesses |
|---|---|---|---|---|---|
| Value Mapping Tool | Bocken, Rana & Short (2015) | Idea generation tool analysing the value perceptions of different partners | Paper-based | Consideration of multiple forms of value | Circular design<br><br>No consideration of Value Absence and Value Surplus |
| Sustainable Value Analysis Tool (SVAT) | Yang *et al.* (2017) | Idea generation tool analysing the value perceptions of different partners at each life cycle phase according to the TBL | Paper-based | Consideration of multiple forms of value | Wrong perspective on the value<br><br>Value Perceptions limited to the value created within the TBL<br><br>Suboptimal groupings of multiple forms of value |

After evaluating the strengths of weaknesses of the current tools in literature, the value-mapping table (Figure 42) was created. A full-page figure of the module can be found in Appendix A (Figure A.19).

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| | Value Captured | Value Destroyed | Value Missed/Absent | Value Surplus | Value Opportunity |
|---|---|---|---|---|---|
| Actors & Stakeholders | | | | | |
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**Figure[5] 42: Value-mapping table**

Bocken *et al.* (2013) was the first to create a tool that facilitated multi-stakeholder perceptions of value across multiple forms of value. Bocken *et al.* (2015) further developed the Value Mapping Tool by adding more groups of stakeholders and by creating greater differentiation among value forms but kept the "Value Mapping Tool" name. As the design of the value-mapping table is greatly influenced by the work done by Bocken *et al.* (2013) and Bocken *et al*. (2015), it holds a similar name.

The reason why the wording of "table" was chosen in naming the tool is its design. Both the Value Mapping Tool of Bocken (2013) and Bocken *et al*. (2015) as well as the newly developed Cambridge Value Mapping Tool (Stark *et al.,* 2017) and Stakeholder Value Creation Framework (Freudenreich, Lüdeke-Freund & Schaltegger, 2019), have circular designs.

A table layout's design is not affected if stakeholders are added or excluded from an analysis – the table's rows are simply more or less populated. A circle design, however, is affected, as the circle needs to be divided into smaller or bigger segments, respectively. A table design is therefore chosen for the value-mapping table as it allows for a generic layout that can be used in multiple workshop case study contexts.

The stakeholder that would be present in all business models in the context of this would be the end-user segment, energy provision enterprise, urban informal community and local government. These stakeholders

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[5] Similar to what was discussed in Figure 22, although the module is called the Value Mapping *Table*, this illustration is classified as a figure as it depicts the module

are therefore already populated in the module (as seen in Appendix A). Future work can be conducted to develop guiding cards that would be able to provide suggestions of what parties to include in the analysis under specific conditions.

Unlike Bocken *et al*. (2015), the environment (that is, the environmental dimensions of sustainable development) is not considered as a stakeholder. The impact on the environment (positive or negative) is sufficiently considered in the sustainable development indicators table (Section 4.3.1) and therefore omitted in the design of this module.

The definitions of the different forms of value are listed in 'Different Forms of Value' Guiding Card (Figure 43 below). The content of the design card is an adaptation of the work of Yang *et al*. (2017). They group Value Missed and Value Destroyed together, leading to idea generation taking place in a single block. No specific reason is provided for this grouping. It is assumed that this grouping was made as Yang *et al*. (2017) see value missed and value destroyed as similar forms of value, and therefore the space reserved for their idea generation can be shared. As value also considers value that is not yet present, value missed is considered to be more closely related than value destroyed, which refers to "something that undermines value". Value absence and value missed are therefore grouped together, whereas value destroyed is considered on its own.

| | Definition | Examples |
|---|---|---|
| Value captured | The benefit delivered to the company and its stakeholders | Improved energy efficiency, zero emissions, high financial returns |
| Value destroyed | Something exists but undermines value | Poor working conditions Pollution |
| Value missed | Something exists but is not exploited | By-products underutilised Inefficient use of equipment |
| Value absence | Something required which does not exist | Temporary lack of labour or infrastructure Lack of financial returns |
| Value surplus | Something exists but is not required | Overproduction Repeated work |

**Figure 43: 'Different Forms of Value' Guiding Card (adapted from** Yang et al. (2017)**)**

Yang *et al*. (2017) also group the idea generation for Value Absence & Value Surplus together as they are complementary to each other. The combination allows users to consider how the Value Surplus of some stakeholders can be used to address the value absence of others. The value-mapping table considers value surplus separately to assist with focused idea generation of a specific type of value form. The column of value surplus and value missed/absence can still be compared to analyse whether the value surplus of one stakeholder and the value absence of another stakeholder could be complementary to each other.

As value perception of each stakeholder is evaluated relative to a specific part within the Energy- and/or Other Solutions offering to the end-user segment, users are encouraged to use to the same colour Sticky Notes as to the product/services they are referring to.

Similar to the Energy Value Proposition Canvas, it would be ideal to have the multiple stakeholders represented in the idea generation session; however, if this is not possible then assumptions regarding how value may be perceived from each stakeholder have to be made for the time-being before being validated at a later stage.

**Framework Logic:**

All the tools evaluated in developing this module are used as stand-alone tools. Similarly, the value-mapping table can be used on its own. Although suggesting the BMC of Osterwalder and Pigneur (2010) can be used as a complementary tool for implementing the ideas developed with the value-mapping tool, Bocken *et al.* (2015) do not use the BMC. This study goes beyond using a tool for visualising multi-stakeholders' perceptions of value on its own. It is used in conjunction with the EUC-BMC and its corresponding detail-design modules, allowing a business model-wide perspective on evaluation. It can be concluded the value-mapping table can be used individually or in combination with the EUC-BMC and its corresponding detail-design modules (collectively referred to as Cluster of Canvas Modules in Section 4.4).

As to ease the visualisation of what part in the Energy- and/or Other Solutions offering value perception are referring to, users are encouraged to use the same Products/Service colour Sticky Notes.

**Multiple Forms of Value:**

The value-mapping table makes use of the most sophisticated categorisation of forms of value in the literature (the categories of Yang *et al.,* 2017). The value-mapping table groups them in a unique manner to ensure greater focus in idea generation sessions.

**Multi-Stakeholder Engagement:**

As can be seen in the EUC-BMC, Energy Value Propositions Canvas, Partner Interaction Canvas and the End-User Journey Canvas – multiple Partners are involved in delivering both the Energy - and Other Solutions. The number of partners involved could be many and is increased further when not only partners but stakeholders are considered.

The table design of the value-mapping table allows for a large number (20 to be exact) of stakeholders to be listed. The value-mapping table therefore has the capability to list a large number of partners and stakeholders. The current design was made for an A1 size page, but could easily be adapted to an A0 size, creating the ability to list 28 partners or stakeholders.

**Systems Thinking:**

The module allows the visualisation of the multiple forms of value for different stakeholders. This visualisation allows users to identify the different trade-offs emerging between multiple forms of value which provides input to design win-win solutions between the stakeholders.

## 4.4   Synthesising the Modules into the Framework

The Framework for this study is presented in Figure 44 (a full-page version of the figure can be seen in Appendix A – Figure A.20). The illustrated Framework achieves the third research objective: *Deduce a framework to assist in the development of sustainable PSS business models in the energy provision sector.*

The Sustainable Development Indicators Table is located on the left of the composition and indicated with a circled "1" as to specify its position in the suggested Framework sequence. The method of numbering framework elements to indicate the Framework's suggested order corresponds to the logic used by other business model development frameworks such as the Lean Canvas (Maurya, 2010) and the Service Logic BMC (Ojasalo & Ojasalo, 2018). Sustainable Development Indicators are defined and users have the option to assign detailed Specifications to each indicator as to clearly define the sustainability criteria. The Sustainable Development Indicators Table is placed first in the Framework sequence to provide strategic guidance to the design choices made surrounding the development of an energy provision enterprise's business model as they strive to comply with the sustainability criteria.
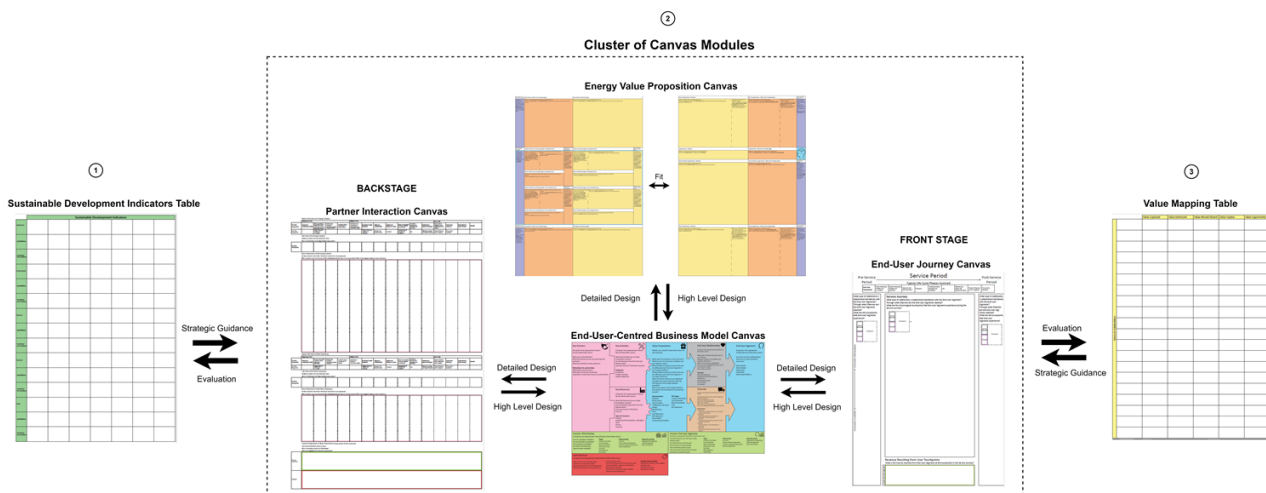


**Figure 44: Framework Overview Diagram**

Once an enterprise's Sustainable Development Indicators have been defined by the Framework users (as discussed in Section 4.3.1), idea generation of the enterprise's business model can take place through the modules in the "Cluster of Canvas Modules". Indicated through the dashed rectangle, the "Cluster of Canvas Modules" is composed of the EUC-BMC, Energy Value Proposition Canvas, Partner Interaction Canvas and End-User Journey Canvas. As discussed, the module takes a high-level design perspective on the different building blocks that make up an entire business model. If users desire to design each of the building blocks in a more detailed manner, then the Energy Value Proposition Canvas, Partner Interaction Canvas and End-User Journey Canvas can be used. The overlap of the building blocks of the EUC-BMC and the other modules in the "Cluster of Canvas Modules" is indicated through different coloured outlines corresponding to the building block colours. The choice of the modules within the "Cluster of Canvas Modules" is dependent on the level of detail design users want to take. If users want to take a high-level design perspective, then the use of the EUC-

BMC on its own would be sufficient. If users desire a detail-design perspective, then the other three modules in the "Cluster of Canvas Modules" should be used. In this case, the EUC-BMC can be used as an overview diagram to relate the detail-design modules to each other such as when the Partner Interaction Table and the End-User Journey Canvas need to be used together to determine financial viability. Finally, users may also decide to use both the EUC-BMC and any or all of the detail-design modules in the "Cluster of Canvas Modules". It should be noted that duplication of Sticky Notes would most likely occur because of the overlap of building blocks.

The populated module/modules in the "Cluster of Canvas Modules" are continually evaluated according to the Sustainable Development Indicators and their Specifications, which in turn provide strategic guidance for the module/modules in the "Cluster of Canvas Modules". The results of this evaluation are visualised in the Compliance/Non-Compliance section of the Sustainable Development Indicators Table through the same Sticky Notes colours used for Products/Services as to demonstrate clearly, to what the compliance/non-compliance evaluation is referring to. The module/module(s) in the "Cluster of Canvas Modules" are further continually evaluated against the last module of the Framework – the value-mapping table. Here, the relevant Products/Services Sticky Note colours are also used to demonstrate what Products/Services resulted in the specific multi-stakeholder value perceptions.

The value-mapping table visualises the value perceptions of multiple stakeholders. It accomplishes this by considering multiple forms of value (value created, value destroyed, value missed/absent, value surplus & value opportunity) and continually evaluating how the multiple stakeholders would perceive the value within the developed module/modules in the "Cluster of Canvas Modules". Therefore, the evaluation in the value-mapping table, in turn, provides strategic direction to the design choices made surrounding the development of an energy provision enterprise's business model.

The framework has a modular design as each module can be used on its own or in any combination with others. However, when used in its entirety, the modules work together to display all relevant trade-offs that exist in the context of this study in a single Framework.

# CHAPTER 5: FRAMEWORK VALIDATION

This chapter seeks to validate the developed Framework when applied within the context of a real-world case study. It consequently considers the results of the Enkanini community survey informing the real-world case study and the results of the evaluation survey conducted after the focus group with experts.
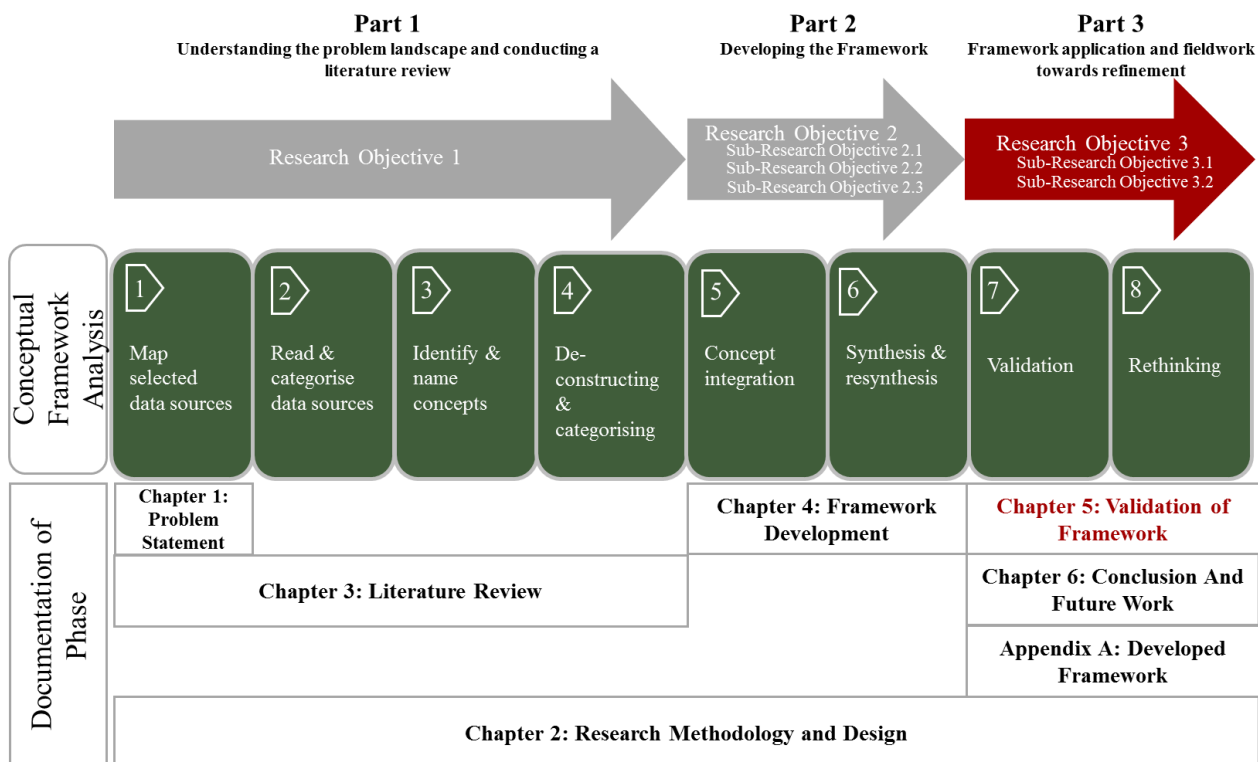


**Figure 45: Context Diagram - Chapter 5**

Figure 45 above demonstrates that Research Objective 3 will be addressed in this chapter.

## 5.1 Enkanini Community Survey Results

The aim of the community survey was to provide insight regarding the households' current energy realities (by investigating their current energy supply mix) and desires as well as their underlying reasons. The current energy supply mix of the Enkanini community is presented in Figure 46.
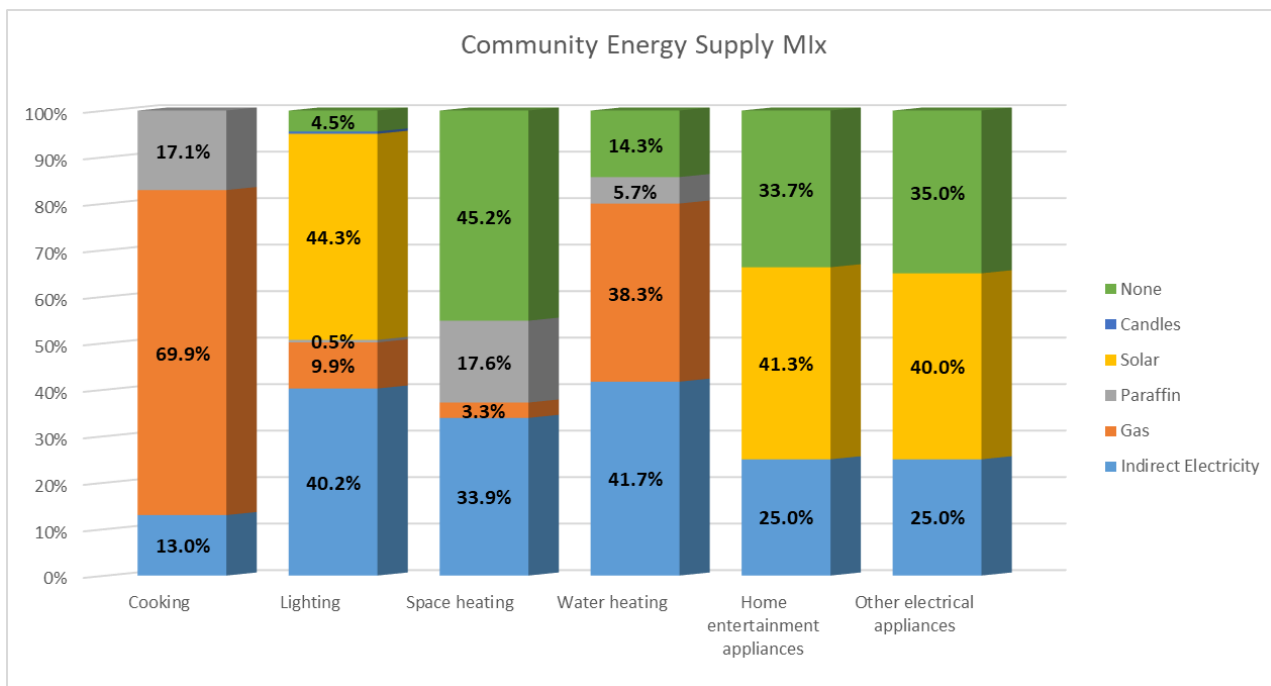
**Figure 46: Community energy supply mix for different energy services**

Energy poverty is most commonly regarded as more than 10% of household expenditure (Bazilian & Nussbaumer, 2010; Department of Energy, 2012). Table 17 demonstrates that the current energy mix results in the community as a whole to fall just below 10% of total expenditure mark with 9.9%. This result represents another aspect of the energy supply mix reality of the community.

**Table 17: Community Fuel Expenditure**

| Average Expenditure on Energy Supply Mix | Average Total Household Expenses | % of Expenditure of Total Expenses |
|---|---|---|
| ZAR 246 | ZAR 2,497 | 9.9% |

The gains and pains experienced by the community for the different energy services are listed in Table 18. In accordance with the structure of the Energy Value Proposition Canvas (section 4.3.3.3); a distinction is made between the gains and pains of the Energy Supply Form and Energy Supply Equipment and the gains and pains of the Energy-Using Products. As discussed in section 2…, the results complement the findings of Smit *et al.* (2019). The gains and pains resulting from the Smit *et al.* (2019) findings are indicated in green to distinguish between the two data sets. The gains and pains are listed according to the frequency in which they appeared in the responses with the most frequently mentioned response placed first.

**Table 18: Gains and Pains experienced within different energy services**

| | Gains Experienced | | Pains Experienced | |
|---|---|---|---|---|
| | **Energy Supply Form & Energy-Supply Equipment** | **Energy-Using Products** | **Energy Supply Form & Energy-Supply Equipment** | **Energy-Using Products** |
| **Cooking** | "it's cheap"; "lasts for a month"; "I want to use electric appliances"; "easy to find" | "it's very quick to cook"; Additionally "... good for warming my house"; "It's good for baking"; "it's safe"; "easy to use"; Doesn't smell bad; Inexpensive Energy-Using Product | Not always available; Have to travel far to purchase; Gives a bad taste to food; Not always available; Not reliable | "risk of fire"; Causes fire; "Makes chest burn" - smoke in the dwelling; "Can't see when the [energy supply] is finished"; "causes fever"; Expensive Energy-Using Product |
| **Lighting** | "Cheap and affordable"; "Lasts longer"; "Safer"; "Use when run out of another [energy source]"; "Bright"; "Easy to use"; "Use when run out of another [energy source]"; Connection is legal | "Very bright"; "No wires that can be stolen by thieves"; "Can use all appliances" | "Too expensive"; "Too expensive to install"; "Not safe" | "Dangerous"; "Risk of fire"; "Does not support all the required appliances"; "Sometimes trips" |
| **Space Heating** | "Cheap"; "Easy to use"; "Fast"; "No load-shedding"; "Lasts long"; "Easy to get"; Not fuel heavy: "does not use a lot" | "Warms house"; "Can use it to bake"; "Warms house and can cook at the same time" | "Load-shedding" | - |
| **Water Heating** | "Cheap and affordable"; "Easy to get"; "Very fast"; "Lasts long"; "Easy to use"; Used as back-up energy source | "Good for cooking and baking"; "Can use all appliances"; "Heats water"; "Fast"; "Easy to use"; "Lasts long"  Can use all electrical appliances | Access limited; "Cannot see when you will run out" | "Too expensive" |
| **Home Entertainment Appliances** | "Convenient"; "Easy to use"; "Affordable"; "Does not use much battery"; "Service is good"; "Lasts long"; "Loyal"; "Does not disappoint" | Allows usage of appliances; "Quality sound"; "Attracts customers"; "Supports all appliances" | Illegal connections unsafe; "Load-shedding"; "Only option"; "Challenges in winter"; "Not connected" | "Cannot use all appliances" |
| **Other Electrical Appliances** | "Easy to use"; "Cheap"; "Powerful"; Allows independence – don't have to bother others; "Fast" | "Appliances charge fast"; "Does not damage cell phone battery"; "Can use all appliances"; "Works with the sun" | Dependent on neighbours' supply; "Only option"; Units run out; "Load-shedding"; Cables get stolen; "Only option"; "Don't always have money" | "All my things work with electricity"; "Challenges in winter" |

The gains and pains were used to populate the End-User Profile of the Energy Value Proposition Canvas in the focus group with experts. The results of the evaluation survey after the focus group with experts are discussed below.

## 5.2 Framework Evaluation Survey Results

As discussed in Section 2.3.3.1, a rating scale ranging from 1 to 5 was used in the Framework evaluation survey. The rating scale signifies: Strongly Disagree = 1; Somewhat Disagree = 2; Neither Agree nor Disagree = 3; Somewhat Agree = 4; Strongly Agree = 5.

The evaluation survey allowed participants to evaluate to what extent they consider the modules to have addressed their intended aim (the assigned group of consolidated key concepts). In the cases where the extent to which the modules addressed their assigned group of consolidated key concepts could not be worded in a single question, more than one evaluation question was used. The tables in this section demonstrate the quantitative results from the rating responses of the participants as well as the specific concepts addressed by that specific question. Notable qualitative responses from the open-ended questions within the questionnaire will be discussed. To allow differentiation within results discussion, P1 to P5 were assigned to the different focus group participants.

### 5.2.1 Evaluation of the Framework Modules

As all participants gave a rating of 5 for Question 1.1.1 in Table 19, it demonstrates the agreement among participants that the Sustainable Development Indicators Table succeeded in addressing the consolidated key concepts. One participant affirmed the importance of using the Sustainable Development Indicators Table before the other modules by stating: "… this is the foundation for the enterprise to be built on." (P4). Another participant revealed how the Sustainable Development Indicators Table complements the EUC-BMC, as they observe: "It addresses what Business Model Canvas does not address" (P3).

Question 1.1.2 focuses on whether systems thinking are present within the design of the Sustainable Development Indicators Table. The one participant (P2) who gave a rating of 3 stated that they were "not sure". This points to the need of a longer focus group session to allow all participants to be sure whether they agree if all modules and the framework as a whole work according to its intended design. One participant affirmed the use of visualisation to determine the various trade-offs by stating: "… good to stack the various options to make them visually acceptable" (P3).

As time was limited, no time was spent on evaluating the indicators that were developed by the author (as documented in Figure 23 In Section 4.3.1). Future work can be conducted to determine if the new indicators are more appropriate to the context of energy provision in South African urban informal settlements than the indicators developed by Runsten *et al.* (2018).

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**Table 19: Sustainable Development Indicators Table evaluation**

| Concepts Addressed | Survey Question(s) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1.1)The Sustainable Development Indicators Table facilitates the following: | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | Avg. |
| Consolidated Key Concepts: Establishing enterprise evaluation criteria based on Sustainable Development | 1.1.1) Establishing sustainability criteria for an energy provision enterprise | - | - | - | - | 100% (5) | 5 |
| Key Concept: Systems Thinking | 1.1.2) Uncovering trade-offs between different sustainable development indicators | - | - | 20% (1) | 60% (3) | 20% (1) | 4 |

Question 1.2.1 in Table 20 demonstrates that one participant provided a rating of 3. This is the same participant (P2) who was unsure whether the Sustainable Development Indicators Table appropriately addressed the concept of systems thinking in Question 1.1.2. Here, the participant states, "There are more parties involved than just end-users in the total business model" (P3). This is a lack of understanding of how the EUC-BMC works as the other parties involved are appropriately indicated in the Key Partners block. P5 offered a rating of 4 and observed that the EUC-BMC "May miss some nuances in South African based business". Further investigation can be conducted to understand what South-African-specific nuances are lacking.

The lack of understanding of this module from P2 was again apparent in their 3 rating and comment of "not sure". The other participants offered ratings of 4 or 5. One participant successfully articulated how the EUC-BMC assists in systems thinking through stating: "The BMC helps us to see the entire broad business in one picture, allowing a better understanding of interrelationships. It also allows one to understand how the business will be affected as and when one block/factor changes." (P3).

**Table 20: End-User Centred Business Model Canvas evaluation**

| Concepts Addressed | Survey Question(s) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1.2) The End-User Centred Business Model Canvas (EUC-BMC) facilitates the following: | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | Avg. |
| Consolidated Key Concepts: Holistic Design of an Entire Business Model | 1.2.1) Designing an energy provision enterprise's/ initiative's entire business model on a high-level | - | - | 20% (1) | 60% (3) | 20% (1) | 4 |
| Key Concept: Systems Thinking | 1.2.2) Uncovering trade-offs between the different EUC-BMC blocks | - | - | 20% (1) | 60% (3) | 20% (1) | 4 |

For Question 1.3.1 of Table 21, three participants strongly agreed the Energy Value Proposition Canvas addresses the consolidated key concepts successfully. Comments from these participants range from: "The canvas looks at designing energy solutions in a holistic manner so definitely achieves this." (P4); to "Essential to match pains to gains…" (P3) and finally, "… very useful" (P5). P2 provided a rating of 3 and argued that the Energy Value Proposition Canvas takes an "… entrepreneurial perspective not…" a "… community perspective." As the study aims to assist enterprises, the entrepreneurial perspective is appropriate. As the time constraints led to a decreased focus on the voice of the community, the participant may feel that the community

voice is lacking. This should further be investigated in future work when conducting another focus group that allows more time.

In Question 1.3.2, all participants agreed the supporting guiding cards of Emili *et al.* (2016) worked with the Energy Value Proposition Canvas in a complimentary manner. P2 was one of the participants who offered a 5 rating and stated it was "Very helpful to have different business models to learn from."

Question 1.3.3 reveals an average rating of 4.4 from the participants as P2 also found the guiding cards designed by the author as "… very helpful…". P3 offered a rating of 3, as they suggested the guiding cards could be designed to incorporate local conditions. Offering guidance (through guiding cards) to energy provision enterprises as to how the local conditions could be considered can be investigated in future work. The guiding cards were however updated to correspond to a similar structure to that of PSS types of Tukker (2004) - product-oriented, use-oriented and result-oriented PSSs (discussed in section 3.6.1). This structure allows for increased usability of the cards.

**Table 21: Energy Value Proposition Canvas evaluation**

| Concepts Addressed | Survey Question(s) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1.3) The Energy Value Proposition Canvas facilitates the following: | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | Avg. |
| Consolidated Key Concepts: Designing Solutions Desirable to End-Users | 1.3.1) The Energy Value Proposition Canvas facilitates the designing of energy solutions and related value-adds that would be desirable to end-users | - | - | 20% (1) | 20% (1) | 60% (3) | **4.4** |
| Supporting guiding cards that were used | 1.3.2) The Energy Value Proposition Canvas and the guiding cards of Emili, Cheschin and Harrison (2016) worked together in a complementary manner | - | - | - | 20% (1) | 80% (4) | **4.8** |
| Guiding cards developed by the author | 1.3.3) The supporting cards designed by the researcher were useful in the generation of ideas in the Energy Value Proposition Canvas | - | - | 20% (1) | 20% (1) | 60% (3) | **4.4** |

Question 1.4.1 in Table 22 reveals that all participants agreed that the Partner Interaction Canvas addresses the consolidated key concepts. Both P3 and P4 emphasise the importance of considering multiple stakeholders across the solution life cycle. P3 argues "Stakeholders are very important here since this is a people-heavy process." And P4 supports that "This is a very important approach".

The majority of participants believe that the Partner Interaction Canvas allows solution feasibility to be determined. P2 provided a 5 rating and stated that "After this, you will have a good indication if the business model might be too ambitious or not." This statement demonstrates the participant's correct understanding of the module. P3, however, contends that they do not believe that "… partners alone can determine feasibility or not - there are many more factors." The statement ties in with P3's suggestion in Question 1.3.3 that

advocated for the consideration of local conditions. Other factors, such as local conditions, should be investigated to determine if they should be considered for establishing a solution's feasibility.

Question 1.4.3 represents the only question in the survey where no participants provided a rating of 5. P1 provided a rating of 3 but did not offer an explanation for their rating. The other participants agreed that the module (in conjunction with the End-User Journey Canvas), allows financial viability to be determined, albeit "High level alone, not in detail" (P3). Future work can be conducted to identify how a more detailed analysis of the enterprise's financial can be determined (such as a bespoke balance sheet).

**Table 22: Partner Interaction Canvas evaluation**

| Concepts Addressed | Survey Question(s) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1.4) The Partner Interaction Canvas facilitates the following: | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | Avg. |
| Consolidated Key Concepts: Designing Solutions Desirable to End-Users | 1.4.1) Considering partner co-creation throughout the solution life cycle | - | - | - | 80% (4) | 20% (1) | **4.2** |
| Key Concept: Feasibility | 1.4.2) Determining the feasibility of the solution(s) i.e. whether the solution(s) can be built/developed | - | - | 20% (1) | 20% (1) | 60% (3) | **4.4** |
| Key Concept: Viability | 1.4.3) Determining (in conjunction with the End-User Journey Canvas) the financial viability of the energy provision enterprise/initiative | - | - | 20% (1) | 80% (4) | - | **3.8** |

Question 1.5.1 in Table 23 reveals that all participants strongly agree that the End-User Journey Canvas addressed the consolidated key concepts, with P4 stating that they consolidated key concepts grouping was addressed "… very effectively… ".

**Table 23: End-User Journey Canvas evaluation**

| Concepts Addressed | Survey Question(s) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1.5) End-User Journey Canvas facilitates the following: | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | Avg. |
| Consolidated Key Concepts: Life Cycle End-User Co-creation of the Front Stage | 1.5.1) Designing the various touchpoints with End-Users before, during and after the service journey | - | - | - | - | 100% (5) | 5 |

The consolidated key concepts grouping of the Value Mapping Table is made up of three key concepts. As per the question design of Bocken, Fil & Prabhu (2016), the different key concepts are addressed in separate questions in Table 24 as to not load a single question with multiple variables.

All participants provided a rating of 5 in their response to Question 1.6.1. P3 endorsed the consideration of multiple stakeholders as the module "… helps to spot the barriers ahead of time."

The average rating of 4.6 for Question 1.6.2 points to the agreement of all participants that the module allows for identifying multiple forms of value. P3 affirms the consideration of multiple forms of value for multiple

stakeholders as the "[creation of] lasting value is essential to sustainability and business survival." The different forms of value of the different stakeholders could be complementary as some may have Value Surplus and some Value Absence.

The majority of participants provided a rating of 4 for Question 1.6.3. P3 affirms the use of visualising trade-offs when considering multiple forms of value for multiple stakeholders by stating that it "… is important in the RSA context [as] relationships are key." The ability to visualise the trade-offs in multiple stakeholder value allows a conversation to take place of how positive value can be maximised for all and negative value minimised. Considering the various trade-offs and the effect on the different stakeholders allows cohesive relationships.

**Table 24: Value Mapping Table evaluation**

| Concepts Addressed | Survey Question(s) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1.6) The Value Mapping Table facilitates the following: | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | Avg. |
| Key Concepts: Multi-Stakeholder Engagement | 1.6.1) Including the perspective of multiple actors and stakeholders | - | - | - | - | 100% (5) | 5 |
| Key Concept: Multiple forms of value | 1.6.2) Identification of various forms of value (positive or negative) within the developed value proposition | - | - | - | 40% (2) | 60% (3) | 4.6 |
| Key Concept: Systems Thinking | 1.6.3) Uncovering trade-offs concerning value for multiple stakeholders | - | - | - | 80% (4) | 20% (1) | 4.2 |

### 5.2.2 Evaluation of the Framework

As discussed in section 1.3, "The aim of the study is to develop a framework that facilitates the development of a sustainable PSS business model for energy provision enterprises in a South African urban informal context." Question 2.1 in Table 25 considered whether the developed modules were, in fact, the correct modules to use to achieve the aim of this study. All participants answered "Yes" to this question. It would therefore suggest that future work should be limited to the improvement of the developed modules as they are sufficient within the study's context. P1 recommends that the Framework be "… used in a very iterative way so that the chosen business model can be tested an adapted quickly and regularly."

**Table 25: Module Composition evaluation**

| Concepts Addressed | Survey Question | | |
|---|---|---|---|
| | | Yes | No |
| Combination of Framework modules | 2.1) Are the different Framework modules the correct modules to use for the development of a sustainable Product-Service System (PSS) business model for an energy provision enterprise in a South African urban informal context? | 100% (5) | - |

Question 2.2 is phrased in the same manner in which Emili, Cheschin and Harrison (2016) phrased a question to evaluate the clarity and usability of their developed framework. If the relationships between the modules are clear, the Framework is easier to use and thus systems thinking (through the consideration of various trade-offs) is improved. P2 offered a rating of 3 and acknowledged that "there was a lot going on in a short amount of time." which made the Framework "… difficult to follow at some point.". As discussed earlier, future work can be conducted to determine the suitable amount of time needed for a focus group to systematically go through all the modules of the Framework, ensuring understanding from all participants. P3 called for "… bolder colours.". The blue colour within the Value Proposition Canvas- and End-User Segments building blocks is changed to be brighter. This allowed the blue outlines within the Energy Value Proposition Canvas to be brighter and thus the connection between the two modules clearer. P5 offered a rating of 5 and praised the Framework for taking a "Nice approach to clearly articulate overlap."

**Table 26: Framework usage evaluation**

| Concepts Addressed | Survey Question | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Avg. |
| Clarity, usability and systems thinking | 2.2) Do you agree with the following statement: The different relationships of the modules to one another are clear? | - | - | 20% (1) | 60% (3) | 20% (1) | **4** |

Question 2.3 specifically addresses to what extent the Framework corresponds to the intended aim of the research study. P2 offered a rating of 3 as they would like to first "… see it applied and the outcome implemented…" in the real-world before offering an evaluation. A real-world implementation falls outside the scope of this study and could be considered for future work. P4 supported the Framework design by stating that "…the framework definitely helps with thinking through energy solutions for low-income households and also very importantly addresses implementation so is not an entirely theoretical exercise."

**Table 27: Study Aim evaluation**

| Concept Addressed | Survey Question | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Avg. |
| Aim of the study | 2.3) Do you agree with the following statement: The Framework facilitates the development of a sustainable Product-Service System (PSS) business model for an energy provision enterprise in a South African urban informal context? | - | - | 20% (1) | 20% (1) | 60% (3) | **4.4** |

Question 2.4 asked participants "How can the Framework be improved for the South African urban informal, energy access context?" The responses of the participants are summarised as:

- Create a simplified version of the Framework as an introductory framework to users (P1 and P3)
- Incorporate the end-users' opinion and experience more (P2)
- Consider end-users' ability to pay (P5)

A simplified version could be designed in the future to assist users in understanding the Framework better. Similarly, the consideration of end-users' voice, experience and ability to pay can be studied.

### 5.2.3   Concluding remarks

Although the time allocated for the focus group was constrained, the participants could see the promising value that the Framework has to offer when implemented in a real-world context. As discussed, in all the questions using a five-point Likert scale, the Framework did not receive a rating below that of a 3 (Neither Agree nor Disagree). As discussed, Question 1.4.3 was also the only question where no participant provided a rating of 5 (Strongly Agree). Finally, Question 2.3 addressed whether the Framework corresponds to the intended aim of the study. The average rating of 4.4 offered by participants signifies its suitability to the context of this study.

Chapter 6 will provide the conclusions, limitations and recommendations of the study.

# CHAPTER 6:   CONCLUSION AND RECOMMENDATIONS

This study aimed to develop sustainable product-service system business models for energy provision in South African urban informal settlements. Three secondary objectives were formulated in order to achieve the primary objective of the study. The research was conducted in three parts. In Part 1, an in-depth narrative literature review established the problem landscape and provided the main concepts of the topic. In Part 2, the framework was developed using concept integration and grouping, as well as synthesising and resynthesising the available information. Part 3 focused on a case study analysis as validation of the developed framework.

This chapter presents the conclusions on the findings of the research, possible limitations of the study are described, and recommendations for future research are made.
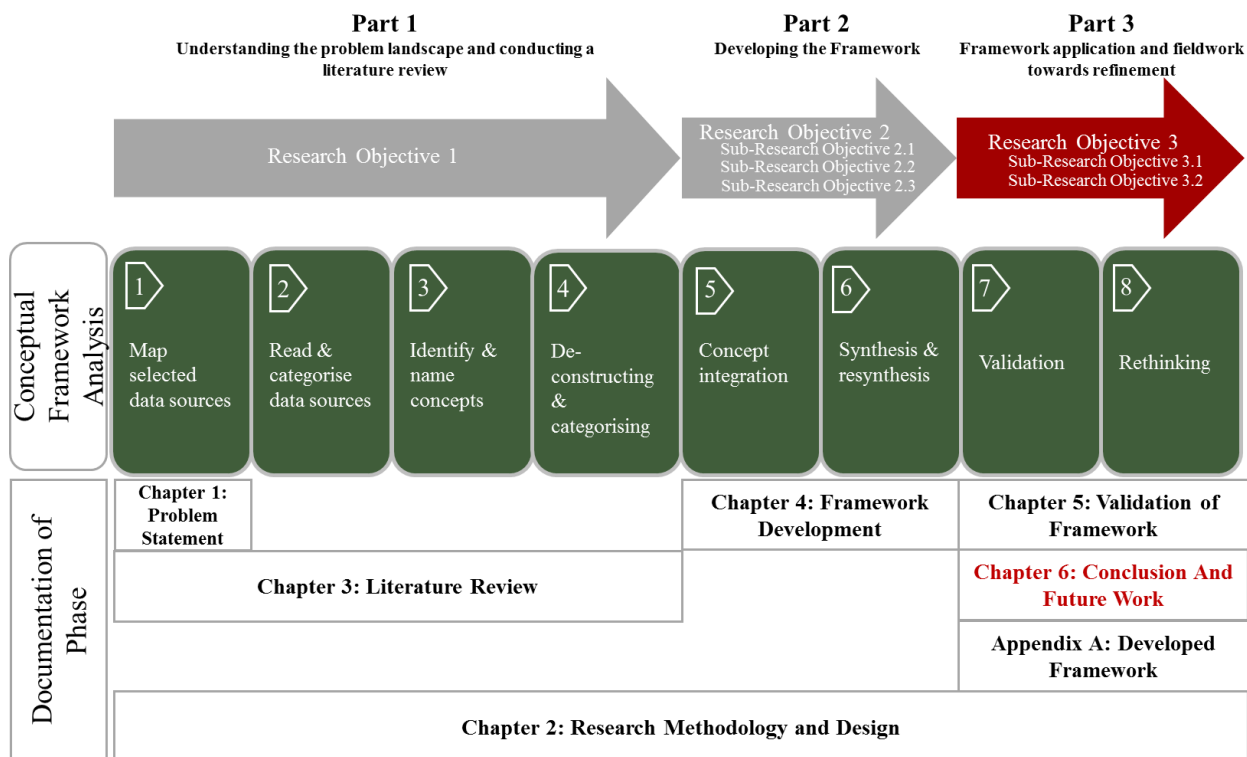


**Figure 47: Context Diagram - Chapter 6**

The context diagram in Figure 47 above, demonstrates that this chapter falls under part 3 of the research study. Step 8, rethinking, will specifically be addressed in this chapter.

## 6.1   Research Summary

This section presents a summary of the main research findings, according to the three-part research structure introduced in Chapter 2. The first two parts used existing data, and the third part consisted of a case study analysis.

This research study set out to design a framework that would be able to facilitate the development of a sustainable PSS business model for energy provision enterprises in a South African urban informal context. In order to achieve this, the study set out to achieve three objectives, which are set within three parts of the research design.

The first objective was to evaluate the context of energy provision in South African urban informal settlements with the aim of identifying concepts emerging out of the literature. The second objective was to deduce a framework to assist in developing sustainable PSS business models in the South African urban informal context. Finally, the third objective was to verify and validate the developed framework in the context of a specific case study.

A summary of how these research objectives were achieved is discussed in detail below.

### 6.1.1   Part 1

This part of the research study aimed to address the first research objective:

> *Research Objective 1: Evaluate the context of energy provision in South African urban informal settlements with the aim of identifying concepts emerging out of the literature*

As to not violate the tenets of induction, a narrative literature review was conducted in which the researcher adopted an interpretive theoretical perspective in the form of grounded theory. Insights were gained through both engaging with researchers and practitioners from multiple disciplines, working in the South African urban informal context; and continuously reviewing literature. This flexible approach of continuously shifting the focus of a research study as new insights are gained, allowed the researcher to frame a problem statement that was responsive to the real-world context of South African urban informal settlements.

The narrative literature review first provided insight into the context of urban informal settlements in South Africa and the resulting energy poverty gap. To ensure that this study aligned with sustainability and consequently, the SDGs, a high-level overview of sustainability was provided. Following the overview, four different bodies of the literature were analysed: energy access, the base of the pyramid (BOP), business models and product-service systems (PSS). Specific concepts correlating to sustainability were also identified in each of these bodies of literature (see Figure 11).

Chapter 3 ensued with an extensive literature review of four bodies of knowledge. These were energy access; low-income contexts (BOP); business models and PSS. The main concepts correlating to sustainability in each of these bodies of knowledge were identified and provided with a description.

The literature review confirmed there is no agreed-upon universal definition of energy access. Energy access statistics worldwide is predominantly focused on whether households have access to grid electrification or not (Clements *et al.* 2019). This focus on a grid connection does not allow off-grid technologies such as solar mini-kits, solar home systems and mini-grids as part of the energy access statistics. Therefore, this study supports

the move away from a binary view of energy access to allow all types of energy interventions to be considered as contributors to improved energy access.

The main concepts of sustainable energy access reflected in the literature review are sustainable energy development; development measurement criteria; bottom-up planning; usability of energy; multi-stakeholder engagement.    This entailed evaluating sustainable development across social, economic, environmental, institutional and technological factors. It demanded an understanding of the end-users needs and desires, but also the ability to supply and energy service with the potential to meet these needs and desires. Finally, this required an understanding of the indicators of sustainable development as enterprise development evaluation criteria and the many stakeholders involved as well as their roles and responsibilities.

BOP refers to the largest but poorest socio-economic groups in the global income pyramid working in predominantly informal markets. In the South African context, this can be translated to those who live on less than ZAR20 a day, representing over 25 per cent of the South African population. The BOP is also characterised by lack of access to basic services such as education, sanitation, energy provision and public health. Chapter 3 indicated the following main concepts for BOP: desirability; feasibility; viability; consideration of sustainability; multi-stakeholder collaboration. This means the solutions would have to be attractive to the end-users whilst still being possible from a technical and organisational as well as financial perspective. The solutions would also have to be scalable to millions of people and involve multiple stakeholders to overcome barriers.

Although the term business model has been used commonly in the literature, scholars have not agreed on a single definition. For this study, Osterwalder and Pigneur's (2014) description of a business model as the rationale of how an organisation creates, delivers, and captures value is used. Sustainable business models yielded five main concepts. The first concept is a sustainable business strategy that is incorporated into the business. The second concept sets out TBL indicators as evaluation criteria for sustainability. The third concept is creating a multi-stakeholder collaboration that ensures positive solutions for all. The fourth concept regards the system as a whole, with its interrelated relationships between elements in order to evaluate multiple options. The fifth concept reflects on the different forms of value from the stakeholders' viewpoints.

PSS is described as a system of products, service, supporting networks and infrastructure designed to be competitive, satisfy customers' needs and have a lower environmental impact than traditional business models. Chapter 3 revealed several main concepts for sustainable product-service systems. These main concepts are product and service combinations; jobs-to-be-done; new modes of ownership; consideration of sustainability; life cycle thinking; multi-stakeholder engagement; customer co-creation. These concepts translate into solutions that offer a mixture of tangible products and intangible services. It contemplates the tasks that require completion from the customer's outlook and the impacts on the TBL dimensions of sustainability. Product ownership and timelines of ownership transfers are considered as well as the contributions of multiple stakeholders that assist in creating and delivering PSS solutions. Finally, the literature showed that an offer's

entire life cycle and its corresponding sub-processes need to viewed holistically and should involve customers in the multiple phases of the PSS life cycle.

Part 1 of the study addressed research objective 1, provided contextualisation and a firm theoretical foundation for the research study.

### 6.1.2   Part 2

This part of the research study aimed to address all the sub-objectives of the second research objective:

*Research Objective 2: Deduce a framework to assist in the development of sustainable PSS business models in the South African urban informal context*

> *Sub-Objective 2.1: Reduce the number of concepts (identified in Objective 1) by integrating and grouping the different concepts together*
> *Sub-Objective 2.2: Identify current tools available in literature and evaluate their adequacy in the context of this study*
> *Sub-Objective 2.3: Develop a framework (based on the evaluation findings of Sub-Objective 2.2) that adequately addresses the reduced concepts of Sub-Objective 2.1*

Chapter 4 commenced with a visualisation of how the different concepts identified in Chapter 3 were reduced through a process of integration and grouping, to eventually form a reduced number of concepts - named consolidated key concepts. These multiple main concepts are condensed to customer's value co-creation; multi-stakeholder engagement; consideration of various forms of value and triple bottom line. The reduction of multiple concepts discovered in Chapter 3 addressed sub-objective 2.1. Figure 21 further demonstrated the relationship between consolidated key concepts, modules and the Framework.

The next sub-objective 2.2 was also brought to light through systematically identifying and evaluating tools existing in the literature. Similar to Emili (2017), the tools were evaluated according to their strengths and weaknesses in the context of this research study.

The insights gained from these strengths and weaknesses evaluations are used to design the different modules of the Framework, with some modules having additional guiding cards. The chapter resumes by discussing the adequacy of each developed module to address the concepts assigned to them. Section 4.4 communicates the logic through the Framework overview diagram (Figure 44) and consequently expresses the achievement of sub-objective 2.3.

### 6.1.3   Part 3

This part of the research study aimed to address all the sub-objectives of the third research objective:

> *Research Objective 3: Verify and validate the developed framework in the context of a specific case study*
>
> > *Sub-Objective 3.1: Determine the energy supply mix realities and desires of households within urban informal settlements, using a specific case study*
> >
> > *Sub-Objective 3.2: Validate the developed framework with experts in industry, using a specific case study and formulate an adapted framework*

The Enkanini settlement was chosen as a case study that allowed the Framework to be investigated within a real-world context. To be able to provide an alternative energy supply solution to the Enkanini community, an energy provision enterprise requires insight into the community's energy supply mix realities and desires. Through a paper-based questionnaire that was administered by field researchers, insight was gained into households' current energy reality through understanding their energy supply mix. It was found that on average, a household spends 9.9% of their total monthly expenses on their energy supply mix – a number dangerously close to the 10% threshold where households are conventionally classified as energy poor.

To gain a deeper understanding of a household's current energy supply realities and desires, a range of open-ended, why-probing questions were asked in the questionnaire. The why-probing questions allowed households to voice the underlying reasons behind their current- and desired energy supply mix as well as the reasons for running out of energy supply sources for specific energy services. To correspond to the logic used in the Framework (specifically the Energy Value Proposition Canvas - section 4.3..), the reasons provided by the community were categorised according to whether they inform the "gains" or "pains" of their current or desired energy supply mix.

It was found that, by segmenting the community survey data into three different groups, the focus group results of Smit *et al.* (2019) could complement this study's gains and pains results. The segmentation entailed grouping the households according to their energy profile, which resulted in three different groups: indirect electricity users, solar electricity users and divergent energy users (those who do not use indirect electricity or SHSs). As the energy realities of the different energy groups are illustrated, the combination of data sets makes a nuanced contribution to the body of knowledge. The gains and pains results of the different energy groups are documented in Appendix E.2. To further represent the three different energy groups, the energy supply mix for the three energy groups, along with their monthly energy supply expense can also be seen in Appendix E.1.

To inform the Framework from the bottom-up, the gains and pains results of the different energy groups were combined to represent the Enkanini as a single market segment, reducing complexity for new users of the tool. The combined gains and pains results are listed in section 5.1.2. These results, along with the energy supply mix results allow sub-objective 3.1 to be met.

To achieve sub-objective 3.2, a focus group was conducted with experts in the energy sector as the Framework was applied to a real-world case study (Enkanini). Although there was limited time allocated for the focus group session, the Framework was successful in facilitating the participants to develop of a sustainable PSS

business model for a hypothetical enterprise. After the focus group, an electronic survey allowed the participants to evaluate the various components of the Framework (predominantly using a five-point Likert scale).

Key findings of the Framework evaluation survey revealing its suitability to the context of the study were:

- Not one of the ratings offered to the participants were below that of a 3 (Neither Agree nor Disagree)
- A rating of 5 (Strongly Agree) was received from at least one participant at each question - except one question (Question 1.4.3) which examined how well the Framework provides an indication of financial viability
- An average rating of 4.4 was provided by participants when asked if the Framework achieved the aim of this research study

It can be concluded that, in the time-constrained focus group session, participants could see the promising value that the Framework has to offer to a real-world implementation. The qualitative responses provided by the participants were used to make appropriate adaptations to the Framework, consequently addressing sub-objective 3.2. As all adaptations were minor, they were worked into the Framework and discussed in Chapter 4.

## 6.2  Study Limitations

There are certain limitations that should be acknowledged and taken into consideration when interpreting the findings of this study.

Limitations, as discussed in Section 1.5:

- Energy provision for productive activities related to enterprises and energy for community facilities such as street lighting and buildings was not considered as the Framework was developed to be specific to energy provision for households
- The study focused on the South African urban informal context and made use of a single case study in Stellenbosch - Enkanini. Therefore, the results of the study are not generalisable to other urban informal communities.
- The developed framework is used in a focus group setting where theoretical solutions for the Enkanini case study were designed. The use of the Framework in developing solutions with the goal of real-world implementing falls outside the scope of this study

Other limitations of the study include:

- As per the constructivist epistemological stance and interpretivist theoretical perspective that was adopted by this study, the identified concepts and the integration and grouping of concepts are subject to the researcher's bias of interpretation

- The bias of interpretation should further be acknowledged when the participant's own words could not be used, resulting in the researcher translating the various qualitative results of the community survey into pains and gains

- The focus group conducted with experts in the energy sector was limited to a four-hour session. The session, consequently, did not allow for the different modules of the Framework to be completed in detail

- Although the focus group participants offered a wealth of knowledge and experience in the South African urban informal context, the focus group lacked participation of those in local and national government, manufacturing, large corporates and targeted community residents

The following section provides recommendations for future studies. Some of the recommendations for future studies are derived from the limitations set out in this section.

## 6.3  Future Study Recommendations

Future works resulting from the limitations include:

- Further work is necessary to adapt the Framework or create separate, complementary frameworks to consider both energy provision for productive activities related to enterprises as well as energy for community facilities such as street lighting and buildings

- Since informal settlements typically arise because of governmental incapacity to serve a growing urban population, other countries in the developing world are likely to experience the housing and grid electrification challenges of South Africa. The Framework can be adapted according to the specific country's requirements

- Further research is necessary to determine a suitable number of focus groups and time allocation in each focus group to allow the systematic population of all the modules of the Framework, ensuring understanding from all participants

- Future studies should emphasise the inclusion of the local governments, manufacturers, large corporates (such as banks and insurers) and targeted community residents

## 6.4 Concluding Remarks

Although South Africa has often been classified as an upper-middle-income country, the profound socio-economic inequalities are evident in the rural and urban informal settlements. It is estimated that 10 per cent of the population live in informal settlements. Roughly, 4 million people live in urban informal settlements without access to energy services and experiencing unique challenges and difficult circumstances (Daily Maverick, 2019). Providing sustainable energy services to these highly dynamic and largely unpredictable communities have been met with several challenges and market barriers. The government has been unable to provide sustainable energy services to these marginalised communities. New urban planning and service delivery policies need to be developed, as previous top-down policies for energy provision are not feasible anymore. It has been suggested that by considering sustainability, multi-stakeholder collaboration and end-user desirability, PSS business models could offer a promising solution to the market barriers in the urban informal context. With this in mind, this research study was undertaken with the explicit desire to develop a tool to consider the multiple trade-offs within the urban informal context to allow the development of a sustainable PSS business model. It is hoped that a PSS business model that is end-user friendly will contribute to providing sustainable energy services to urban informal settlements in order to alleviate poverty and improve human development.

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# APPENDIX A: DEVELOPED FRAMEWORK

Figure A.1 below provides context to where Appendix A fits into the study.
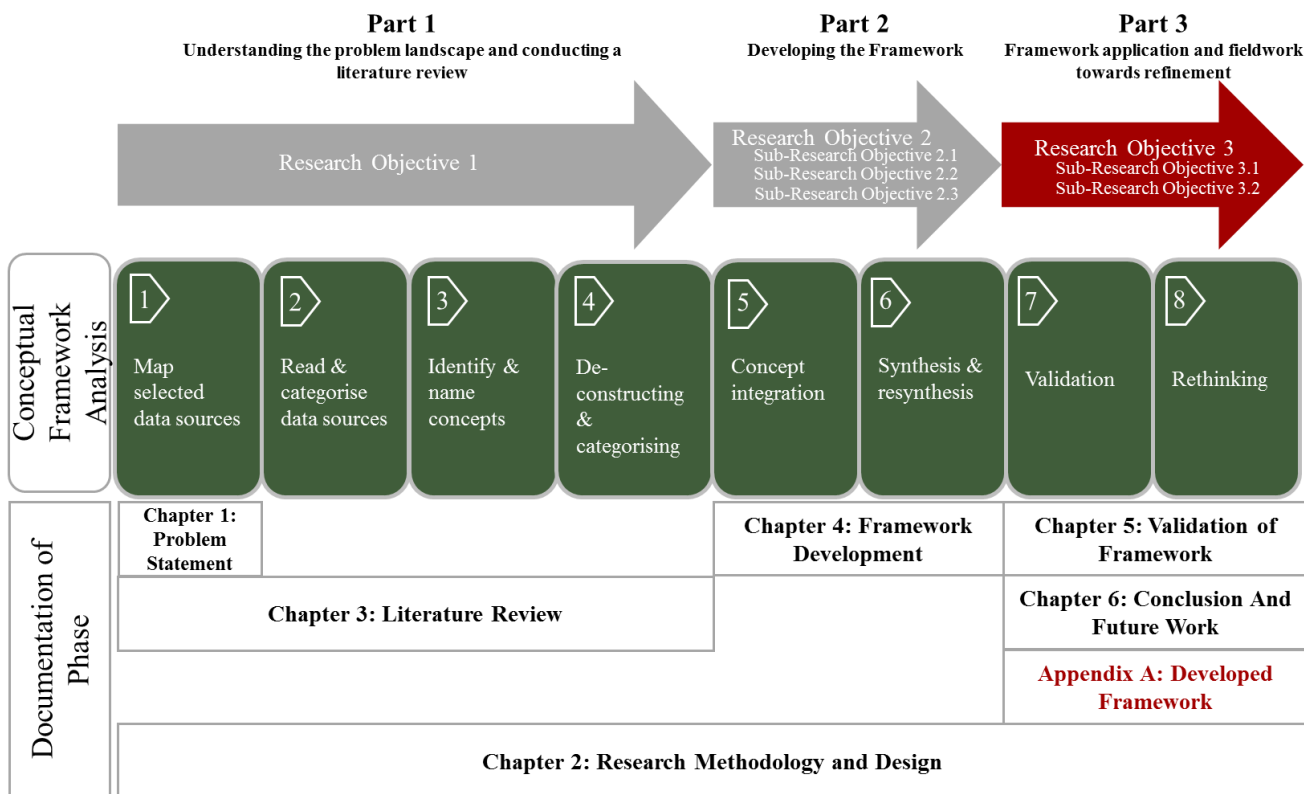


**Figure A.1: Context Diagram - Appendix A**

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| Sustainable Development Indicators | | | | | | |
|---|---|---|---|---|---|---|
| Institutional | | | | | | |
| Indicator Specifications | | | | | | |
| Indicator Compliance/ Non-compliance | | | | | | |
| Environmental | | | | | | |
| Indicator Specifications | | | | | | |
| Indicator Compliance/ Non-compliance | | | | | | |
| Technical | | | | | | |
| Indicator Specifications | | | | | | |
| Indicator Compliance/ Non-compliance | | | | | | |
| Economic | | | | | | |
| Indicator Specifications | | | | | | |
| Indicator Compliance/ Non-compliance | | | | | | |
| Social | | | | | | |
| Indicator Specifications | | | | | | |
| Indicator Compliance/ Non-compliance | | | | | | |

**Figure A.2: Sustainable Development Indicators Table (printed portrait on A1 size paper)**

126
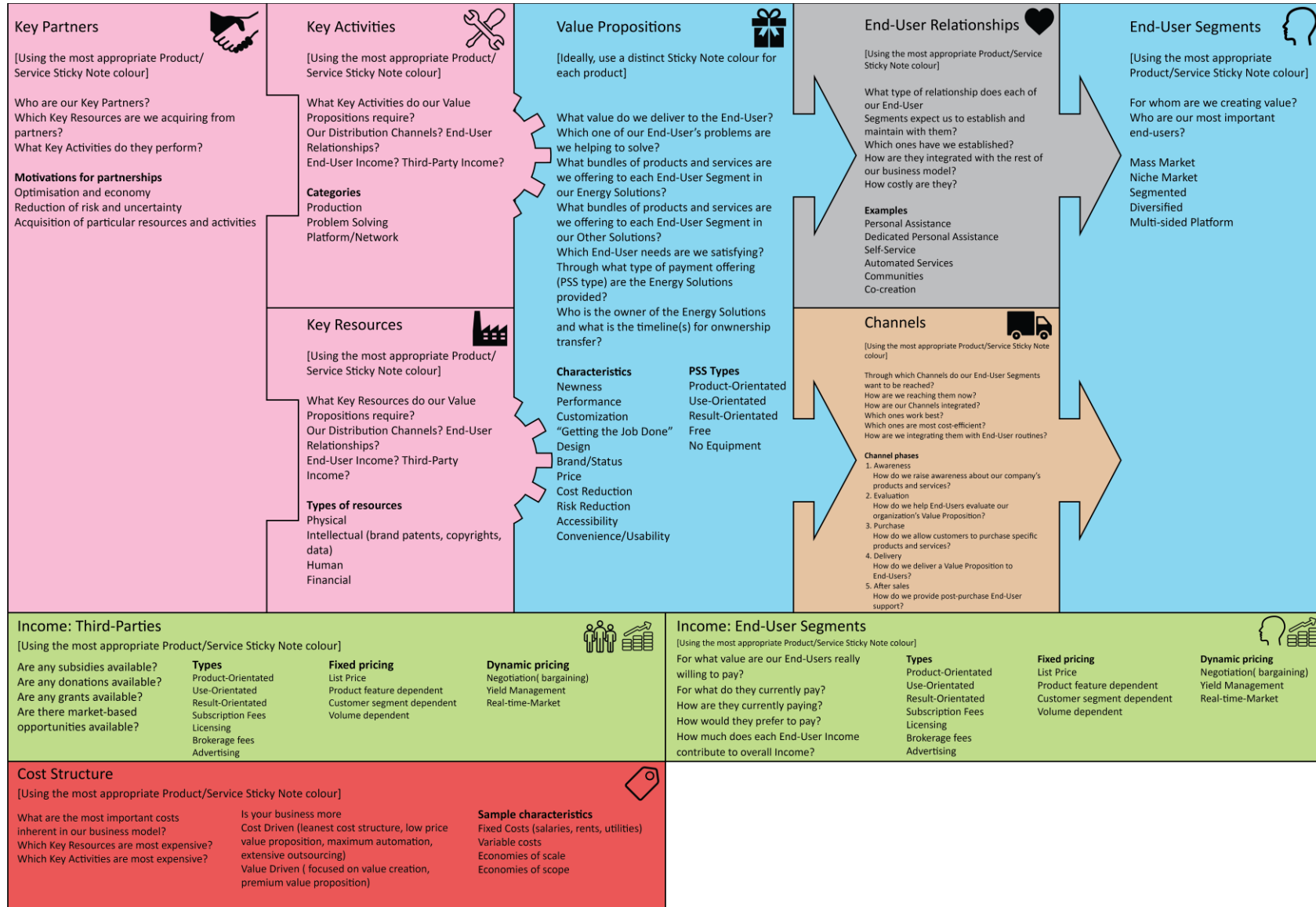
**Figure A.3: End-User-Centred Business Model Canvas (EUC-BMC) (printed landscape on A1 size paper)**

## Key Partners

[Using the most appropriate Product/ Service Sticky Note colour]

Who are our Key Partners?
Which Key Resources are we acquiring from partners?
What Key Activities do they perform?

**Motivations for partnerships**
Optimisation and economy
Reduction of risk and uncertainty
Acquisition of particular resources and activities

## Key Activities

[Using the most appropriate Product/ Service Sticky Note colour]

What Key Activities do our Value Propositions require?
Our Distribution Channels? End-User Relationships?
End-User Income? Third-Party Income?

**Categories**
Production
Problem Solving
Platform/Network

## Key Resources

[Using the most appropriate Product/ Service Sticky Note colour]

What Key Resources do our Value Propositions require?
Our Distribution Channels? End-User Relationships?
End-User Income? Third-Party Income?

**Types of resources**
Physical
Intellectual (brand patents, copyrights, data)
Human
Financial

## Value Propositions

[Ideally, use a distinct Sticky Note colour for each product]

What value do we deliver to the End-User?
Which one of our End-User's problems are we helping to solve?
What bundles of products and services are we offering to each End-User Segment in our Energy Solutions?
What bundles of products and services are we offering to each End-User Segment in our Other Solutions?
Which End-User needs are we satisfying?
Through what type of payment offering (PSS type) are the Energy Solutions provided?
Who is the owner of the Energy Solutions and what is the timeline(s) for ownership transfer?

| **Characteristics** | **PSS Types** |
| --- | --- |
| Newness | Product-Orientated |
| Performance | Use-Orientated |
| Customization | Result-Orientated |
| "Getting the Job Done" | Free |
| Design | No Equipment |
| Brand/Status | |
| Price | |
| Cost Reduction | |
| Risk Reduction | |
| Accessibility | |
| Convenience/Usability | |

## End-User Relationships

[Using the most appropriate Product/Service Sticky Note colour]

What type of relationship does each of our End-User
Segments expect us to establish and maintain with them?
Which ones have we established?
How are they integrated with the rest of our business model?
How costly are they?

**Examples**
Personal Assistance
Dedicated Personal Assistance
Self-Service
Automated Services
Communities
Co-creation

## Channels

[Using the most appropriate Product/Service Sticky Note colour]

Through which Channels do our End-User Segments want to be reached?
How are we reaching them now?
How are our Channels integrated?
Which ones work best?
Which ones are most cost-efficient?
How are we integrating them with End-User routines?

**Channel phases**
1. Awareness
   How do we raise awareness about our company's products and services?
2. Evaluation
   How do we help End-Users evaluate our organization's Value Proposition?
3. Purchase
   How do we allow customers to purchase specific products and services?
4. Delivery
   How do we deliver a Value Proposition to End-Users?
5. After sales
   How do we provide post-purchase End-User support?

## End-User Segments

[Using the most appropriate Product/Service Sticky Note colour]

For whom are we creating value?
Who are our most important end-users?

Mass Market
Niche Market
Segmented
Diversified
Multi-sided Platform

**Figure A.4: End-User-Centred Business Model Canvas (EUC-BMC) – Top Section**

**Income: Third-Parties**

[Using the most appropriate Product/Service Sticky Note colour]

Are any subsidies available?
Are any donations available?
Are any grants available?
Are there market-based opportunities available?

**Types**
Product-Orientated
Use-Orientated
Result-Orientated
Subscription Fees
Licensing
Brokerage fees
Advertising

**Fixed pricing**
List Price
Product feature dependent
Customer segment dependent
Volume dependent

**Dynamic pricing**
Negotiation( bargaining)
Yield Management
Real-time-Market

**Income: End-User Segments**

[Using the most appropriate Product/Service Sticky Note colour]

For what value are our End-Users really willing to pay?
For what do they currently pay?
How are they currently paying?
How would they prefer to pay?
How much does each End-User Income contribute to overall Income?

**Types**
Product-Orientated
Use-Orientated
Result-Orientated
Subscription Fees
Licensing
Brokerage fees
Advertising

**Fixed pricing**
List Price
Product feature dependent
Customer segment dependent
Volume dependent

**Dynamic pricing**
Negotiation( bargaining)
Yield Management
Real-time-Market

**Cost Structure**

[Using the most appropriate Product/Service Sticky Note colour]

What are the most important costs inherent in our business model?
Which Key Resources are most expensive?
Which Key Activities are most expensive?

Is your business more
Cost Driven (leanest cost structure, low price value proposition, maximum automation, extensive outsourcing)
Value Driven ( focused on value creation, premium value proposition)

**Sample characteristics**
Fixed Costs (salaries, rents, utilities)
Variable costs
Economies of scale
Economies of scope

**Figure A.5: End-User-Centred Business Model Canvas (EUC-BMC) – Bottom Section**

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| Gain Creators: Other Offerings & Value-Adds | Gain Creators: Other Forms of Energy Supply | Gain Creators: Electricity Supply |
|---|---|---|
| [Using the most appropriate Product/ Service Sticky Note colour] What are the **Gain Creators** your **Other Solution(s)** provide when trying to get an Other job done? | [Using the most appropriate Product/ Service Sticky Note colour] What are the **Gain Creators** your **Energy Solution(s)** provides when trying to get a job done within Energy Services? | [Using the most appropriate Product/ Service Sticky Note colour] What are the **Gain Creators** your **Energy Solution(s)** provides when trying to get a job done within Energy Services? |

**Products & Services: Other Offerings & Value-Adds**

[Ideally, use a distinct Sticky Note colour for each Product] What are the **Products** and **Services** involved in the **Other Solution(s)**?

**Products: Other Forms of Energy Supply - Renewable Sources**

[Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy Supply Forms, Energy Sources, Energy Supply Equipment and Energy Supply Equipment Delivery Systems** involved in the Energy Solution(s)?

[Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy-Using Products** involved in the Energy Solution(s)?

**Offer(s): Other Forms of Energy Supply - Renewable Sources**

[Using the most appropriate Product Sticky Note colour] Through what **type of payment offering** is the Energy Supply Equipment and/or Energy-Using Products provided? Who is the **owner** of the Energy Supply Equipment and/or Energy-Using Products and what are the **timelines for ownership transfer**?

**Products: Electricity Supply - Renewable Sources**

[Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy Supply Forms (AC or DC electricity), Energy Sources and Energy Supply Equipment and Energy Supply Equipment Delivery Systems** involved in the Energy Solution(s)?

[Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy-Using Products** involved in the Energy Solution(s)?

**Offer(s): Electricity Supply - Renewable Sources**

[Using the most appropriate Product Sticky Note colour] Through what **type of payment offering** is the Energy Supply Equipment and/or Energy-Using Products provided? Who is the **owner** of the Energy Supply Equipment and/or Energy-Using Products and what are the **timelines for ownership transfer**?

**Services: Other Forms of Energy Supply - Renewable Sources**

[Using the most appropriate Product Sticky Note colour if the Service is specific to a Product] What are the **Services** involved in the Energy Solution(s)?

**Services: Electricity Supply - Renewable Sources**

[Using the most appropriate Product Sticky Note colour if the Service is specific to a Product] What are the **Services** involved in the Energy Solution(s)?

**Products: Other Forms of Energy Supply - Non-renewable Sources**

[Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy Supply Forms, Energy Sources, Energy Supply Equipment and Energy Supply Equipment Delivery Systems** involved in the Energy Solution(s)?

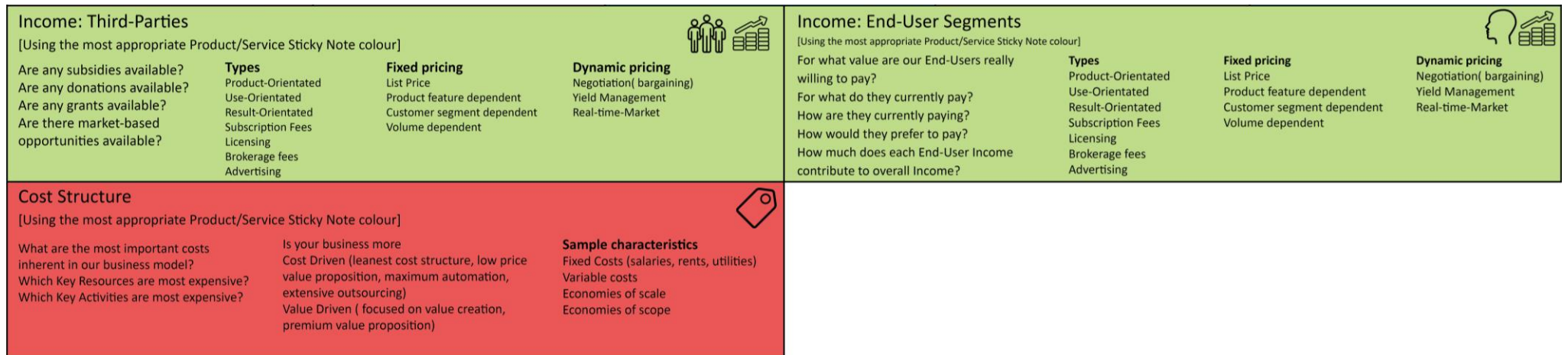[Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy-Using Products** involved in the Energy Solution(s)?

**Offer(s): Other Forms of Energy Supply - Non-renewable Sources**

[Using the most appropriate Product Sticky Note colour] Through what **type of payment offering** is the Energy Supply Equipment and/or Energy-Using Products provided? Who is the **owner** of the Energy Supply Equipment and/or Energy-Using Products and what are the **timelines for ownership transfer**?

**Products: Electricity Supply - Non-renewable Sources**

[Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy Supply Forms (AC or DC electricity), Energy Sources and Energy Supply Equipment and Energy Supply Equipment Delivery Systems** involved in the Energy Solution(s)?

[Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy-Using Products** involved in the Energy Solution(s)?

**Offer(s): Electricity Supply - Non-renewable Sources**

[Using the most appropriate Product Sticky Note colour] Through what **type of payment offering** is the Energy Supply Equipment and/or Energy-Using Products provided? Who is the **owner** of the Energy Supply Equipment and/or Energy-Using Products and what are the **timelines for ownership transfer**?

**Services: Other Forms of Energy Supply - Non-renewable Sources**

[Using the most appropriate Product Sticky Note colour if the Service is specific to a Product] What are the **Services** involved in the Energy Solution(s)?

**Services: Electricity Supply - Non-renewable Sources**

[Using the most appropriate Product Sticky Note colour if the Service is specific to a Product] What are the **Services** involved in the Energy Solution(s)?

| Pain Relievers: Other Offerings & Value-Adds | Pain Relievers: Other Forms of Energy Supply | Pain Relievers: Electricity Supply |
|---|---|---|
| [Using the most appropriate Product/ Service Sticky Note colour] What are the **Pain Relievers** the **Other Solutions** provides before, during and after trying to get Other job done? | [Using the most appropriate Product/ Service Sticky Note colour] What are the **Pain Relievers** the **Energy Solution(s)** provides before, during and after trying to get a job done within Energy Services? | [Using the most appropriate Product/ Service Sticky Note colour] What are the **Pain Relievers** the **Energy Solution(s)** provides before, during and after trying to get a job done within Energy Services? |

**Figure A.6: Energy Value Map (printed portrait on A0 size paper)**

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| Gain Creators: Other Offerings & Value-Adds | Gain Creators: Other Forms of Energy Supply | | Gain Creators: Electricity Supply | | |
|---|---|---|---|---|---|
| [Using the most appropriate Product/ Service Sticky Note colour] What are the **Gain Creators** your **Other Solution(s)** provide when trying to get an Other job done? | [Using the most appropriate Product/ Service Sticky Note colour] What are the **Gain Creators** your **Energy Solution(s)** provides when trying to get a job done within Energy Services? | | [Using the most appropriate Product/ Service Sticky Note colour] What are the **Gain Creators** your **Energy Solution(s)** provides when trying to get a job done within Energy Services? | | |

| Products & Services: Other Offerings & Value- Adds | Products: Other Forms of Energy Supply - Renewable Sources | | Offer(s): Other Forms of Energy Supply - Renewable Sources | Products: Electricity Supply - Renewable Sources | | Offer(s): Electricity Supply - Renewable Sources |
|---|---|---|---|---|---|---|
| [Ideally, use a distinct Sticky Note colour for each Product] What are the **Products** and **Services** involved in the **Other Solution(s)**? | [Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy Supply Forms**, **Energy Sources**, **Energy Supply Equipment and Energy Supply Equipment Delivery Systems** involved in the Energy Solution(s)? | [Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy-Using Products** involved in the Energy Solution(s)? | [Using the most appropriate Product Sticky Note colour] Through what **type of payment offering** is the **Energy Supply Equipment** and/or **Energy-Using Products** provided? Who is the **owner** of the **Energy Supply Equipment** and/or **Energy-Using Products** and what are the **timelines for ownership transfer**? | [Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy Supply Forms (AC or DC electricity)**, **Energy Sources** and **Energy Supply Equipment and Energy Supply Equipment Delivery Systems** involved in the Energy Solution(s)? | [Ideally, use a distinct Sticky Note colour for each Product] What are the **Energy-Using Products** involved in the Energy Solution(s)? | [Using the most appropriate Product Sticky Note colour] Through what **type of payment offering** is the **Energy Supply Equipment** and/or **Energy-Using Products** provided? Who is the **owner** of the **Energy Supply Equipment** and/or **Energy-Using Products** and what are the **timelines for ownership transfer**? |

| Services: Other Forms of Energy Supply - Renewable Sources | | | Services: Electricity Supply - Renewable Sources | | |
|---|---|---|---|---|---|
| [Using the most appropriate Product Sticky Note colour if the Service is specific to a Product] What are the **Services** involved in the Energy Solution(s)? | | | [Using the most appropriate Product Sticky Note colour if the Service is specific to a Product] What are the **Services** involved in the Energy Solution(s)? | | |

**Figure A.7: Energy Value Map – Top Section**

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| | Products: Other Forms of Energy Supply - Non-renewable Sources | | Offer(s): Other Forms of Energy Supply - Non-renewable Sources | Products: Electricity Supply - Non-renewable Sources | | Offer(s): Electricity Supply - Non-renewable Sources |
|---|---|---|---|---|---|---|
| | [Ideally, use a distinct Sticky Note colour for each Product]<br>What are the **Energy Supply Forms, Energy Sources, Energy Supply Equipment and Energy Supply Equipment Delivery Systems** involved in the Energy Solution(s)? | [Ideally, use a distinct Sticky Note colour for each Product]<br>What are the **Energy-Using Products** involved in the Energy Solution(s)? | [Using the most appropriate Product Sticky Note colour]<br>Through what **type of payment offering** is the **Energy Supply Equipment** and/or **Energy-Using Products** provided? Who is the **owner** of the **Energy Supply Equipment** and/or **Energy-Using Products** and what are the **timelines for ownership transfer**? | [Ideally, use a distinct Sticky Note colour for each Product]<br>What are the **Energy Supply Forms (AC or DC electricity), Energy Sources** and **Energy Supply Equipment and Energy Supply Equipment Delivery Systems** involved in the Energy Solution(s)? | [Ideally, use a distinct Sticky Note colour for each Product]<br>What are the **Energy-Using Products** involved in the Energy Solution(s)? | [Using the most appropriate Product Sticky Note colour]<br>Through what **type of payment offering** is the **Energy Supply Equipment** and/or **Energy-Using Products** provided? Who is the **owner** of the **Energy Supply Equipment** and/or **Energy-Using Products** and what are the **timelines for ownership transfer**? |
| | **Services: Other Forms of Energy Supply - Non-renewable Sources** | | | **Services: Electricity Supply - Non-renewable Sources** | | |
| | [Using the most appropriate Product Sticky Note colour if the Service is specific to a Product]<br>What are the **Services** involved in the Energy Solution(s)? | | | [Using the most appropriate Product Sticky Note colour if the Service is specific to a Product]<br>What are the **Services** involved in the Energy Solution(s)? | | |
| **Pain Relievers: Other Offerings & Value-Adds** | **Pain Relievers: Other Forms of Energy Supply** | | | **Pain Relievers: Electricity Supply** | | |
| [Using the most appropriate Product/ Service Sticky Note colour]<br>What are the **Pain Relievers** the **Other Solutions** provides before, during and after trying to get Other job done? | [Using the most appropriate Product/ Service Sticky Note colour]<br>What are the **Pain Relievers** the **Energy Solution(s)** provides before, during and after trying to get a job done within Energy Services? | | | [Using the most appropriate Product/ Service Sticky Note colour]<br>What are the **Pain Relievers** the **Energy Solution(s)** provides before, during and after trying to get a job done within Energy Services? | | |

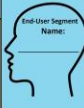**Figure A.8: Energy Value Map – Bottom Section**

**Gains: Energy Services - Electricity**

[Using the same Energy Service Sticky Note colour]
What are the **Gains** surrounding the **Energy-Using Products** that want to be maximised when trying to get the below-mentioned jobs done?

[Using the same Energy Service Sticky Note colour]
What are the **Gains** surrounding the **energy supply and energy supply equipment** that want to be maximised when trying to get the below-mentioned jobs done?

**Gains: Energy Services - Other Forms of Energy Supply**

[Using the same Energy Service Sticky Note colour]
What are the **Gains** surrounding the **energy-using products** that want to be maximised when trying to get the below-mentioned jobs done?

[Using the same Energy Service Sticky Note colour]
What are the **Gains** surrounding the **energy supply and energy supply equipment** that want to be maximised when trying to get the below-mentioned jobs done?

**Gains: Other (Beyond Energy Services)**

[Using the same Jobs to be Done: Other Sticky Note colour]
What are the **Gains** that want to be maximised when trying to get the below-mentioned **Other jobs** done?

---

**Energy Services - Electricity**

[Ideally, use a distinct Sticky Note colour for each Energy Service]
What are the **Energy Services** to be addressed with **electricity**?

**Energy Services - Other Forms of Energy Supply**

[Ideally, use a distinct Sticky Note colour for each Energy Service]
What are the **Energy Services** to be addressed with **other forms of energy supply**?

End-User Segment Name:

---

**Jobs to be Done: Energy Services - Electricity**

[Using the same Energy Service Sticky Note colour]
What are the specific **jobs to be done** within the above-mentioned Energy Services?

**Jobs to be Done: Energy Services - Other Forms of Energy Supply**

[Using the same Energy Service Sticky Note colour]
What are the specific **jobs to be done** within the above-mentioned Energy Services?

**Jobs to be Done: Other (Beyond Energy Services)**

[Ideally, use a distinct Sticky Note colour and only using the appropriate Energy Service Sticky Note colour if necessary]
What are the **jobs to be done related to** specific jobs within Energy Services?

---

**Pains: Energy Services - Electricity**

[Using the same Energy Service Sticky Note colour]
What are the **Pains** experienced with the **energy-using products** before, during and after trying to get the above-mentioned jobs done?

[Ideally, use a distinct Sticky Note colour and only using the appropriate Energy Service Sticky Note colour if necessary]
What are the **Pains** experienced with the **energy supply and energy supply equipment** before, during and after trying to get the above-mentioned jobs done?

**Pains: Energy Services - Other Forms of Energy Supply**

[Using the same Energy Service Sticky Note colour]
What are the **Pains** experienced with the **energy-using products** before, during and after trying to get the above-mentioned jobs done?

[Ideally, use a distinct Sticky Note colour and only using the appropriate Energy Service Sticky Note colour if necessary]
What are the **Pains** experienced with the **energy supply and energy supply equipment** before, during and after trying to get the above-mentioned jobs done?

**Pains: Other (Beyond Energy Services)**

[Using the same Jobs to be Done: Other Sticky Note colour]
What are the **Pains** experienced before, during and after trying to get the **Other jobs** done?

**Figure A.9: End-User Profile (printed portrait on A0 size paper)**

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| Gains: Energy Services - Electricity | | Gains: Energy Services - Other Forms of Energy Supply | | Gains: Other (Beyond Energy Services) |
|---|---|---|---|---|
| [Using the same Energy Service Sticky Note colour]<br>What are the **Gains** surrounding the **Energy-Using Products** that want to be maximised when trying to get the below-mentioned jobs done? | [Using the same Energy Service Sticky Note colour]<br>What are the **Gains** surrounding the **energy supply and energy supply equipment** that want to be maximised when trying to get the below-mentioned jobs done? | [Using the same Energy Service Sticky Note colour]<br>What are the **Gains** surrounding the **energy-using products** that want to be maximised when trying to get the below-mentioned jobs done? | [Using the same Energy Service Sticky Note colour]<br>What are the **Gains** surrounding the **energy supply and energy supply equipment** that want to be maximised when trying to get the below-mentioned jobs done? | [Using the same Jobs to be Done: Other Sticky Note colour]<br>What are the **Gains** that want to be maximised when trying to get the below-mentioned **Other jobs** done? |
| **Energy Services - Electricity** | | **Energy Services - Other Forms of Energy Supply** | | End-User Segment Name: |
| [Ideally, use a distinct Sticky Note colour for each Energy Service]<br>What are the **Energy Services** to be addressed with **electricity**? | | [Ideally, use a distinct Sticky Note colour for each Energy Service]<br>What are the **Energy Services** to be addressed with **other forms of energy supply**? | | |
| **Jobs to be Done: Energy Services - Electricity** | | **Jobs to be Done: Energy Services - Other Forms of Energy Supply** | | Jobs to be Done: Other (Beyond Energy Services) |
| [Using the same Energy Service Sticky Note colour]<br>What are the specific **jobs to be done** within the above-mentioned Energy Services? | | [Using the same Energy Service Sticky Note colour]<br>What are the specific **jobs to be done** within the above-mentioned Energy Services? | | [Ideally, use a distinct Sticky Note colour and only using the appropriate Energy Service Sticky Note colour if necessary]<br>What are the **jobs to be done related to** specific jobs within Energy Services? |

**Figure A.10: End-User Profile – Top and Middle Section**

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| Pains: Energy Services - Electricity | | Pains: Energy Services - Other Forms of Energy Supply | | Pains: Other (Beyond Energy Services) |
|---|---|---|---|---|
| [Using the same Energy Service Sticky Note colour]<br>What are the **Pains** experienced with the **energy-using products** before, during and after trying to get the above-mentioned jobs done? | [Ideally, use a distinct Sticky Note colour and only using the appropriate Energy Service Sticky Note colour if necessary]<br>What are the **Pains** experienced with the **energy supply and energy supply equipment** before, during and after trying to get the above-mentioned jobs done? | [Using the same Energy Service Sticky Note colour]<br>What are the **Pains** experienced with the **energy-using products** before, during and after trying to get the above-mentioned jobs done? | [Ideally, use a distinct Sticky Note colour and only using the appropriate Energy Service Sticky Note colour if necessary]<br>What are the **Pains** experienced with the **energy supply and energy supply equipment** before, during and after trying to get the above-mentioned jobs done? | [Using the same Jobs to be Done: Other Sticky Note colour]<br>What are the **Pains** experienced before, during and after trying to get the **Other jobs** done? |

**Figure A.11: End-User Profile - Bottom Section**

Typical Life Cycle of an Energy Solution

| | Beginning of Life (BOL) | | | | Middle of Life (MOL) | | | | | | | End of Life (EOL) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Provider Perspective** | Research & Development (R&D) | Discovery and Design of Energy Solution (Energy Supply and/or Energy Supply Equipment and/or Energy-Using Products) | Business Case Proposal & Third-Party Financing of Energy Solution | Production and/or Procurement of Energy Solution | Distribution and Construction of Energy Solution at Community Location | Marketing & Retail Assistance | Selling and Administration | Logistics and Transport to Users | Before Use Operations (Training Installation and Assembly) | Operations, Monitoring & Evaluation and Reporting | Maintenance, Repair and Support | Energy Solution Collection and/or Disassembly and/or Upgrade | Post-service Follow-up | Remanufacture and/or Recycle | Disposal |
| **End-User Segment Perspective** | | Project Awareness, Triability and Co-creation | | | | Solution Awareness, Triability and Evaluation | Payment and Administration | Transport | Training Received, Assembly and Installation | Use | Maintenance, Repair and Support Received | Product Disposal and/or Upgrade | Post-service Feedback | | |

Life Cycle of the Energy Solution(s)

[Ideally use a distinct Life Cycle Sticky Note colour]

What is the **Life Cycle** of the **Energy Solution** being offered?

| **Provider Perspective** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Partner Interactions of the Energy Solution(s)

[Answer the below on the Product/ Service Sticky Note colour(s) that is most appropriate]

**Who** is involved in each Life Cycle phase? What **contribution** will they make to the Energy Solution? What do they **expect in return** for their contribution?

Typical Life Cycle of Other Solution(s)

| | Beginning of Life | | | | Middle of Life | | | | | | | End of Life | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Provider Perspective** | Research & Development (R&D) | Discovery and Design of Solution (Other Offerings & Value-Adds) | Business Case Proposal & Third-Party Financing of Solution | Production and/or Procurement of Solution | Distribution of Solution to Community Location | Marketing & Retail Assistance | Selling and Administration | Logistics and Transport to Users | Before Use Operations (Training Installation and Assembly) | Operations, Monitoring & Evaluation and Reporting | Maintenance, Repair and Support | Solution Collection and/or Disassembly and/or Upgrade | Post-service Follow-up | Remanufacture and/or Recycle | Disposal |
| **End-User Perspective** | | Project Awareness, Triability and Co-creation | | | | Solution Awareness, Triability and Evaluation | Payment and Administration | Transport | Training Received, Assembly and Installation | Use | Maintenance, Repair and Support Received | Product Disposal and/or Upgrade | Post-service Feedback | | |

Life Cycle of the Other Solution(s)

[Ideally use a distinct Life Cycle Sticky Note colour]

What is the **Life Cycle** of the **Other Solutions** being offered?

| **Provider Perspective** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Partner Interactions of the Other Solution(s)

[Answer the below on the Product/ Service Sticky Note colour(s) that is most appropriate]

**Who** is involved in each Life Cycle phase? What **contribution** will they make to the Other Solutions? What do they **expect in return** for their contribution?

Financial Implications of Partner Interactions (Energy Solution & Other Solution(s))

[Use the same Sticky Note colours as above]

What is the **income** received from **Third Parties**?

What are the **expenses** in the above Partner Interactions?

| Income: Third Party | |
|---|---|
| Cost Structure | |

**Figure A.12: Partner Interaction Canvas (printed portrait on A0 size paper)**

Typical Life Cycle of an Energy Solution

| Provider Perspective | Beginning of Life (BOL) | | | | Middle of Life (MOL) | | | | | | Maintenance, Repair and Support | End of Life (EOL) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Research & Development (R&D) | Discovery and Design of Energy Solution (Energy Supply and/or Energy Supply Equipment and/or Energy-Using Products) | Business Case Proposal & Third-Party Financing of Energy Solution | Production and/or Procurement of Energy Solution | Distribution and Construction of Energy Solution at Community Location | Marketing & Retail Assistance | Selling and Administration | Logistics and Transport to Users | Before Use Operations (Training Installation and Assembly) | Operations, Monitoring & Evaluation and Reporting | Maintenance, Repair and Support | Energy Solution Collection and/or Disassembly and/or Upgrade | Post-service Follow-up | Remanufacture and/or Recycle | Disposal |
| End-User Segment Perspective | | Project Awareness, Triability and Co-creation | | | | Solution Awareness, Triability and Evaluation | Payment and Administration | Transport | Training Received, Assembly and Installation | Use | Maintenance, Repair and Support Received | Product Disposal and/or Upgrade | Post-service Feedback | | |

Life Cycle of the Energy Solution(s)

[Ideally use a distinct Life Cycle Sticky Note colour]

What is the **Life Cycle** of the **Energy Solution** being offered?

| Provider Perspective | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |

Partner Interactions of the Energy Solution(s)

[Answer the below on the Product/ Service Sticky Note colour(s) that is most appropriate]

**Who** is involved in each Life Cycle phase? What **contribution** will they make to the Energy Solution(s)? What do they **expect in return** for their contribution?

**Figure A.13: Partner Interaction Canvas - Top Section**

Typical Life Cycle of Other Solution(s)

| | Beginning of Life | | | | Middle of Life | | | | | | | | End of Life | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Provider Perspective | Research & Development (R&D) | Discovery and Design of Solution (Other Offerings & Value-Adds) | Business Case Proposal & Third-Party Financing of Solution | Production and/or Procurement of Solution | Distribution of Solution to Community Location | Marketing & Retail Assistance | Selling and Administration | Logistics and Transport to Users | Before Use Operations (Training Installation and Assembly) | Operations, Monitoring & Evaluation and Reporting | Maintenance, Repair and Support | Solution Collection and/or Disassembly and/or Upgrade | Post-service Follow-up | Remanufacture and/or Recycle | Disposal |
| End-User Perspective | | Project Awareness, Triability and Co-creation | | | | Solution Awareness, Triability and Evaluation | Payment and Administration | Transport | Training Received, Assembly and Installation | Use | Maintenance, Repair and Support Received | Product Disposal and/or Upgrade | Post-service Feedback | | |

Life Cycle of the Other Solution(s)

[Ideally use a distinct Life Cycle Sticky Note colour]

What is the **Life Cycle** of the **Other Solutions** being offered?

| Provider Perspective | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |

Partner Interactions of the Other Solution(s)

[Answer the below on the Product/ Service Sticky Note colour(s) that is most appropriate]

**Who** is involved in each Life Cycle phase? What **contribution** will they make to the Other Solutions? What do they **expect in return** for their contribution?

**Figure A.14: Partner Interaction Canvas - Middle Section**

Financial Implications of Partner Interactions (Energy Solution & Other Solution(s))

[Use the same Sticky Note colours as above]

What is the **income** received from **Third Parties**?

What are the **expenses** in the above Partner Interactions?

| Income: Third Party | |
| --- | --- |
| Cost Structure | |

**Figure A.15: Partner Interaction Canvas - Bottom Section**

## Pre-Service Period

## Service Period

## Post-Service Period

Typical Life Cycle Phases/ End-User Touchpoints

| End-User Perspective | Project Awareness, Triability and Co-creation | Solution Awareness, Triability and Evaluation | Payment and Administration | Transport | Training Received, Assembly and Installation | Use | Maintenance, Repair and Support Received | Product Disposal and/or Upgrade | Post-service Feedback |
|---|---|---|---|---|---|---|---|---|---|

[Either considering the Energy Solution(s) and the Other Solution(s) together or separately, using different Sticky Note colours]

What type of relationship is established/maintained with the End-User Segments? Through what Channels are the End-User Segments reached? What are the touchpoints that End-User Segments experience?

(End-User Relationship)
(Channels)
(Touchpoint illustartion or description)

### Service Journey

[Either considering the Energy Solution(s) and the Other Solution(s) together or separately, using different Sticky Note colours]

What type of relationship is established/maintained with the End-User Segments?
Through what Channels are the End-User Segments reached?
What are the chronological touchpoints that End-User Segments experience during the Service Journey?

(End-User Relationship)
(Channels)
(Touchpoint illustartion or description)

[Either considering the Energy Solution(s) and the Other Solution(s) together or separately, using different Sticky Note colours]

What type of relationship is established/maintained with the End-User Segments? Through what Channels are the End-User Segments reached? What are the touchpoints that End-User Segments experience?

(End-User Relationship)
(Channels)
(Touchpoint illustartion or description)

### Revenue Resulting from User Touchpoints

What is the income received from End-User Segments at the touchpoints in the Service Journey?

Income: End-User Segments

**Figure A.16: End-User Journey Canvas (printed landscape on A1 size paper)**

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## Service Period

Typical Life Cycle Phases/ End-User Touchpoints

| End-User Perspective | Project Awareness, Triability and Co-creation | Solution Awareness, Triability and Evaluation | Payment and Administration | Transport | Training Received, Assembly and Installation | Use | Maintenance, Repair and Support Received | Product Disposal and/or Upgrade | Post-service Feedback |
|---|---|---|---|---|---|---|---|---|---|

[Either considering the Energy Solution(s) and the Other Solution(s) together or separately, using different Sticky Note colours]

What type of relationship is established/maintained with the End-User Segments?
Through what Channels are the End-User Segments reached?
What are the touchpoints that End-User Segments experience?

(End-User Relationship)
(Channels)
(Touchpoint illustartion or description)

### Service Journey

[Either considering the Energy Solution(s) and the Other Solution(s) together or separately, using different Sticky Note colours]

What type of relationship is established/maintained with the End-User Segments?
Through what Channels are the End-User Segments reached?
What are the chronological touchpoints that End-User Segments experience during the Service Journey?

(End-User Relationship)
(Channels)
(Touchpoint illustartion or description)

[Either considering the Energy Solution(s) and the Other Solution(s) together or separately, using different Sticky Note colours]

What type of relationship is established/maintained with the End-User Segments?
Through what Channels are the End-User Segments reached?
What are the touchpoints that End-User Segments experience?

(End-User Relationship)
(Channels)
(Touchpoint illustartion or description)

**Figure A.17: End-User Journey Canvas – Top Section**

## Revenue Resulting from User Touchpoints

What is the income received from End-User Segments at the touchpoints in the Service Journey?

Income: End-User Segments

**Figure A.18: End-User Journey Canvas – Middle Section:**

| | | Value Captured | Value Destroyed | Value Missed/Absence | Value Surplus | Value Opportunity |
|---|---|---|---|---|---|---|
| Partners & Stakeholders | End-Users | | | | | |
| | Community | | | | | |
| | Energy Provision Enterprise | | | | | |
| | Energy Provision Enterprise Employees | | | | | |
| | Local Government | | | | | |
| | Suppliers | | | | | |
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**Figure A.19: Value-mapping table (printed portrait on A1 paper size)**

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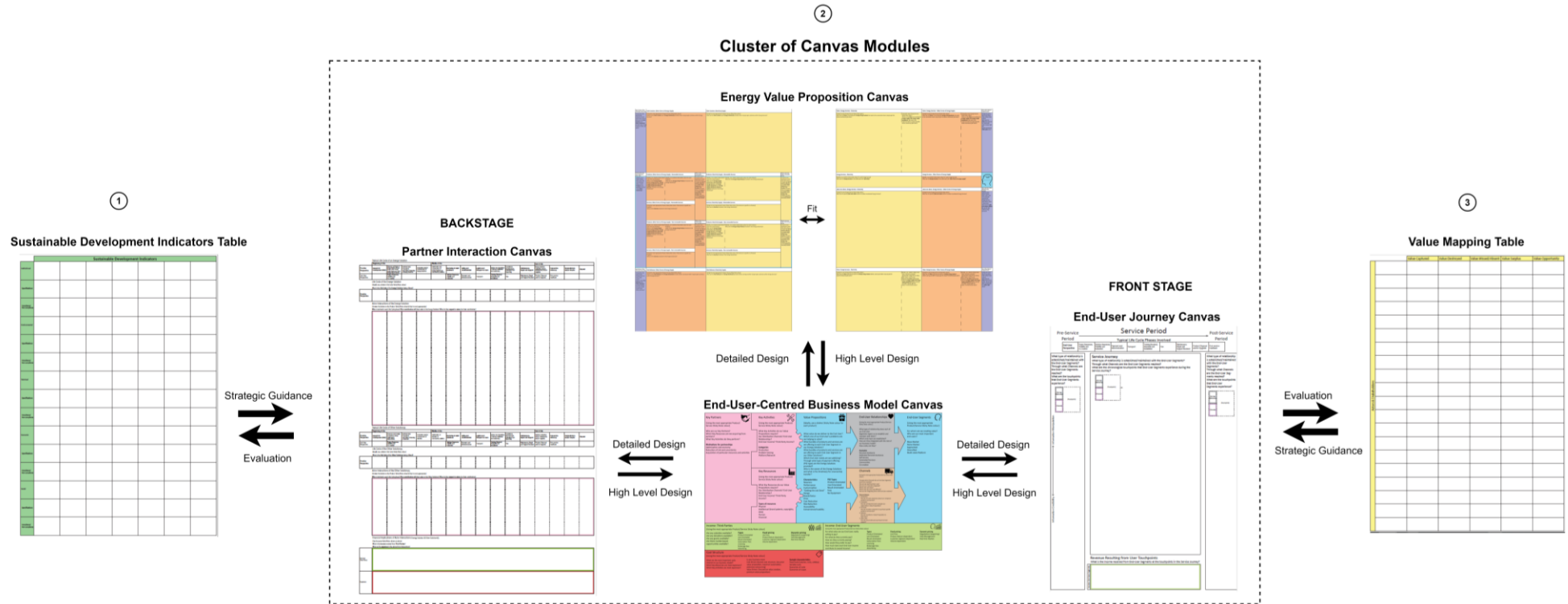
**Figure A.20: Framework Overview Diagram (printed landscape on A1 size paper)**

# APPENDIX B: COMMUNITY SURVEY

## B.1 Community Survey Consent Form

| TITLE OF RESEARCH PROJECT: | A Business Case for Renewable Energy Technology Leapfrogging in Informal Settlements |
|---|---|
| REFERENCE NUMBER: | SU-HSD-002753 |
| PRINCIPAL INVESTIGATOR: | GF (Rickus) Cronje |
| ADDRESS: | Cnr Banhoek Road & Joubert Street, Stellenbosch, 7600 <br><br> Department of Industrial Engineering |
| CONTACT NUMBER: | 0764801515 |
| EMAIL: | 16983165@sun.ac.za |

**STELLENBOSCH UNIVERSITY**

**CONSENT TO PARTICIPATE IN RESEARCH**

Dear participant

Kindly note that I am a Master's student in Industrial Engineering at Stellenbosch University. You are asked to participate in a research study entitled "A Business Case for Renewable Energy Technology Leapfrogging in Informal Settlements".

Please take some time to read the information presented here, which will explain the details of this project and contact me if you require further explanation or clarification of any aspect of the study. This study has been approved by the Research Ethics Committee (REC) at Stellenbosch University and will be conducted according to accepted and applicable national and international ethical guidelines and principles.

## 1) Introduction:

Solar Home Solutions (SHS) provides an opportunity where renewable energy technologies can be used in urban informal settlements to skip or "leapfrog" fossil fuel technologies into a quicker accessible and greener technology future. An example of technology leapfrogging is seen by how developing countries transitioned from no phone services, skipping past landlines and moved directly to cell phones.

## 2) Purpose of the study:

The aim of the research is to facilitate technology leapfrogging in urban informal settlements through the development of a business model. Enkanini informal settlement will be studied to develop a business model that is applicable, practical, desirable and feasible. By developing a business model that uses renewable energy technology rather than current, fossil dependent technology, this research study informs to the South African Government how to address urgent and challenging housing and electrification problems in urban informal settlements in an environmentally friendly manner.

## 3) Procedure:

Voluntary participants will be asked to come to the Enkanini Research Centre to answer a series of questions regarding energy services. Alternatively, this process can take place in your home if it is easier for you and if you feel comfortable with it.

## 4) Time:

The procedure will take approximately 45-60 minutes.

## 5) Risks:

There are no negative effects for participating in the study.

## 6) Benefits:

There are no benefits for participating in the study. The study will help inform research as to the current state of energy consumption in Enkanini and lead to the development of a renewable energy business model that is applicable, practical, desirable and feasible to the community.

## 7) Confidentiality:

All participants will be assigned an Identification Code (ID) that will ensure participant confidentiality. Participants will be referred to by their ID numbers unless permission is otherwise given or as required by law.

## 8) Data Storage:

Completed questionnaires will be stored and locked in the office of my either my two research supervisors (Dr. Josephine Musango or Mrs Imke de Kock) where no one will have access to the tapes. A participant's personal data (name, telephone number, physical address etc.) will be stored on a folder on the internet that is password protected. Only the primary investigator, the research supervisor (Dr. Josephine Musango) and the co-supervisor (Mrs Imke de Kock) will have access to the personal data of participants.

If you have any questions or concerns about the research, please feel free to contact me, Rickus Cronje, at 076 480 15 15 or email 16983165@sun.ac.za. Alternatively, you can contact my research supervisor, Josephine Musango at (021) 881 3924 or email josephine.musango@spl.sun.ac.za.

**RIGHTS OF RESEARCH PARTICIPANTS:** You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché (mfouche@sun.ac.za / 021 808 4622) at the Division for Research Development. You have the right to receive a copy of this Consent form.

**B.2 Community Questionnaire**

# Enkanini Household Composition and

# Energy Consumption Questionnaire

Prepared by: George Frederick Cronje

Stellenbosch University

Dear participant. This questionnaire forms part of my Master's degree in Industrial Engineering. Please fill it in as best possible. Your response will be kept confidential and anonymous.

## A. General information

| | |
|---|---|
| Date: _____ | Time: _____ |
| Field researcher number: _____ | Location (section): _____ |
| Structure type: (mark with X)  □ Residential only  □ Residential-cum-Business | |

## B. Energy services

**Please indicate your household fuel use for the following energy services:**

a)  Cooking:

Please fill in this table about **cooking** products as best you can:

*please include the activity of making tea or coffee

| Type of appliance | Number of appliances in dwelling | Brand / amount of burners | Watt | Year of purchase | Hours of use per work day per appliance | Hours of use per work week |
|---|---|---|---|---|---|---|
| Paraffin stove | | | ■ | | | |
| LPG (gas) stove | | | ■ | | | |
| Kettle | | | | | | |
| Gasifier stove (wood pellets) | | | ■ | | | |
| Electric stove | | | | | | |
| Wood/charcoal burning stove | | | ■ | | | |
| Other (please specify) _____ | | | | | | |

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Please fill in this table about **<u>cooking</u>** fuels as best you can:

| **Fuel name** | **Proportion of fuel use (%)** | **Why do you use this fuel?** |
|---|---|---|
| Paraffin | | _____ _____ |
| LPG (gas) | | _____ _____ |
| Indirect electricity | | _____ _____ |
| Wood pellets (iShack stove) | | _____ _____ |
| Wood | | _____ _____ |
| Generator (mark with X) □ Petrol □ Diesel | | _____ _____ |
| Other (please specify) _____ | | _____ _____ |
| | 100% | |

Do you ever run out of fuels for **<u>cooking</u>** activities? (mark with X)    □ Yes □ No

If yes, why? _____

_____

_____

What fuel/fuels would you prefer to use for **<u>cooking</u>** activities and why?

_____

_____

_____

b) Lighting:

Please fill in this table about **lighting** products as best you can:

| Type of appliance | Number of appliances in dwelling | Brand | Watt | Year of purchase | Hours of use per work day per appliance | Hours of use per work week |
|---|---|---|---|---|---|---|
| Energy saver bulbs (Compact fluorescent lamp) | | | | | | |
| Incandescent bulbs | | | | | | |
| LED bulbs (e.g. iShack bulbs) | | | | | | |
| Outdoor security light | | | | | | |
| Electric lantern | | | | | | |
| Paraffin lamp | | | | | | |
| Gas lamp | | | | | | |
| Battery lamp | | | | | | |
| Battery lantern | | | | | | |
| Solar lantern | | | | | | |
| Torch | | | | | | |
| Candles | | | | | | |
| Open fire | | | | | | |
| Other (please specify) _____ _____ _____ | | | | | | |

Please fill in this table about __lighting__ fuels as best you can:

| Fuel name | Proportion of fuel use (%) | Why do you use this fuel? |
|---|---|---|
| Paraffin | | _____ _____ |
| LPG (gas) | | _____ _____ |
| Indirect electricity | | _____ _____ |
| Solar (iShack) | | _____ _____ |
| Candles | | _____ _____ |
| Wood | | _____ _____ |
| Generator (mark with X) □ Petrol  □ Diesel | | _____ _____ |
| Dry cell batteries | | _____ _____ |
| Car battery | | _____ _____ |
| Other    (please    specify) _____ | | _____ _____ |
| | 100% | |

Do you ever run out of fuels for __lighting__ activities? (mark with X)    □ Yes □ No

If yes, why? _____

_____

_____

What    fuel/fuels    would    you    prefer    to    use    for    __lighting__    activities    and    why?

_____

_____

_____

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c) Space heating:

Please fill in this table about **space heating** products as best you can:

| Type of appliance | Number of appliances in dwelling | Brand and model name | Watt | Year of purchase | Hours of use per work day per appliance | Hours of use per work week |
|---|---|---|---|---|---|---|
| Electric heater | | | | | | |
| Gasifier stove (wood pellets) | | | ■ | | | |
| Paraffin stove | | | ■ | | | |
| LPG (gas) stove | | | ■ | | | |
| Charcoal heater | | | ■ | | | |
| Open fire | | | ■ | | | |
| Other (please specify) _____ | | | | | | |

Please fill in this table about **space heating** fuels as best you can:

| Fuel name | Proportion of fuel use (%) | Why do you use this fuel? |
|---|---|---|
| Paraffin | | _____ _____ |
| LPG (gas) | | _____ _____ |
| Indirect electricity | | _____ _____ |
| Wood | | _____ _____ |
| Other (please specify) _____ | | _____ _____ |
| | 100% | |

Do you ever run out of fuels for **space heating** activities? (mark with X)  □ Yes  □ No

If yes, why? _____

_____

_____

What fuel/fuels would you prefer to use for **space heating** activities and why? _____

_____

_____

    d)  <u>Water heating:</u>

Please fill in this table about **water heating** products as best you can:

*please keep in mind this is for bathing and washing dishes and clothes

| Type of appliance | Number of appliances in dwelling | Brand and model / amount of burners | Watt | Year of purchase | Hours of use per work day per appliance | Hours of use per work week |
|---|---|---|---|---|---|---|
| Kettle | | | | | | |
| Paraffin stove | | | ■ | | | |
| LPG (gas) stove | | | ■ | | | |
| Electric stove | | | | | | |
| Gasifier stove (wood pellets) | | | ■ | | | |
| Wood/charcoal burning stove | | | ■ | | | |
| Other (please specify) _____ | | | | | | |

Please fill in this table about **water heating** fuels as best you can:

| Fuel name | Proportion of fuel use (%) | Why do you use this fuel? |
|---|---|---|
| Paraffin | | _____ _____ |
| LPG (gas) | | _____ _____ |
| Indirect electricity | | _____ _____ |
| Solar water heaters | | _____ _____ |
| Wood | | _____ _____ |
| Other (please specify) _____ | | _____ |
| | 100% | |

Do you ever run out of fuels for **water heating** activities? (mark with X)  ☐ Yes  ☐ No

If yes, why? _____

_____

_____

What fuel/fuels would you prefer to use for **water heating** activities and why?

_____

_____

_____

e) Cooling:

Please fill in this table about **cooling** products as best you can:

| Type of appliance | Number of appliances in dwelling | Brand and model name | Watt | Year of purchase | Hours of use per work day per appliance | Hours of use per work week |
|---|---|---|---|---|---|---|
| Electric fan | | | | | | |
| Other (please specify) _____ | | | | | | |

Please fill in this table about **cooling** fuels as best you can:

| Fuel name | Proportion of fuel use (%) | Why do you use this fuel? |
|---|---|---|
| Indirect electricity | | _____ _____ |
| Other (please specify) _____ | | _____ _____ |
| | 100% | |

Do you ever run out of fuels for **cooling** activities? (mark with X)  □ Yes □ No

If yes, why? _____

_____

_____

What fuel/fuels would you prefer to use for **cooling** activities and why?

_____

_____

_____

    f)   Home entertainment appliances:

Please fill in this table about **home entertainment appliances** as best you can:

| Type of appliance | Number of appliances in dwelling | Brand and model name | Watt | Year of purchase | Hours of use per work day per appliance | Hours of use per work week |
|---|---|---|---|---|---|---|
| Television | | | | | | |
| DVD player | | | | | | |
| DVD player with radio | | | | | | |
| Radio □ DC (iShack) □ AC (indirect electricity) □ Batteries | | | | | | |
| DSTV | | | | | | |
| Other (please specify) _____ | | | | | | |

Please fill in this table about **home entertainment appliance** fuels as best you can:

| Fuel name | Proportion of fuel use (%) | Why do you use this fuel? |
|---|---|---|
| Indirect electricity | | _____ _____ |
| Solar (iShack) | | _____ _____ |
| Dry cell batteries | | _____ _____ |
| Other (please specify) _____ | | _____ _____ |
| | 100% | |

Do you ever run out of fuels for **home entertainment appliance** activities? (mark with X)

☐ Yes  ☐ No

If yes, why? _____
_____
_____

What fuel/fuels would you prefer to use for **home entertainment appliance** activities and why?
_____
_____

g) Other electric appliances:

Please fill in this table about other **electric appliances** as best you can:

| Type of appliance | Number of appliances in dwelling | Brand and model | Watt | Year of purchase | Hours of use per work day per appliance | Hours of use per work week |
|---|---|---|---|---|---|---|
| Fridge | | | | | | |
| Solar fridge (DC) | | | | | | |
| Freezer | | | | | | |
| Iron | | | | | | |
| Hair dryer | | | | | | |
| Microwave | | | | | | |
| Toaster | | | | | | |
| Washing machine | | | | | | |
| Computer | | | | | | |
| Laptop charger | | | | | | |
| Cell phone charger | | | | | | |
| Portable charger | | | | | | |
| Other (please specify) _____ _____ _____ | _____ _____ _____ | _____ _____ _____ | _____ _____ _____ | _____ _____ _____ | _____ _____ _____ | _____ _____ _____ |

Please fill in this table about other **electric appliance** fuels as best you can:

| Fuel name | Proportion of fuel use (%) | Why do you use this fuel? |
|---|---|---|
| Indirect electricity | | _____ _____ |
| Solar (iShack) | | _____ _____ |
| Car battery | | _____ _____ |
| Other (please specify) _____ | | _____ _____ |
| | 100% | |

Do you ever run out of fuels for other **electric appliance** activities? (mark with X)  □ Yes  □ No

If yes, why? _____

_____

_____


What fuel/fuels would you prefer to use for other **electric appliance** activities and why?

_____

_____

_____

## C. Fuels

| Fuel name | Buy from nearby Spaza shops in Enkanini | Buy from nearby Spaza shops in Kaya-mandi | Buy from shops in Stellen-bosch Industrial area | Buy from shops in Stellen-bosch town | Gather from environ-ment | Produce own | Other (please specify) |
|---|---|---|---|---|---|---|---|
| Paraffin | | | | | | | |
| LPG (gas) | | | | | | | |
| Wood | | | | | | | |
| Candles | | | | | | | |
| Dry cell batteries | | | | | | | |
| Car battery | | | | | | | |
| Generator □ Petrol □ Diesel | | | | | | | |
| Other (please specify) _____ _____ _____ _____ | | | | | | | |

Please tick (✓) how you obtain your fuel sources:

Please fill in this table about fuels as best you can:

| Fuel name | How much of each fuel type do you use weekly or monthly? (kg/units/litres) | What is the unit cost per fuel type? (Rand per kg/Unit/Litres) | How much does the household spend weekly or monthly on each fuel type (on the average)? (Rand) |
|---|---|---|---|
| Paraffin | □ Weekly □ Monthly _____ | _____ | □ Weekly □ Monthly _____ |
| LPG (gas) | □ Weekly □ Monthly _____ | _____ | □ Weekly □ Monthly _____ |
| Solar electricity | □ Weekly □ Monthly _____ | _____ | □ Weekly □ Monthly _____ |
| Indirect electricity connection | ███████████████ | ███████████████ | □ Weekly □ Monthly _____ |
| Wood | □ Weekly □ Monthly _____ | _____ | □ Weekly □ Monthly _____ |
| Candles | □ Weekly □ Monthly _____ | _____ | □ Weekly □ Monthly _____ |
| Dry cell batteries | □ Weekly □ Monthly _____ | _____ | □ Weekly □ Monthly _____ |
| Car battery | □ Weekly □ Monthly _____ | _____ | □ Weekly □ Monthly _____ |
| Generator □ Petrol □ Diesel | □ Weekly □ Monthly _____ | _____ | □ Weekly □ Monthly _____ |
| Other (please specify) _____ _____ | □ Weekly □ Monthly _____ | _____ | □ Weekly □ Monthly _____ |

## D. Dwelling and household details

<table>
<tr><td colspan="2">1. Preferred language: (mark with X) □ English □ isiXhosa □ Afrikaans<br><br>□ Other (please specify) _____</td></tr>
<tr><td>2. Gender of participant: (mark with X) □<br><br>Male □ Female</td><td>3. Gender of the head of the household: (mark with X) □ Male □ Female</td></tr>
<tr><td>4. Age of the head of the household: _____</td><td>5. Do you own or rent this structure? (mark with X) □ Owner □ Tenant</td></tr>
</table>

| 6. How many people live in this dwelling (including yourself)? _____ | 7. Please provide more details on each of the household members: |
|---|---|

| Person number | Age | Gender (mark with X) |
|---|---|---|
| 1 | | □ Male □ Female |
| 2 | | □ Male □ Female |
| 3 | | □ Male □ Female |
| 4 | | □ Male □ Female |
| 5 | | □ Male □ Female |
| 6 | | □ Male □ Female |
| 7 | | □ Male □ Female |
| 8 | | □ Male □ Female |
| 9 | | □ Male □ Female |
| 10 | | □ Male □ Female |

8. How many people over the age of 16 are unemployed (not in school and not working)? _____

9. How many people are retired? _____

10. How many people over the age of 16 do paid work? _____

*(Repeat this for **every** working person)*

| **Paid worker nr.1:** | |
|---|---|
| Gender (mark with X): □ Male □ Female | Age: _____ |
| Are you a permanent employee or do you work on contract basis? (mark with X)<br>□ Permanent □ Contract | When do you receive your salary/loans? (mark with X)<br>□ Daily □ Monthly □ Weekly |
| In what area do you work? (e.g. Stellenbosch Central, Stellenbosch Industrial, Klapmuts, Somerset West, Enkanini etc.) _____ | |
| How much do you get paid? R_____ | |

**Paid worker nr.2:**

| | |
|---|---|
| Gender (mark with X): ☐ Male ☐ Female | Age: _____ |
| Are you a permanent employee or do you work on contract basis? (mark with X) <br><br> ☐ Permanent ☐ Contract | When do you receive your salary/loans? (mark with X) <br><br> ☐ Daily ☐ Monthly ☐ Weekly |

In what area do you work? (e.g. Stellenbosch Central, Stellenbosch Industrial, Klapmuts, Somerset West, Enkanini etc.) _____

How much do you get paid? R_____

**Paid worker nr.3:**

| | |
|---|---|
| Gender (mark with X): ☐ Male ☐ Female | Age: _____ |
| Are you a permanent employee or do you work on contract basis? (mark with X) <br><br> ☐ Permanent ☐ Contract | When do you receive your salary/loans? (mark with X) <br><br> ☐ Daily ☐ Monthly ☐ Weekly |

In what area do you work? (e.g. Stellenbosch Central, Stellenbosch Industrial, Klapmuts, Somerset West, Enkanini etc.) _____

How much do you get paid? R_____

**Paid worker nr.4**

| | |
|---|---|
| Gender (mark with X): ☐ Male ☐ Female | Age: _____ |
| Are you a permanent employee or do you work on contract basis? (mark with X) <br><br> ☐ Permanent ☐ Contract | When do you receive your salary/loans? (mark with X) <br><br> ☐ Daily ☐ Monthly ☐ Weekly |

In what area do you work? (e.g. Stellenbosch Central, Stellenbosch Industrial, Klapmuts, Somerset West, Enkanini etc.) _____

How much do you get paid? R_____

**Paid worker nr.5:**

| | |
|---|---|
| Gender (mark with X): ☐ Male ☐ Female | Age: _____ |
| Are you a permanent employee or do you work on contract basis? (mark with X) <br> ☐ Permanent ☐ Contract | When do you receive your salary/loans? (mark with X) <br> ☐ Daily ☐ Monthly ☐ Weekly |

In what area do you work? (e.g. Stellenbosch Central, Stellenbosch Industrial, Klapmuts, Somerset West, Enkanini etc.) _____

How much do you get paid? R_____

**Income:**

11 a) Other sources of household income per month

| Income source: | | Amount (Rand) |
|---|---|---|
| Government grants (mark with X) | ☐ Disability | |
| | ☐ Childcare | |
| | ☐ Pension | |
| | ☐ Social relief | |
| | ☐ Other (please specify) _____ _____ | |
| Donations | | |
| Interest on savings | | |
| Rental income | | |
| Personal loans | | |
| Small business (please explain) e.g. sell wood to people of Enkanini. _____ _____ _____ | | |
| Other (please specify) _____ _____ | | |

b) How does the household manage cash surplus? (mark with X)

☐ Invest in own business            ☐ Spend on leisure activities

☐ Spend on personal care            ☐ Save

☐ Repay loans                       ☐ Lend to family/friends

☐ Send money to family/friends (please specify town/province where money is sent)

_____

☐ Other (please specify) _____

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**Expenses:**

12 a) How much does the household spend per week or month on? (Mark with X if the expense is monthly or weekly)

| Expense | Amount (Rand) |
|---|---|
| Cell phone (contract, airtime and data) | ☐ Monthly ☐ Weekly |
| Food | ☐ Monthly ☐ Weekly |
| Water | ☐ Monthly ☐ Weekly |
| Drinks and alcohol | ☐ Monthly ☐ Weekly |
| Clothes | ☐ Monthly ☐ Weekly |
| Medical expenses | ☐ Monthly ☐ Weekly |
| Child care e.g. diapers | ☐ Monthly ☐ Weekly |
| Personal care (Hair, nails etc.) | ☐ Monthly ☐ Weekly |
| Rent | ☐ Monthly ☐ Weekly |
| Education | ☐ Monthly ☐ Weekly |
| Household expenses (appliances, cleaning products, toiletries) | ☐ Monthly ☐ Weekly |
| Travel/transportation | ☐ Monthly ☐ Weekly |
| DSTV subscription | ☐ Monthly ☐ Weekly |
| Leisure or free time activities e.g. playing pool, knitting, gym | ☐ Monthly ☐ Weekly |
| Sending money home to relatives | ☐ Monthly ☐ Weekly |
| Gifts and donations e.g. birthdays, church donations | ☐ Monthly ☐ Weekly |
| House maintenance | ☐ Monthly ☐ Weekly |
| Loan repayment | ☐ Monthly ☐ Weekly |
| Small business expenses | ☐ Monthly ☐ Weekly |
| Insurance | ☐ Monthly ☐ Weekly |
| Other (please specify)<br><br>_____<br><br>_____<br><br>_____<br><br>_____<br><br>_____ | _____ ☐ Monthly ☐ Weekly<br><br>_____ ☐ Monthly ☐ Weekly<br><br>_____ ☐ Monthly ☐ Weekly<br><br>_____ ☐ Monthly ☐ Weekly<br><br>_____ ☐ Monthly ☐ Weekly |

b) How does the household manage cash shortfalls? (mark with X all options that apply)

☐ Loans from friends     ☐ Loans from family

☐ Loans from bank     ☐ Savings

☐ Stokvel     ☐ Other (please specify) _____

c) Do you charge your cell phone at home? (mark with X) ☐ Yes ☐ No
   If no, how much do you spend to charge it somewhere else? R _____

**Savings:**

13 a) Does this household belong to a Savings Club e.g. Stokvel or Goi Goi? (mark with X)

☐ Yes  ☐ No

b) If yes, on average how much do you save monthly? R_____

c) What are you saving for? _____

_____

_____

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## B.3 Identification of lightbulbs

Energy saver bulbs (Compact fluorescent lamp)

Incandescent bulbs

LED bulbs (iShack bulbs)

# APPENDIX C: HOUSEHOLD COMPOSITION & PROFILE RESULTS

## C.1 Household Composition
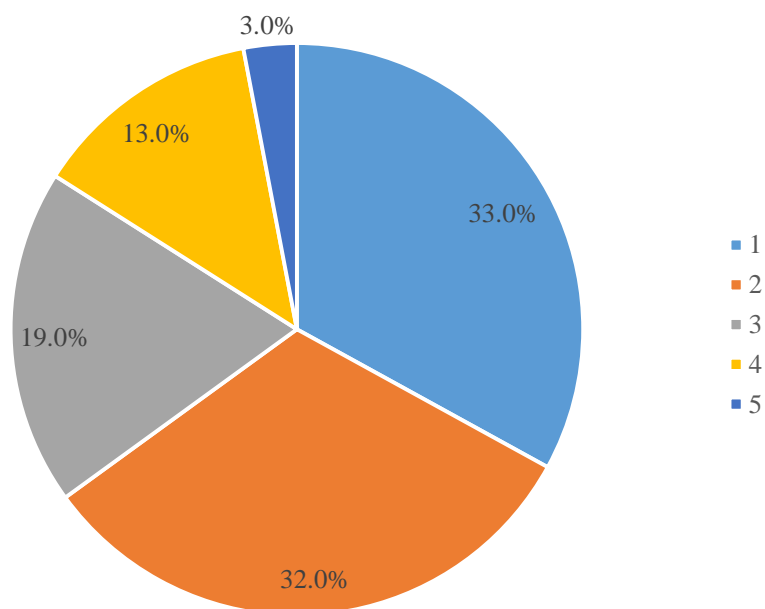


**Figure C.1: Household Composition: Number of People per Dwelling**

## C.2 Household profile

**Table C.1 Household Type**

| Household Types | Number of Households |
|---|---|
| 1 Adult | 32 |
| 1 Adult, 1 Child | 18 |
| 1 Adult, 2 Children | 3 |
| 1 Adult, 3 Children | 1 |
| 2 Adults | 15 |
| 2 Adults, 1 Child | 14 |
| 2 Adults, 2 Children | 5 |
| 3 Adults | 3 |
| 3 Adults, 1 Child | 5 |
| 3 Adults, 2 Children | 3 |
| 4 Adults | 1 |
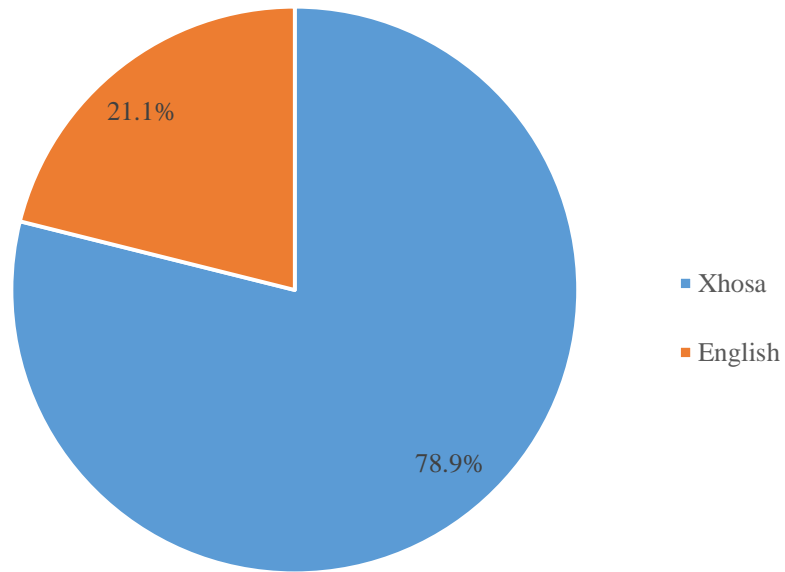
**Figure C.2: Preferred Language**
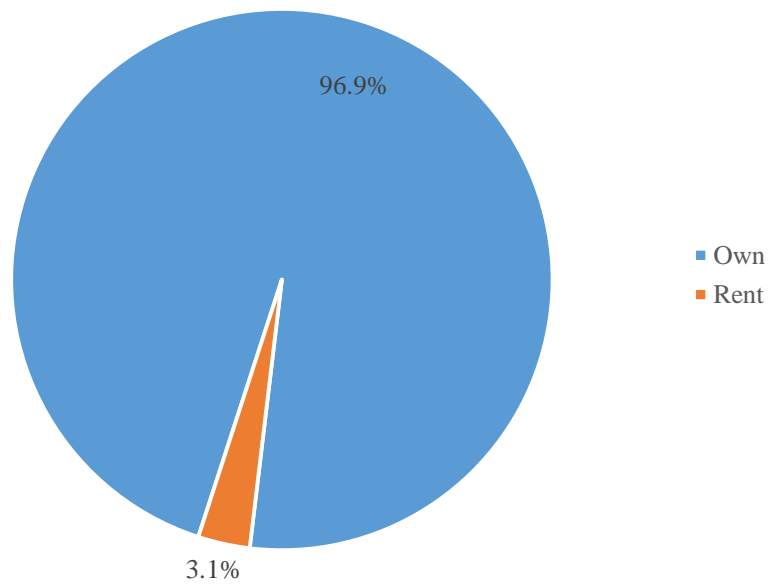


**Figure C.3: Percentage of Owners Who Rent or Own the Structures**

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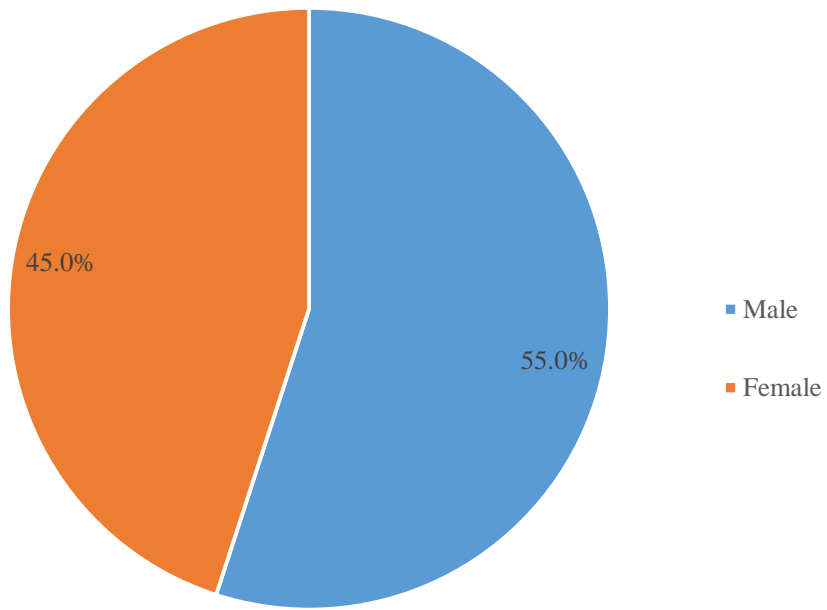
**Figure C.4: Gender of Household Head**

# APPENDIX D: HOUSEHOLD MONETARY FLOWS

## D.1 Household Income Profile:
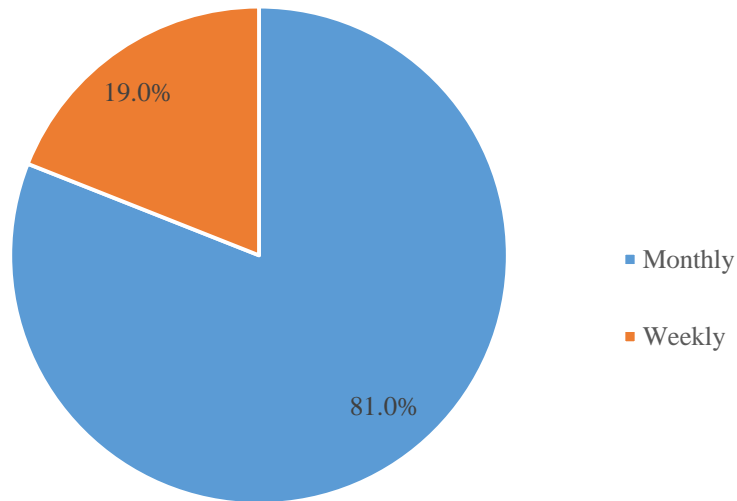


**Figure D.1: Frequency of Salary**
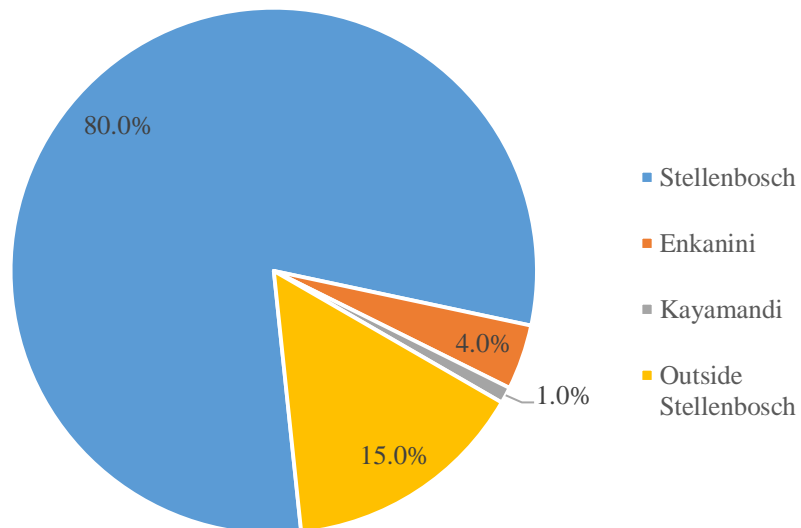


**Figure D.2: Location of Work**
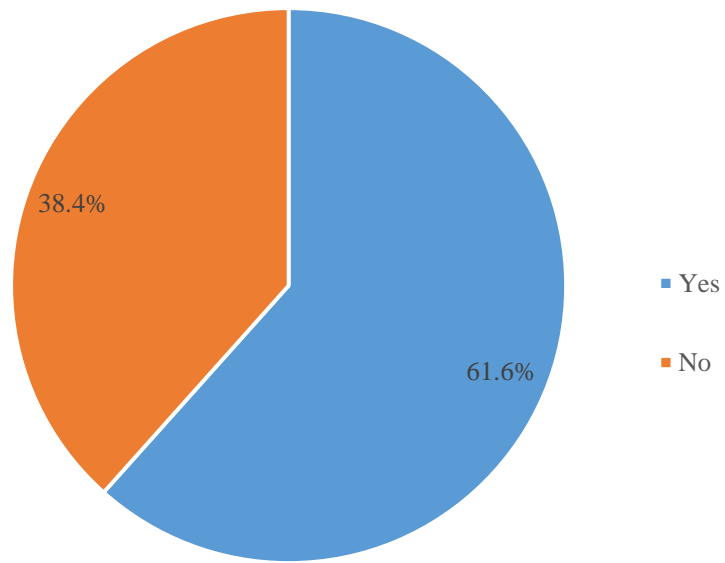
**Figure D.3: Percentage of Those Belonging to a Savings Club**
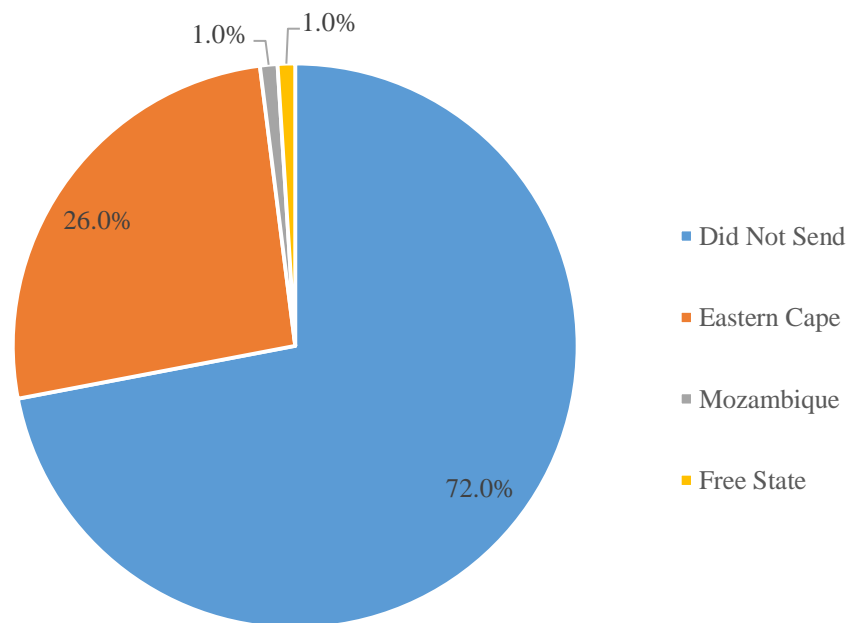


**Figure D.4: Sending Money to Friends or Relatives**
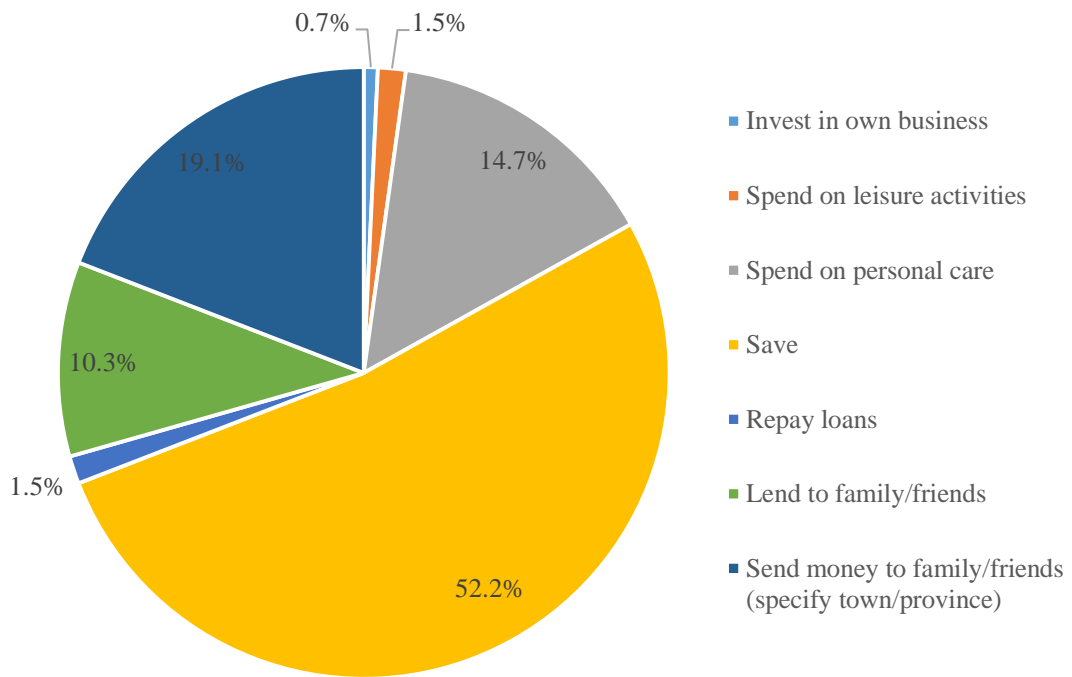
**Figure D.5: How households spend surplus money**
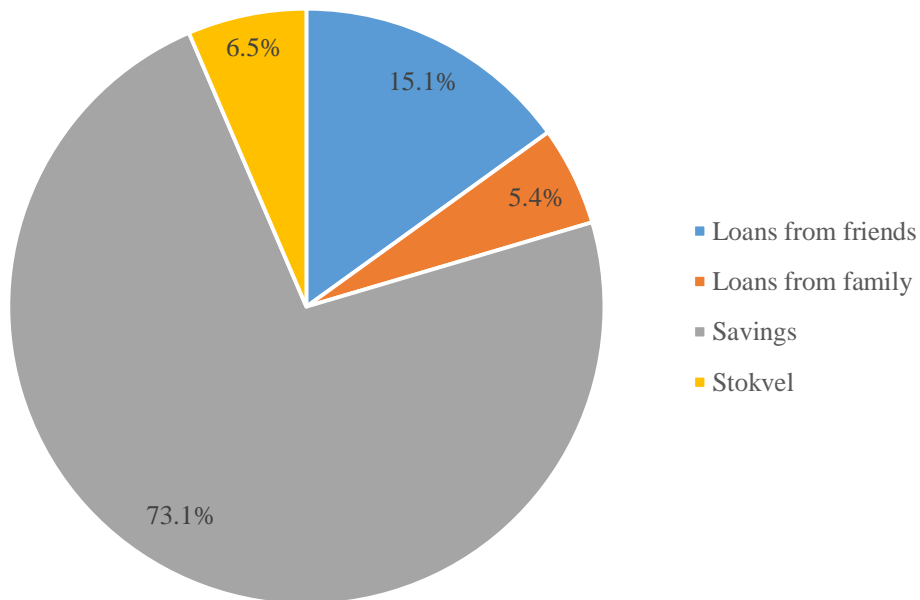


**Figure D.6: How Households Manage Cash Shortfalls**

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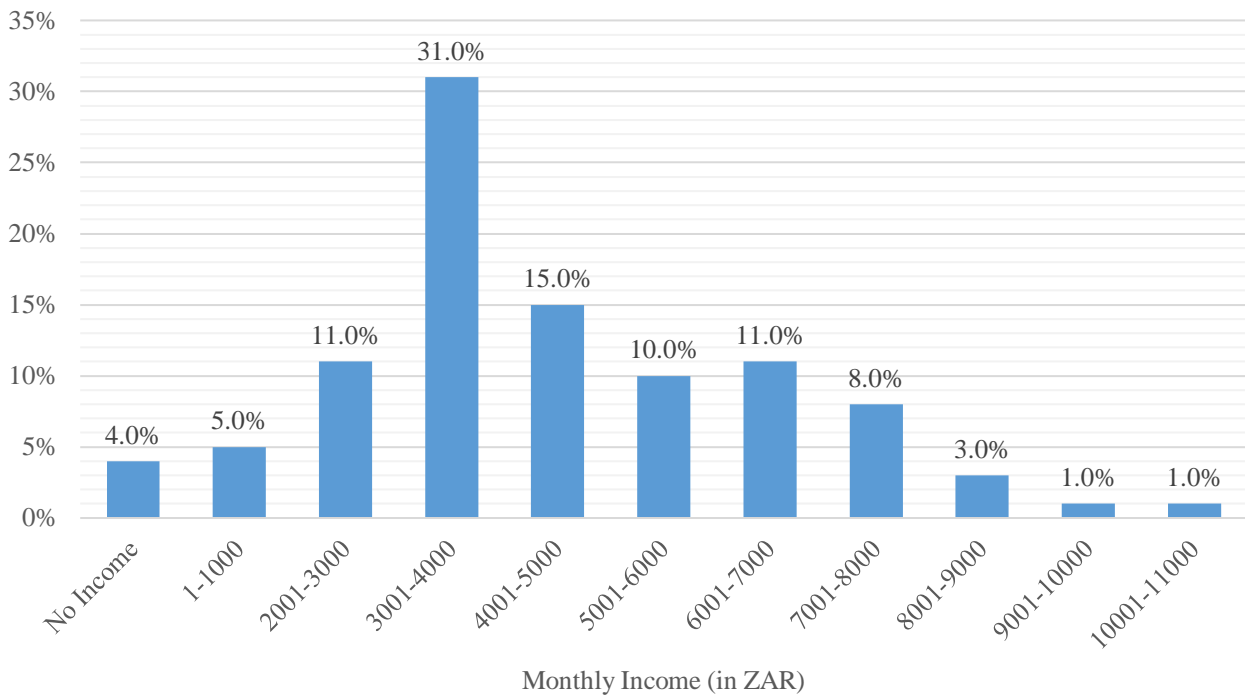
**Figure D.7: Monthly household income distribution**
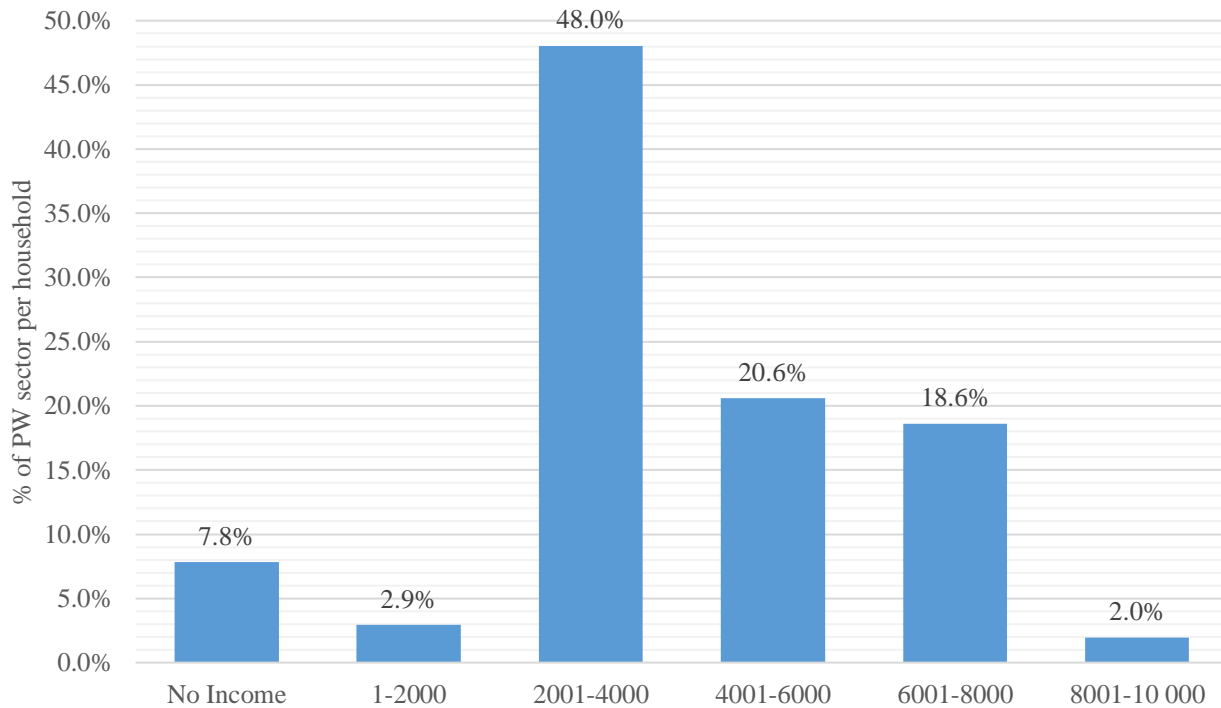


**Figure D.8: Monthly Paid Work (PW) Income from the Sampled Households**
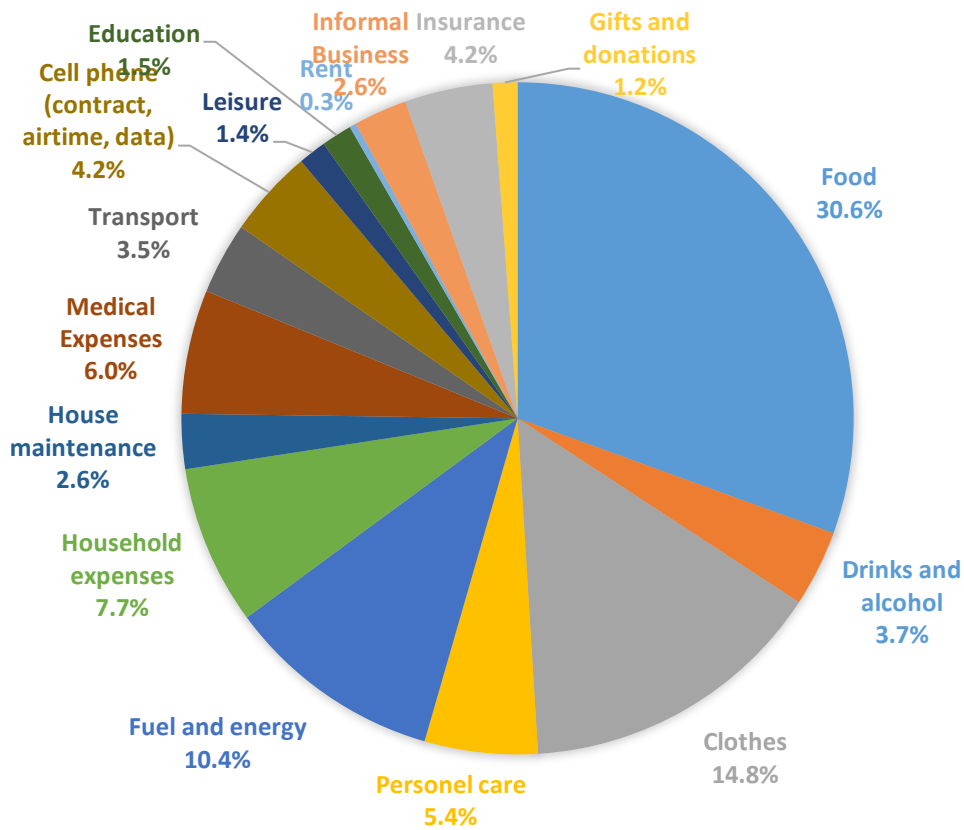
**Figure D.9: Household Monthly Expenditure**

# APPENDIX E: ENERGY RESULTS OF COMMUNITY SURVEY

## E.1 Household Energy Supply Mix and Fuel Expenditure
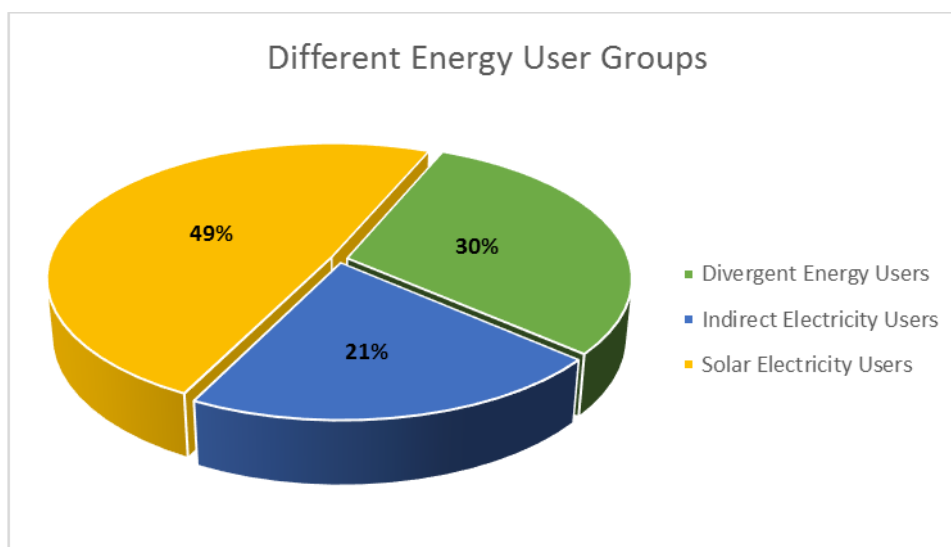


**Figure E.1 Proportion of Different Energy User Groups**

**Table E.1: Fuel Expenditure per Energy User Group**

| Energy User Group | Average Expenditure on Energy Supply Mix | Average Total Household Expenses | % of Expenditure of Total Expenses |
|---|---|---|---|
| **Divergent Energy Users** | ZAR 193 | ZAR 1,861 | 10.4% |
| **Solar Electricity Users** | ZAR 220 | ZAR 2,689 | 8.2% |
| **Indirect Electricity Users** | ZAR 294 | ZAR 2,960 | 9.9% |
| **All Users** | **ZAR 246** | **ZAR 2,497** | **9.9%** |

## E.1.1 Divergent Energy Users:
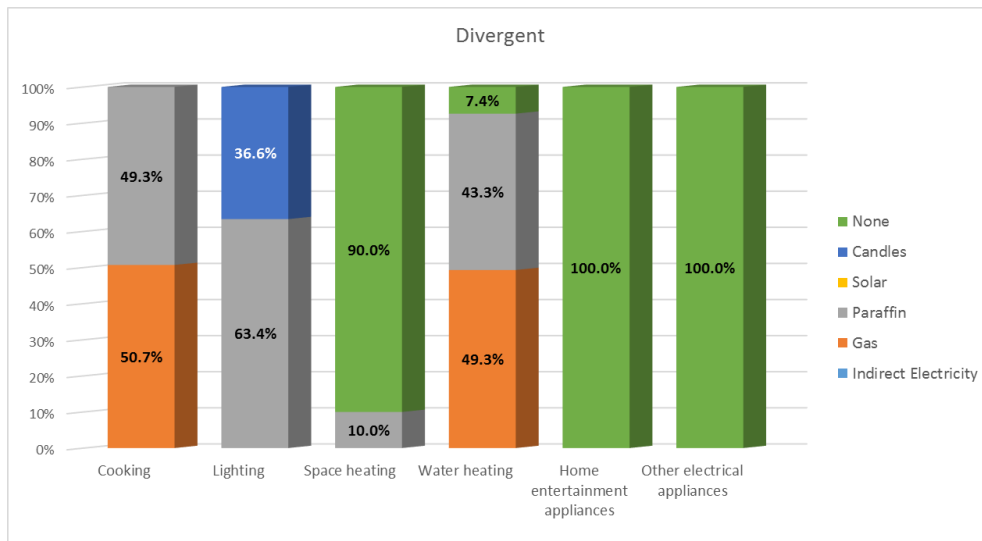


**Figure E.2: Divergent Energy Users – Energy Supply Mix for Different Energy Services**

**Table E.2: Divergent Energy Users Fuel Expenditure**:

|  | Total Monthly Household Income | Average Monthly Expenditure on Energy Supply Mix | Total Monthly Household Expenses | % of Energy Supply Mix Expenditure of Total Expenses |
|---|---|---|---|---|
| **Divergent Energy Users** | ZAR 3,005 | ZAR 193 | ZAR 1,861 | 10.4% |

## E.1.2: Indirect Electricity Users:
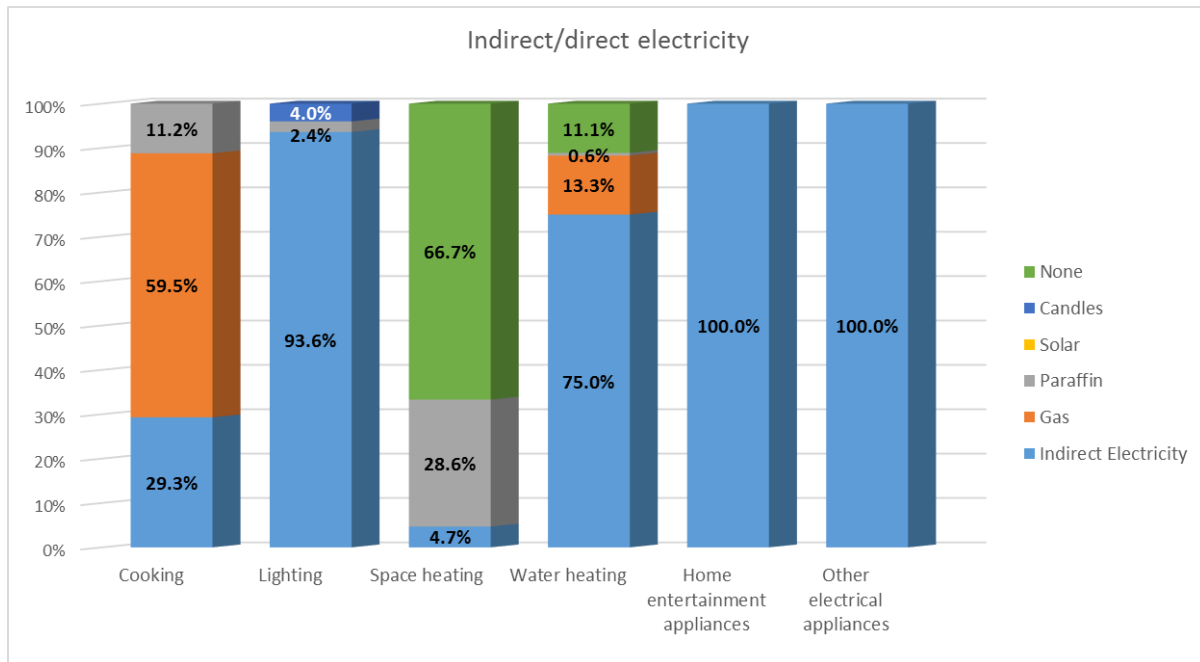


**Figure E.3: Indirect Electricity Users – Energy Supply Mix for Different Energy Services**

**Table E.3: Indirect Electricity Users - Fuel Expenditure**

|  | Total Household Income | Average Expenditure on Fuel Mix | Total Household Expenses | % of Expenditure of total Expenses |
|---|---|---|---|---|
| **Indirect Electricity Users** | ZAR 5,200 | ZAR 294 | ZAR 2,960 | 9.9% |

**E.1.3 Solar Electricity Users:**
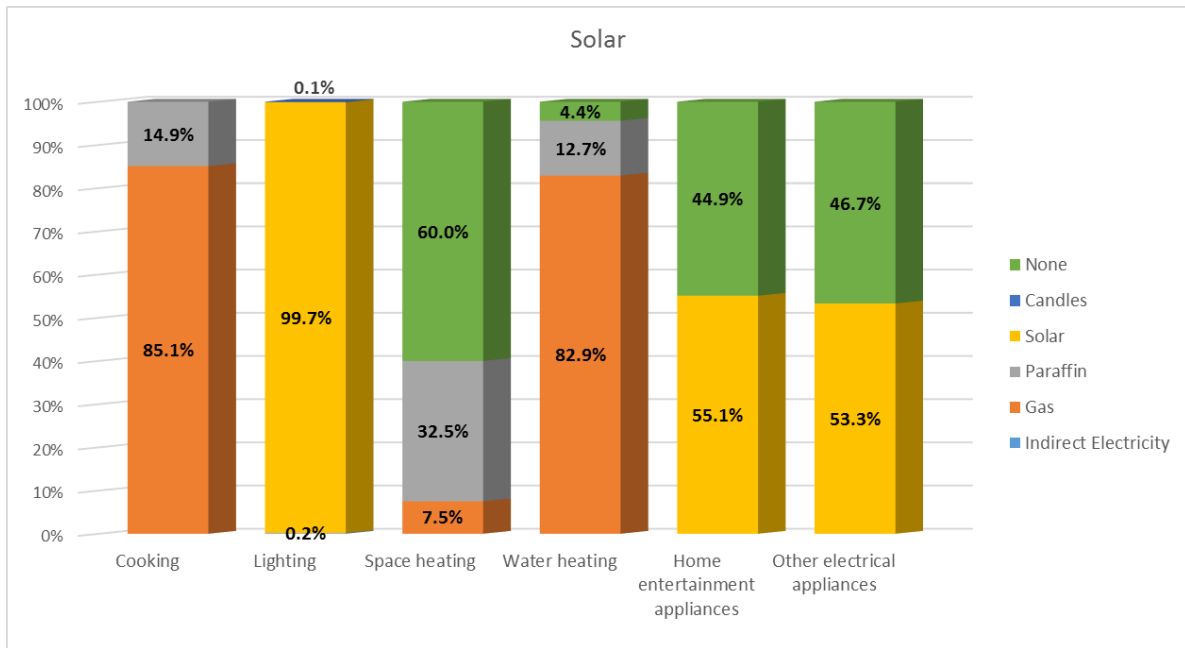


**Figure E.4: Solar Electricity Users – Energy Supply Mix for Different Energy Services**

**Table E.4: Solar Electricity Users - Fuel Expenditure**

|  | Total Household Income | Average Expenditure on Fuel Mix | Total Household Expenses | % of Expenditure of total Expenses |
|---|---|---|---|---|
| **Solar Electricity Users** | ZAR 4,896 | ZAR 220 | ZAR 2,689 | 8.2% |

# E.2 Gains and Pains Experienced by Different Energy User Groups

## E.2.1 Cooking

**Table E.5: Gains and Pains Experienced by Different Energy User Groups for Cooking**

| | Energy User Group | Energy Supplies Used | Propor-tion of Household Energy Supply Mix | Gains Experienced | | Pains Experienced | |
|---|---|---|---|---|---|---|---|
| | | | | Energy Supply & Energy-Supply Equipment | Energy-Using Products | Energy Supply & Energy-Supply Equipment | Energy-Using Products |
| **Cooking** | Divergent Energy Users | Paraffin | 49.3% | "it's cheap"; "lasts long" | Additionally "... good for warming my house"; "It's good for baking" | Not always available Have to travel far to purchase Gives a bad taste to food | Causes fire; "Makes chest burn" - smoke in the dwelling; "causes fever"; |
| | | Gas | 50.7% | "lasts for a month" | "it's very quick to cook"; "it's safe"; "easy to use"; Doesn't smell bad | "far where we get the" energy supply | "Can't see when the [energy supply] is finished"; "risk of fire" |
| | | Grid Electricity | - | "I want to use electric appliances" | "fast"; "easy to use"; "affordable" | | |
| | Indirect Electricity Users | Paraffin | 11.2% | - | Inexpensive Energy-Using Product | - | - |
| | | Gas | 59.5% | "stays for the whole month" - | "Quick to cook"; "safe"; "easy to use" | - | Expensive Energy-Using Product |
| | | Indirect Electricity | 29.3% | "I want to use my appliances"; | "safe"; "easy to use" | Not always available; Not reliable | - |
| | | Grid Electricity | - | "lasts long"; "can use all the appliances we have" | "fast for cooking" | - | - |
| | Solar Electricity Users | Paraffin | 14.9% | "cheap" | Additionally "... Makes house warm"; "baking bread" | - | - |
| | | Gas | 85.1% | - | "very quick for cooking"; "easy to use" | - | "can't see when it's running out" |
| | | Grid Electricity | - | "easy to find"; "affordable"; | "Fast to cook"; "easy to use" | - | - |

## E.2.2 Lighting

**Table E.6: Gains and Pains Experienced by Different Energy User Groups for Lighting**

| | Energy User Group | Energy Supplies Used | Proportion of Household Energy Supply Mix | Gains Experienced | | Pains Experienced | |
|---|---|---|---|---|---|---|---|
| | | | | Energy Supply & Energy-Supply Equipment | Energy-Using Products | Energy Supply & Energy-Supply Equipment | Energy-Using Products |
| **Lighting** | Divergent Energy Users | Paraffin | 63.4% | "Cheap and affordable"; "Lasts longer"; "Safer"; Secure against theft | "Bright" | - | |
| | | Candles | 36.6% | "Very cheap"; Gives good light; Quick lighting | - | - | Cause fire |
| | | Grid Electricity | - | "Bright"; "Easy to use"; "Can use a fridge" | - | "Too expensive" | - |
| | | Solar | - | "Right" | - | "Too expensive to install" | |
| | Indirect Electricity Users | Paraffin | 2.4% | - | - | - | - |
| | | Indirect Electricity | 93.6% | "Safe"; "Can use all appliances" | "Bright" "Easy to use" | - | - |
| | | Candles | 4.0% | - | - | "Not safe" | |
| | | Grid Electricity | - | - | "Can use all appliances" | Unavailable at times | - |
| | | Solar | - | Connection is legal | - | - | "Sometimes trips" |
| | Solar Electricity Users | Paraffin | 0.2% | Available when other sources fail | - | - | - |
| | | Solar | 99.7% | "Affordable" | "Very bright" | - | - |
| | | Candles | 0.1% | - | - | - | - |
| | | Grid Electricity | - | "Very cheap" | - | - | - |

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## E.2.3 Space heating

**Table E.7: Gains and Pains Experienced by Different Energy User Groups for Space Heating**

| | Energy User Group | Energy Supplies Used | Proportion of Household Energy Supply Mix | Gains Experienced | | Pains Experienced | |
|---|---|---|---|---|---|---|---|
| | | | | Energy Supply & Energy-Supply Equipment | Energy-Using Products | Energy Supply & Energy-Supply Equipment | Energy-Using Products |
| **Space Heating** | Divergent Energy Users | Paraffin | 10% | "Cheap"; "Easy to use" | "Warms house" | - | - |
| | | Gas | - | - | - | - | - |
| | | Grid Electricity | - | "Fast" | - | "Load shedding" | - |
| | | Solar | - | "Not expensive"; "No load shedding" | - | - | - |
| | Indirect Electricity Users | Paraffin | 28.6% | "Not expensive"; "Lasts long" | "Warms house"; "Can use it to bake" | - | - |
| | | Gas | - | - | - | - | - |
| | | Indirect Electricity | 4.7% | - | - | - | - |
| | | Grid Electricity | - | - | - | - | - |
| | Solar Electricity Users | Paraffin | 32.5% | "Affordable"; "Easy to get" ; Not fuel heavy - "does not use a lot" | "Warms house"; "Warms house and can cook at the same time" | - | - |
| | | Gas | 7.5% | - | - | - | - |
| | | Grid Electricity | - | - | - | - | - |

## E.2.4 Water heating

**Table E.8: Gains and Pains Experienced by Different Energy User Groups for Water Heating**

| | Energy User Group | Energy Supplies Used | Propor-tion of Household Energy Supply Mix | Gains Experienced | | Pains Experienced | |
|---|---|---|---|---|---|---|---|
| | | | | Energy Supply & Energy-Supply Equipment | Energy-Using Products | Energy Supply & Energy-Supply Equipment | Energy-Using Products |
| **Water Heating** | Divergent Energy Users | Paraffin | 43.3% | "Cheap and affordable"; "Easy to get" | "Good for cooking and baking" | - | - |
| | | Gas | 49.3% | "Very fast"; "Lasts long"; "Affordable" | - | Access limited | "Too expensive" |
| | | Grid Electricity | - | "Fast"; "Easy to use" | "Can use all appliances" | Access limited | - |
| | Indirect Electricity Users | Paraffin | 28.6% | "Affordable" | - | - | - |
| | | Gas | - | - | - | - | - |
| | | Indirect Electricity | 4.7% | "Fast" | - | - | - |
| | | Grid Electricity | - | "Fast"; "Easy to use" | - | - | - |
| | Solar Electricity Users | Paraffin | 12.7% | "Affordable"; Used as back-up energy source | "Heats water" | - | - |
| | | Gas | 82.9% | "Affordable"; "Less expensive" | "Fast"; "Easy to use"; "Lasts long" | "Cannot see when you will run out" | - |
| | | Grid Electricity | - | "Fast"; "Affordable" | Can use all electrical appliances | - | - |

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## E.2.5 Home Entertainment Appliances

**Table E.9: Gains and Pains Experienced by Different Energy User Groups for Home Entertainment Appliances**

| | Energy User Group | Energy Supplies Used | Propor-tion of Household Energy Supply Mix | Gains Experienced | | Pains Experienced | |
|---|---|---|---|---|---|---|---|
| | | | | Energy Supply & Energy-Supply Equipment | Energy-Using Products | Energy Supply & Energy-Supply Equipment | Energy-Using Products |
| **Home Entertainment Appliances** | Divergent Energy Users | Grid Electricity | - | - | - | - | - |
| | Indirect Electricity Users | Indirect Electricity | 100% | "Convenient" "Easy to use" | Allows usage of appliances; "Quality sound"; "Attracts customers" | Illegal connections unsafe | "Cannot use all appliances" |
| | | Grid Electricity | - | "Affordable" "Easy to use" | "Supports all appliances" | "Load shedding" | - |
| | Solar Electricity Users | Solar | 55.1% | "Not expensive"; "Convenient"; "Does not use much battery"; "Service is good"; "Lasts long"; "Loyal"; "Does not disappoint" | | "Only option"; "Challenges in winter" | "Give us more appliances" |
| | | Grid Electricity | - | | "Supports all appliances" | "Not connected" | |

## E.2.6 Other Electric Appliances

**Table E.10: Gains and Pains Experienced by Different Energy User Groups for Other Electric Appliances**

| | Energy User Group | Energy Supplies Used | Propor-tion of Household Energy Supply Mix | Gains Experienced | | Pains Experienced | |
|---|---|---|---|---|---|---|---|
| | | | | Energy Supply & Energy-Supply Equipment | Energy-Using Products | Energy Supply & Energy-Supply Equipment | Energy-Using Products |
| Other Electrical Appliances | Divergent Energy Users | Solar | - | "Easy to use"; "Cheap" | - | - | - |
| | | Grid Electricity | - | "Easy to use"; "Affordable" | "Appliances charge fast" | Dependent on neighbours'' supply | - |
| | Indirect Electricity Users | Indirect Electricity | 100% | "Powerful"; "Easy to use" | "Does not damage cellphone battery"  "Can use all appliances" | "Only option" | - |
| | | Grid Electricity | - | "Powerful" | "Can use all appliances" | Units run out; "Load shedding"; Cables get stolen | "All my things work with electricity" |
| | Solar Electricity Users | Solar | 53.3% | "Affordable"  Allows independence – don't have to bother others  "Easy to use"; "Cheap"; "Less expensive" | Can charge appliances at home; "Works with the sun" | "Only option"; "Only affordable option"; "Don't always have money" | "Challenges in winter" |
| | | Grid Electricity | - | "Fast"; "Easy to use" | "Can use all appliances" | - | - |

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# APPENDIX F: FOCUS GROUP

## F.1 Focus Group Consent Form

| | |
|---|---|
| **TITLE OF RESEARCH PROJECT:** | A Business Case for Renewable Energy Technology Leapfrogging in Informal Settlements |
| **REFERENCE NUMBER:** | SU-HSD-002753 |
| **PRINCIPAL INVESTIGATOR:** | GF (Rickus) Cronje |
| **ADDRESS:** | Cnr Banhoek Road & Joubert Street, Stellenbosch, 7600 Department of Industrial Engineering |
| **CONTACT NUMBER:** | 0764801515 |
| **EMAIL:** | 16983165@sun.ac.za |

**STELLENBOSCH UNIVERSITY**

**CONSENT TO PARTICIPATE IN RESEARCH**

_____

Dear participant

Kindly note that I am a Master's student in Industrial Engineering at Stellenbosch University. You are asked to participate in a research study entitled "A Business Case for Renewable Energy Technology Leapfrogging in Informal Settlements."

Please take some time to read the information presented here, which will explain the details of this project and contact me if you require further explanation or clarification of any aspect of the study.

## 5) Introduction:

The South African Government's strategies for alleviating energy poverty through the low-cost housing programme and the New Household National Electrification Strategy are slow to implement, keep households entrenched in energy poverty and is greatly dependent on fossil fuels. Some households have to wait up to decades to receive an electric connection, whose electricity may not be able to sustain throughout the month, leading them to make use of dangerous coping mechanisms such as paraffin and candles. There is a need for both interim and long-term solutions to the current strategy of grid expansion to alleviate energy poverty and provide safe and affordable "bundle of services" to residents of informal settlements

## 6) Purpose of the study:

Energy access enterprises could provide much needed solutions to the lack of energy provision in urban informal settlements. When compared to grid electricity, alternative forms of energy are notoriously challenging to adopt by end-users as they are seen as inferior. A business model development framework would assist an energy access initiative to take into consideration the needs of residents of informal settlements and offer them satisfactory value-adds.

This study therefore aims to contribute towards increasing the effectiveness and efficiency of energy access enterprises through the development of a business model framework that facilitates the business model design process.

## 7) Procedure:

**Voluntary participants will be presented and guided-through the researcher's developed business model development framework. There will, at all times, be an opportunity for clarification questions from the participants. There will be an opportunity provided for a quick break.**

**Participants will be ask to collaborate with other participants in populating the framework with ideas of solving an energy access challenge for a case study community. Thereafter participants will evaluate and provide feedback whether the framework is theoretically sound as well as its appropriateness and effectiveness for the South African and Enkanini context. This evaluation will be done through means of a questionnaire.**

## 8) Time:

The procedure will take 4 hours. The allocated time for the different activities are:
- Explanation and understanding of the framework – 1 hour
- Break – 15min.
- Population of the framework – 1.5 hours
- Break – 15min.
- Presentation of ideas as well as evaluation and feedback of the framework – 1 hour

## 5) Risks:

There are no negative effects for participating in the study.

## 6) Benefits:

There are no particular, direct benefits for participating in the study. However, by participating in the validation and verification of the framework, participants assist in contributing to a tool that can be used to decrease energy poverty in urban informal settlements of South Africa. Furthermore, the knowledge gained in the session as well as the framework (post publishing) could potentially be used by the participants in future endeavours.

## 7) Confidentiality:

All participants will be assigned an Identification Code (e.g. P7) that will ensure participant confidentiality. Participants will be referred to by their identification Code unless permission is otherwise given or as required by law.

**8) Questionnaire Answers & Recordings:**

The questionnaire answers will be recorded digitally. As to ensure accuracy of suggestions and recommendations, the evaluation and feedback will be recorded on a digital recorder. The participant may request to review and edit the recording.

**9) Data Storage:**

A participant's questionnaire answers and the corresponding recording will be stored on an online folder that is password protected. Only myself, and my three research supervisors will have access to the personal data of prospective participants.

**10) Participation and withdrawal:**

Participation is completely voluntary and withdrawal at any time during the research study can occur without any negative consequences. Participants can choose not to answer certain questions and still remain in the study.

Below you will be given the opportunity to participate in the survey and thereby indicate your consent. Note that your indication of your willingness to participate will be recorded solely so that we will know that we should not send you reminders in this regard.

| DECLARATION BY THE PARTICIPANT |
| --- |

If I choose to participate in this research project, it will automatically be assumed that I declare the following:
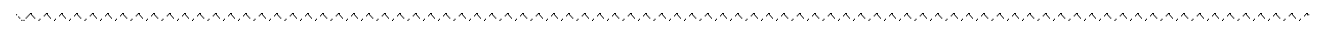
- o   I have read the above information and it is written in a language with which I am fluent and comfortable.

- o   I have had a chance to ask questions and all my questions have been adequately answered.

- o   I understand that taking part in this study is voluntary and I have not been pressurised to take part.

- o   I may choose to leave the study at any time and will not be penalised or prejudiced in any way.

- o   All issues related to privacy and the confidentiality and use of the information I provide have been explained to my satisfaction.

As the **participant** I would like to select the following option:

|  | I accept the invitation to participate in your research project, and if I decide to be <u>interviewed</u> it would automatically mean that I have given consent for my responses to be used confidentially and anonymously. |
| --- | --- |
|  | I decline the invitation to participate in your research project. |

If you have any questions or concerns about the research, please feel free to contact me at 076 480 15 15 or email 16983165@sun.ac.za. Alternatively, you can contact my research supervisor, Josephine Musango at (021) 881 3924 or email josephine.musango@spl.sun.ac.za.

**RIGHTS OF RESEARCH PARTICPANTS:** You may withdraw your consent at any time and discontinue participation without penalty.  You are not waiving any legal claims, rights or remedies because of your participation in this research study.  If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché [mfouche@sun.ac.za / 021 808 4622] at the Division for Research Development.  You have the right to receive a copy of this Consent form.

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**DECLARATION BY THE PRINCIPAL INVESTIGATOR**

As the **principal investigator** I hereby declare that the information contained in this document has been thoroughly explained to the participant.  I also declare that the participant has been encouraged (and has been given ample time) to ask any questions.  In addition I would like to select the following option:

|  | The conversation with the participant was conducted in a language in which the participant is fluent. |
|---|---|
|  | The conversation with the participant was conducted with the assistance of a translator, and this "Consent Form" is available to the participant in a language in which the participant is fluent. |

_____
**Signed at (place)**

_____     _____
**Signature of Principle Investigator**                              **Date**

## F.2 Framework Evaluation Survey

**Table F.1: Post-Focus Group Framework Evaluation Survey**

Rating scale: Strongly Agree = 5; Somewhat Agree = 4; Neither Agree nor Disagree = 3; Somewhat Disagree = 2; Strongly Disagree = 1

### 1) THIS SECTION CONCERNS THE DIFFERENT MODULES OF THE FRAMEWORK

#### 1.1) The Sustainable Development Indicators Table facilitates the following:

|  | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1.1.1) Establishing sustainability criteria for an energy provision enterprise |  |  |  |  |  |
| Please explain your response above |  |  |  |  |  |
| 1.1.2) Uncovering trade-offs between different sustainable development indicators |  |  |  |  |  |
| Please explain your response above |  |  |  |  |  |

#### 1.2) The End-User Centred Business Model Canvas (EUC-BMC) facilitates the following:

|  | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1.2.1) Designing an energy provision enterprise's entire business model on a high-level |  |  |  |  |  |
| Please explain your response above |  |  |  |  |  |
| 1.2.2) Uncovering trade-offs between the different EUC-BMC blocks |  |  |  |  |  |
| Please explain your response above |  |  |  |  |  |

#### 1.3) The Energy Value Proposition Canvas facilitates the following:

|  | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1.3.1) The Energy Value Proposition Canvas facilitates the designing of energy solutions and related value-adds that would be desirable to end-users |  |  |  |  |  |
| Please explain your response above |  |  |  |  |  |
| 1.3.2) The Energy Value Proposition Canvas and the guiding cards of Emili, Cheschin and Harrison (2016) worked together in a complementary manner |  |  |  |  |  |
| Please explain your response above |  |  |  |  |  |
| 1.3.3) The guiding cards designed by the researcher were useful in the generation of ideas in the Energy Value Proposition Canvas |  |  |  |  |  |
| Please explain your response above |  |  |  |  |  |

#### 1.4) The Partner Interaction Canvas facilitates the following:

|  | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1.4.1) Considering partner co-creation throughout the solution lifecycle |  |  |  |  |  |
| Please explain your response above |  |  |  |  |  |
| 1.4.2) Determining the feasibility of the solution(s) i.e. whether the solution(s) can be built/developed |  |  |  |  |  |
| Please explain your response above |  |  |  |  |  |
| 1.4.3) Determining (in conjunction with the End-User Journey Canvas) the financial viability of the energy provision enterprise |  |  |  |  |  |
| Please explain your response above |  |  |  |  |  |

**1.5) End-User Journey Canvas facilitates the following:**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1.5.1) Designing the various touchpoints with End-Users before, during and after the service journey | | | | | |
| Please explain your response above | | | | | |

**1.6) The Value Mapping Table facilitates the following:**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1.6.1) Including the perspective of multiple actors and stakeholders | | | | | |
| Please explain your response above | | | | | |
| 1.6.2) Identification of various forms of value (positive or negative) within the developed value proposition | | | | | |
| Please explain your response above | | | | | |
| 1.6.3) Uncovering trade-offs concerning value for multiple stakeholders | | | | | |
| Please explain your response above | | | | | |

**2) THIS SECTION CONCERNS THE DEVELOPED FRAMEWORK**

| | Yes | No |
|---|---|---|
| 2.1) Are the different Framework modules the correct modules to use for the development of a sustainable Product-Service System (PSS) business model for an energy provision enterprise (whether in the private or public sector) in a South African urban informal context? | | |
| Please explain your response above | | |

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 2.2) Do you agree with the following statement: The different relationships of the modules to one another are clear? | | | | | |
| Please explain your response above | | | | | |
| 2.3) Do you agree with the following statement: The Framework facilitates the development of a sustainable Product-Service System (PSS) business model for an energy provision enterprise in a South African urban informal context? | | | | | |
| Please explain your response above | | | | | |
| 2.4) How can the Framework be improved for the South African urban informal, energy access context? | | | | | |
| 2.5) Any other comments? | | | | | |

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