Factors influencing household energy transition to LPG in JTG District Municipality, Northern Cape, South Africa.

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DECLARATION

I, Jane Kelebogile Nkadimang, with student number [redacted], declare that this dissertation was composed and written by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

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ABSTRACT

South Africa is at the nexus of transforming the energy sector at an accelerated pace with a transformative and radical approach. Given the country's pursuit of reducing carbon emissions and managing the current energy crisis through a diversified energy mix for households, the outcome will lead to reduced reliance on a single energy source such as electricity, or dependence on harmful and unclean energy sources. For the country to achieve this energy mix, this study acknowledges the role LPG could play in reducing energy poverty by exploring the various factors impeding greater adoption of LPG. The study of rural household fuel choices and fuel-switching patterns can influence the improvement or development of local policies to support practical initiatives aimed at safe and sustainable energy transition processes in rural households. Using quantitative research methodology, 301 respondents from rural villages in the JTG District Municipality in the Northern Cape Province of South Africa participated in the survey. The descriptive statistical results revealed that factors other than income, affordability, and safety drive energy transition to LPG, particularly in rural households. The energy use patterns aligned with contemporary energy stacking theory, as rural households' energy choices were driven not only by income, but also by availability and functionality. The key finding of the study included the following additional factors as drivers of energy transition to LPG: type of dwellings, family size, access to the LPG market, cylinder size, and education level, all of which influence the perceptions households hold about the usage and benefits of LPG. The study recommends key interventions which include LPG energy fund subsidies for indigent households, policy review, the development of a dedicated LPG rollout strategy at the local government level, and a strategy to participate in the South African Carbon Offset programme. Other practical interventions include market development to improve access to LPG in communities and create local employment and new LPG-supply small businesses as well as marketing or awareness campaigns.

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To my nieces, Thandi Diphatse, Khumo Nkadimang, and Zimkhona and Mbali Masuku, I dedicate my MBA to you. Remember that if Aunty-Janey could do it, so can you. Not even the sky is the limit. I love you, and I believe in you.

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CHAPTER 1: INTRODUCTION AND BACKGROUND OF STUDY

1.1 INTRODUCTION

Less than 200 million people in sub-Saharan Africa currently have access to clean energy options such as liquefied petroleum gas (LPG), natural gas, electricity or improved biomass stoves (International Energy Agency, 2019). This is an alarmingly low number, considering that the total population size of sub-Saharan Africa is recorded by The World Bank (2021) to be just over 1.1 billion. This implies that the majority depend on harmful and unclean energy. According to the International Energy Agency (2019), almost 850 million people in sub-Saharan Africa rely on the traditional use of biomass, while another 60 million rely on kerosene or coal to meet their daily energy needs (International Energy Agency, 2019). This phenomenon of citizens lacking access to modern energy services essential for human development is defined as Energy Poverty. In the context of South Africa (SA), this includes household access to electricity, clean cooking, and heating facilities (Ismail, 2015*)*.

Researchers and policymakers are increasingly recognising gas as part of efforts to reduce energy poverty and attain universal energy access (Kojima, 2011). Gas, such as Liquid Petroleum Gas (LPG), is widely accepted as a modern energy carrier for use in both urban and rural households, particularly because of its ability to provide clean fuel which can be beneficial for the environment and health when applied as household energy (Rosenthal *et al.*, 2018; Kojima, 2011). These modern fuels are considered important enablers of social and economic development (Van der Koon *et al*., 2013) and according to Government, the LPG industry can offer immediate and cost-effective energy solutions to households (Department of Mineral Resources and Energy, 2021). Furthermore, switching between primitive fuels such as firewood, to transitional fuels such as coal, and advanced fuels such as electricity and LPG, has a major impact on the energy system of a country and its economic development (Ripple, 2007; Lay *et al*., 2013). Therefore, household energy choice and fuel switching are central to the concept of household energy transitions (Van der Kroon *et al*., 2013).

This study and others have found that the choice of household energy can be in the form of the 'energy ladder' or 'energy stacking' models (Kowsari & Zerriffi. 2011; Van der Kroon *et al*., 2013; Israel-Akinbo *et al*., 2018), or in the form of a multiple-fuel model, as proposed by Masera *et al*. (2000). Given that the presence of the energy ladder or stacking transition patterns (or the multiple fuel model) could lead to different sets of conclusions and policy recommendations, it is imperative to understand the factors leading to energy transitions in rural households when designing suitable interventions to eliminate energy poverty in rural areas and develop relevant policies to support the energy transition process (Israel-Akinbo *et al*., 2018).

Against this backdrop, this research established which factors contribute to the slow energy transition to LPG in rural households. Based on these findings, it is envisioned that the study will enable industry and government to align their energy policies and the LPG rollout strategy appropriately with energy transition patterns of rural households based in villages across South Africa, particularly for LPG. This study also explored various interventions required to accelerate and promote LPG adoption in rural communities. This switch to LPG for household thermal needs is imperative, as research so far has found that shifting to modern energy fuels, such as LPG and electricity, has a direct positive impact on the welfare of citizens and contributes towards eradicating energy poverty (Kowsari & Zerriffi, 2011; Israel-Akinbo *et al*., 2018). If interventions such as ensuring the use of cleaner fuels and cooking methods and technologies are implemented properly and sustainably, progress towards the five UN 2030 Sustainable Development Goals (SDGs) can be accelerated (Rosenthal *et al*., 2018).

Similar existing research has focused on the description of household energy choice patterns and attempted to identify the determinants of household energy transition beyond income (Masera et al., 2000; Van der Kroon et al., 2013). Other researchers have found that there are mainly two factors, namely, cost and safety (IEA, 2019; Sustainable Energy Africa, 2017) that inhibit the adoption of LPG. Mehlwana and Qase, (1998) found in their study, and others before, that there are other factors, beyond economic reasons, which inform households how to make energy choices. They advance the argument that household decision-making cannot be fully understood without considering the context of sociocultural and political-economic situations, which will be the approach of the researcher. This study discovered other factors that explain this phenomenon by focusing on factors driving or impeding the energy transition of LPG in rural communities.

This research focused on 301 rural households in the municipal district of John Taolo

Gaetsewe (JTG) in the Northern Cape Province of South Africa. This is the first study in South Africa to focus on the drivers of energy substitution of traditional fuels with LPG (a modern fuel source) in the rural household sector, particularly on a large scale. This study provides a framework to understand household energy choices in the villages of JTG District Municipality and presents factors inhibiting the transition towards safer modern thermal sources such as LPG.

This chapter provides an overview of the research problem, including the background that laid the foundation for the purpose, objectives, and reasons why this study is significant. An overview of the research methodology informing the research is briefly discussed (with more detail provided in Chapter 3), followed by the limitations of the study, structure of the chapters, and finally the conclusion.

1.2 BACKGROUND OF STUDY

Approximately 2.6 million humans in developing and least developed countries have died prematurely from household air pollution (HAP) from using dirty fuel (or solid fuel) for household energy (Health Effect Institute, 2018). The use of such energy methods harms the health of society, the environment, and the economy (Van der Kroon *et al.*, 2013). Consequently, the United Nations SDG aims to ensure universal access to reliable, affordable, and modern energy services by 2030. This is one of the main reasons why LPG rollouts in rural communities must be prioritised. However, according to LPG South Africa (2020), the benefits of LPG in South Africa, include relieving pressure on the strained national electrical grid, improving health and safety for citizens (particularly women and children), and curtailing energy poverty, have been greatly underplayed.

According to Sustainable Energy Africa (2017), to successfully address energy poverty for the poor and marginalised, it is essential that the energy use patterns of low-income households be well understood. This study addresses the energy use pattern of rural households and how this influences their energy transition to LPG as a modern fuel over traditional fuels. While South Africa has comparatively manageable levels of energy poverty compared to most African countries, it is still struggling with the development of the economy to the extent that it can support poor people to survive energy poverty (Ismail & Khembo, 2015).

Globally, there is more acceptance for nations to provide their citizens with energy solutions which meet all their energy needs in a functional and sustainable way (UN, 2015). It is highly imperative for households to receive energy in the most appropriate and practical form to fully address their needs (Sustainable Energy Africa, 2017). Energy sources must be consumed appropriately for the services they provide, such as lighting, cooking, cooling, heating, and the production of goods and services (UNDP, 2000). Therefore, governments cannot merely connect households to electricity (UN, 2015) and imagine that this is the answer to all energy demands. The South African government, through the National Development Plan, does make reference to the fact that poor households have wider energy needs, which necessitates an integrated program which will address energy poverty (National Planning Commission, 2012), and the Department of Energy (DoE) is currently working on the development of an Integrated Household Energy Policy (Sustainable Energy Africa, 2017).

The previous sections provided a brief definition and context of energy poverty in South Africa and a synopsis of the benefits of LPG in alleviating energy poverty. The following sections explore household energy transition patterns and related energy theories, followed by South Africa's LPG consumption patterns, and finally, the status of energy poverty and policies at the municipal (JTG District Municipality), provincial (Northern Cape Province), and national levels.

1.3 AIM OF THE STUDY

The aim of this study was to determine the various factors contributing to the slow energy transition towards LPG in rural households in South Africa, with a specific focus on the Northern Cape Province.

1.4 PROBLEM STATEMENT

The literature is unequivocal regarding low adoption of LPG in rural communities, particularly in South Africa. Other researchers have found that the contributing factors include the availability of LPG and household finances (Quinn *et al.*, 2018), whereas other studies advocate for broader research beyond presenting income as the leading factor affecting households' energy choices (Van der Kroon *et al.*, 2013). In view of the latter, this study focused on identifying broader factors affecting the energy transition towards LPG as an alternative source of energy, particularly in rural communities in the Northern Cape Province. The above factors and others are explored further in Chapter 2.

1.5 RESEARCH QUESTIONS

Based on the above problem statement, the main research question was framed as follows:

What factors contribute to the slow energy transition towards LPG in rural households?

The following sub questions were investigated to address the main research question:

- What profiles of rural people in Northern Cape Province determine household energy choices?
- What economic, social, and other external factors influence rural households' energy choices in the Northern Cape?
- What recommendations can be made to assist municipal and provincial management in drafting a regional LPG rollout strategy and promoting household transition to LPG in the rural areas of Northern Cape?
- What recommendations can assist the LPG industry, wholesalers, and retailers in improving the supply of LPG to the customer base of the Northern Cape?

1.6 RESEARCH OBJECTIVES

1.6.1 Primary objective

To determine the factors contributing to the slow energy transition towards LPG in rural households.

1.6.2 Secondary objectives

- To determine the profiles of rural people in the Northern Cape Province, who determine household energy choices.
- Determine the economic, social, and other external factors influencing the energy choices of rural households in the Northern Cape.
- To draw conclusions about the various factors contributing to rural household energy choices.
- To provide recommendations that can assist the LPG industry, wholesalers and

retailers should improve the supply of LPG to the customer base of Northern Cape.

1.7 SIGNIFICANCE OF THE STUDY

The study is significant to various stakeholders, as the knowledge of the factors contributing to the slow energy transition towards LPG in rural areas will bring insights into the attitude of rural consumers towards LPG, the extent to which they know about the benefits of using LPG, and the various factors influencing the energy choices of rural households. This study will provide local governments, wholesalers, retailers, and distributors with market insights into perceptions, preferences, and socio-economic factors contributing to the slow energy transition to LPG in rural communities.

1.8 OVERVIEW OF THE RESEARCH METHODOLOGY AND DESIGN

This study used a quantitative approach. The questionnaire (see Annexure C) was adapted from the Journal of the Geographical Association of Tanzania (2020) and comprised of 40 closed-ended questions. To accommodate the different literacy levels of all the participants, the questions were translated into the local language of Setswana. The questions were rated on a 5-point Likert scale ranging from strongly agree to strongly disagree. A pilot study of 10 randomly selected participants from the village of Gamotlharo (also known as Batlharos village) was conducted, and data were collected from a sample size of 362 municipal residents, calculated using a Survey System software calculator from a population size of 261 363 JTG District Municipality residents. Only 301 questionnaires were considered viable for this study. The collected data were captured in Microsoft Excel and exported to the Statistical Package for Social Scientists (SPSS) version 28.0. Data analysis involved performing descriptive statistics to analyse the profiles of the participants and to determine the frequencies related to each of the variables constituting the factors and factor analysis. The results are presented as graphs, tables, bar charts, and pie charts. Finally, correlations were determined between these factors and how they relate to the adoption of LPG in the Northern Cape. Further details regarding the research methodology and techniques of data collection and analysis are provided in Chapter 3.

1.9 DEMARCATION OF CHAPTERS

This paper has five chapters which are divided as follows:

Chapter 1 provides an introduction and background to the study and an outline of the research problem, questions, and subsequent objectives. It also provides an overview of the different methods and techniques employed by researchers for data collection and analysis. Chapter 2 highlights the theoretical framework underpinning the study and provides key literature related to LPG adoption from both local and international perspectives. Chapter 3 offers more details on the research methods and techniques of data collection and analysis which addresses the research problem defined in Chapter 1. Chapter 4 analyses and discusses the results of the collected data and identifies the differences and similarities which may exist between primary data and the literature. Chapter 5 provides a consolidation of the analysed data and offers recommendations and conclusions of the study.

1.10 CONCLUSIONS

Fuel transition towards cleaner and more efficient fuels, such as LPG, is widely accepted in developed countries, whereas it is generally lower in developing countries. The fuel choice for LPG in South Africa was found to be comparatively lower, particularly in low-income rural households. Therefore, the main aim of this study was to determine the various factors contributing to this slow transition towards LPG in rural households in South Africa, with a particular focus on the Northern Cape Province.

This chapter presented the main objectives of this study, including an overview of the research methodology. The quantitative data collection methodology used entailed households in the village answering a series of close-ended questions from a questionnaire. Following the clear foundation of the study, the next chapter critically reviews the related literature.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The previous chapter provided the foundation for the study, which aimed to establish the various factors contributing to the adoption of LPG in rural households. The purpose of this study is to answer the fundamental research questions of whether the profiles and household characteristics of the rural people in the Northern Cape province, along with their socio-economic standing and other external decision contexts, influence their fuel choices and how this relates to the adoption of LPG. The structure of this chapter is twofold: the first part will postulate the theoretical foundations underpinning the study, whereas the second part will provide a critical analysis of related literature, specifically on LPG adoption in developing countries, the underlying household fuel choices as they relate to the adoption of modern fuels, the country's external environment, and how these concepts fit into the debate. The topics covered in this chapter are organised as follows: LPG consumption, energy transition models, drivers of energy transition in developing countries, and LPG adoption in SA.

2.2 LPG AS A MODERN FUEL

The use of LPG has been cited by the World Bank as one of several pathways for countries to meet the United Nations' sustainable energy goal of providing universal access to clean cooking and heating by 2030 (Kojima, 2011). LPG has been proven to provide clean fuel with both environmental and health benefits, particularly for household energy use (Rosenthal *et al*., 2018). Its exceptional properties have led to its widespread use as a cleaner fuel for domestic heating and cooking. However, further to these applications, it is also utilized in the industrial, commercial, agricultural and automotive sectors (WLPGA, 2017). The following sections provide the context of the LPG market in South Africa.

2.2.1 LPG Market

LPG is a by-product of the petroleum refining process which consists of butane, propane, or a combination of both, and is suitable for cooking, heating spaces, and water (LPG South Africa. 2020). The supply of LPG has mainly been from local refineries, and according to LPG South Africa (2020), it has not been consistent, reliable, or sizeable enough to absorb volatile seasonal demands. Local refineries produce over 80% of the LPG consumed in SA annually, whereas the rest are imported (Competition Commission of SA, 2017). For a long time, the industry struggled to mitigate the inconsistent supply experienced in the market; however, since 2017, there has been a launch of new open-access LPG import and storage terminals from private companies, such as Sunrise Energy (Saldanha Bay) and Bidvest (Richards Bay) which should ease spikes in demand (LPGSA. 2020), particularly during winter seasons and during persistent or harsher ESKOM load shedding stages. According to Sunrise Energy CEO Pieter Coetzee, LPG can provide South Africa with a more favourable energy mix, particularly given that "LPG is between 20% and 50% more cost effective than electricity" for both household thermal needs and light commercial businesses (LPGSA. 2020).

2.2.2 LPG Supply Chain

Because LPG can be easily liquefied, it provides a wide variety of packaging and storage options which can also be easily transported to various markets and remote customers (World LPG Association, 2022). Accordingly, it is an ideal additional power source for rural areas, as it is a widely available and easily scalable clean fuel for household energy use (Rosenthal *et al.*, 2018). The supply and production of LPG include various stakeholders along the value chain. According to the Competition Commission of SA (2017), these include refineries, dealers, distributors, wholesalers, retailers and consumers. In the South African context, producers are involved throughout the supply value chain which includes the acquisition of crude oil, all the way up to the retailing of cylinders). On the other hand, there are major distributors and wholesalers that mainly get involved only on the downstream business of storage, bottling, transportation, and distribution of LPG (Competition Commission of SA, 2017). Some dealers and retailers participate in the refilling of cylinders and sell them to household end-users or small industrial or commercial customers. Figure 2.1 is an illustration of the South African LPG supply chain.

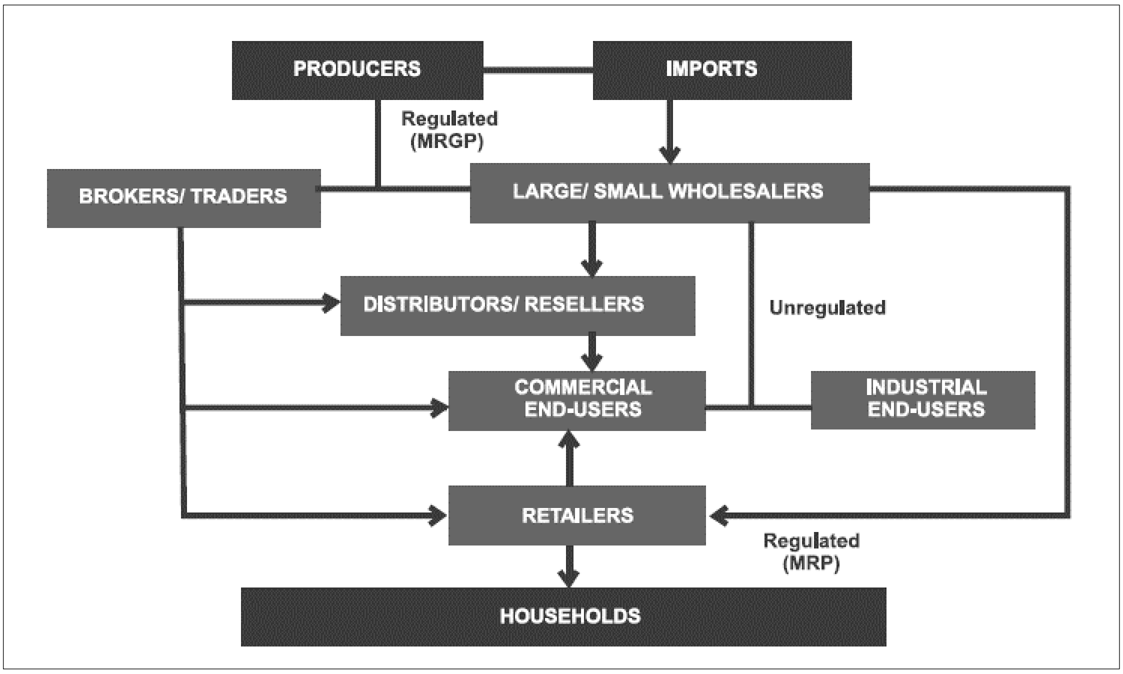

Figure 2. 1: LPG Supply Chain

Source: Commission's classification (Competition Commission of SA, 2017)

2.3 LPG CONSUMPTION

As previously mentioned, the consumption or adoption of LPG in South Africa is very low. The following sections unpack the current situation in South Africa compared to other developing countries.

2.3.1 Consumption of LPG in SA

According to the World LPG Association (2017), nearly half of the global demand for LPG comes from the domestic or residential sector. In this industry, LPG replaces conventional fuels such as wood, charcoal, animal waste, coal, and paraffin, where it offers the greatest benefits. According to the International Energy Agency (2019), bioenergy accounts for nearly two-thirds of the energy source in sub-Saharan Africa. Further across Africa, households mostly depend on the use of unclean energy sources for their household activities (Statistics SA, 2018). In the SA context, according to the White paper on the Renewable Energy Policy (2004), the household energy mix includes firewood and electricity, followed by paraffin, LPG, and coal (Department of Minerals and Energy, 2004). For both the household and commercial sectors, these fuels are primarily used for thermal heating and processing. The majority of disadvantaged and poor South Africans residing in rural and peri-urban areas rely on wood, kerosene, coal, and charcoal for cooking

(Davidson *et al.*, 2016). However, studies on SA reveal that, mostly in rural communities, consumption of LPG is low, and according to the Competition Commission SA (2017), SA is far behind, both globally and within the continent. See Figure 2.2 and Figure 2.3. According to the Department of Energy (2016), the households mostly utilise household energy mostly for cooking at 38%, heating space at 28%, heating water at 20% and the least consumption is for lighting at 5%. Further studies by the Department of Energy (2012) found that household LPG use synchronises with household income level and living standards.

On a global LPG consumption ranking scale, SA was ranked 61st by the Review of Global LP Gas (2014) and 6th on the African continent (Competition Commission SA, 2017). Studies also reveal that countries with a similar GDP per capita as SA, such as India and Brazil, consume exponentially higher levels of LPG at approximately 20 kg per capita annually compared to the lower consumption of SA's of approximately 7 kg per capita on an annual basis (Coetzee, 2021).

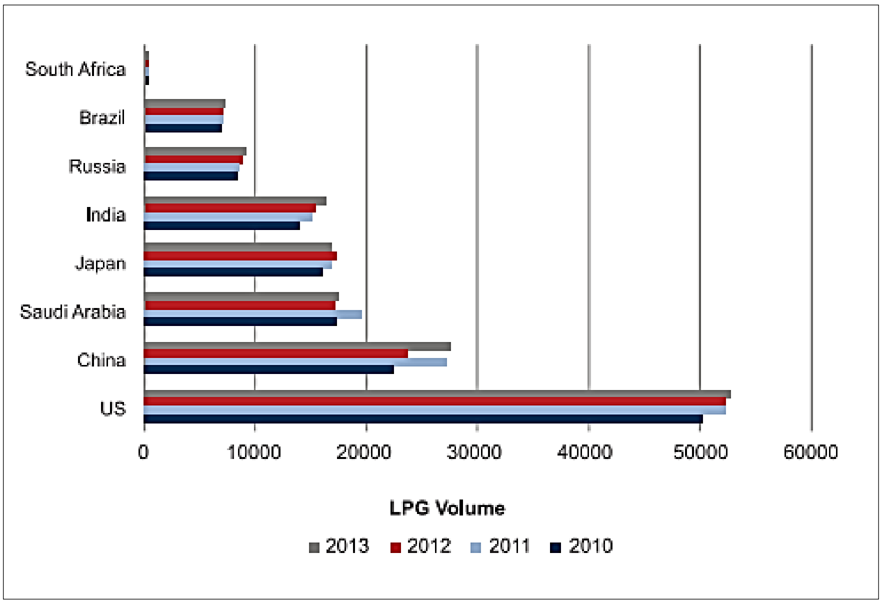

Figure 2. 2: Consumption of LPG in SA relative to other countries (2010 - 2013, 1000 tons)

Source: Argus Statistical Review of Global LPG, 2014

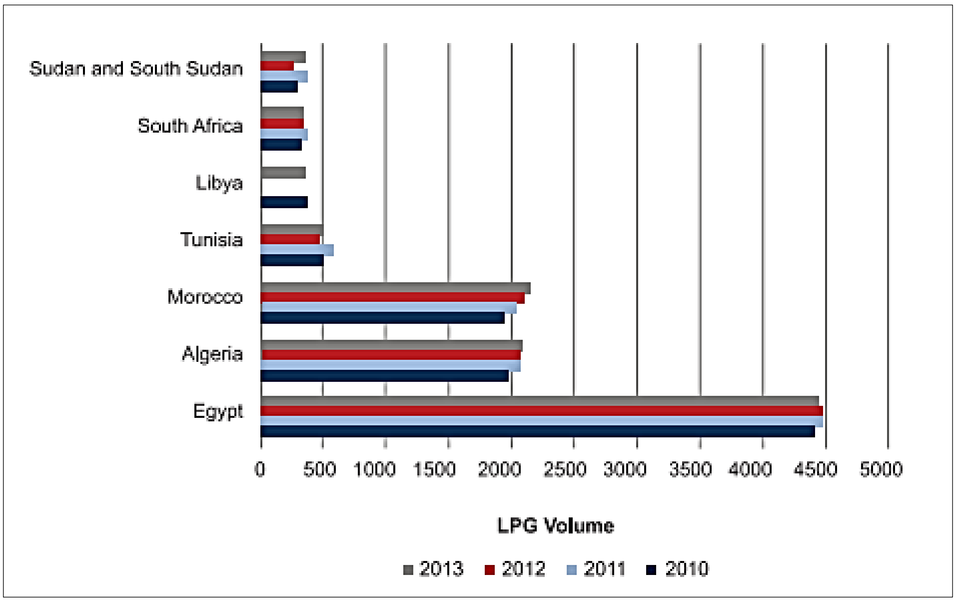

Figure 2. 3: Consumption of LPG in SA relative to other African countries (2010 - 2013, 1000 tons)

Source: Argus Statistical Review of Global LPG, 2014

The country's consumption of LPG used for heating and cooking started increasing around 2005 because of the rolling electricity blackouts (Kamemia & Annegarn, 2016:151). The government requires all local consumers to reduce their dependence on electricity and consider alternative energy sources for household cooking and heating (Department of Mineral Resources and Energy 2021:17). However, SA's low consumption indicates that the country has not taken full advantage of the solutions that LPG can provide during the current energy crisis. According to the Department of Mineral Resources and Energy (2021), the consumption of LPG has not sufficiently increased to offer a meaningful solution for the current energy crisis experienced in SA.

Nonetheless, the positive news is that the demand for domestic LPG will continue to rise steadily between 2010 and 2050 (Department of Energy 2016). On the other hand, the Department of Energy (2016) expects the demand for paraffin to decrease and be almost negligible by 2025, whereas coal demand will continue to increase in the industrial sector, but decline in the residential sector. This change in energy demand can be attributed to improvements in household incomes.

2.3.2 Consumption of LPG in JTG District Municipality

JTGDM IDP (2022) reported that in 2016, the total population with access to electricity was approximately 90% which is an increase of 2% since 2011.

Regarding fuel source household use, the JTGDM IDP (2022) reported the following statistics:76% of households used electricity for their cooking needs, 74% used electricity as their fuel source for heating, and 90% used electricity as their fuel source for lighting.

Table 2.1 below provides a further breakdown of the energy consumption for cooking, which includes LPG and other sources of energy.

Table 2. 1: Main source of energy for cooking

Source: Statistics SA, 2011

	Joe Morolong	Ga-Segonyana	Gamagara	John Taolo Gaetsewe
Electricity from mains	49 867	88 951	45 876	184 693
Other source of electricity (e.g. generator; etc.)	54	32	112	197
Gas	2 190	9 310	4 088	15 587
Paraffin	1 038	1 267	1 064	3 370
Wood	30 679	4 594	2 084	37 358
Coal	41	-	-	41
Animal dung	117	4	-	121
Solar	-	-	147	147
Other	61	-	24	84
None	145	114	261	519
Unspecified	9	136	-	145

Table 2.2 below provides a further breakdown of the energy consumption for lighting, which includes LPG and other sources of energy.

Table 2. 2: Main source of energy for cooking

Source: Statistics SA, 2011

	Joe Morolong	Ga-Segonyana	Gamagara	John Taolo Gaetsewe
Electricity from mains	74 203	94 596	48 794	217 593
Other source of electricity (e.g. generator; etc.)	80	418	62	560
Gas	29	84	47	160
Paraffin	270	2 303	334	2 907
Candles	8 984	6 182	3 752	18 918
Solar	129	477	465	1 071
Other	136	108	-	243
None	141	12	180	333
Unspecified	228	228	23	479

Employment profile:

The JTGDM IDP strategy document reported that the unemployment rate in the district was 30% (Statistic SA,2011). However, it is important to recognise that, according to the report, this did not account for discouraged job seekers, whose inclusion would raise the unemployment rate to 47% (JTGDM IDP, 2022). According to the report, the Joe Morolong local municipality has the highest unemployment rate in the district at 40%, and the municipality with the lowest unemployment rate is the Gamagara Municipality with an unemployment rate of 18%.

Income profile:

Almost 41% of the population in the district does not have a monthly income, while approximately 24 percent earn less than R400 per month (JTGDM IDP, 2022). These numbers demonstrate that the district's economy is in a very dire state which has an impact on fuel choice. According to the report, Gamagara is in a better position than any other local municipality. Comparatively, around 32% of residents in Gamagara do not have a source of income, compared to 44% in Ga-Segonyana, and 42% in Joe Morolong.

2.4 ENERGY POVERTY IN SOUTH AFRICA

The World Economic Forum (2010) defines energy poverty as "a lack of access to sustainable modern energy services and products", whereas other studies describe energy poverty as households' lack of access to clean cooking facilities and electricity, and energy poverty in developing countries mostly emphasises the need for electrification for low-income households both in rural and peri-urban settlements (Dinkelman, 2011). To address the eradication of poverty, the democratic South African Government made it its mission to increase household accessibility to modern energy sources, particularly for low-income households (Department of Energy, 2013). However, despite these efforts by the government, energy poverty and social well-being of poor households have not improved significantly (Godfrey *et al.,* 2016). Understanding the state of energy poverty in both rural and urban households, particularly low-income households, continues to be important (Israel-Akinbo *et al*., 2018).

According to Hailu (2012), the use of energy subsidies is a common method for alleviating energy poverty. When energy subsidies remedy a failure in the market or improve social welfare, they are a justifiable form of government assistance. However, if the purpose of a subsidy is to achieve a societal goal, it is necessary to carefully consider who, what, and how the subsidy will be administered and assessed (World Bank, 2010). However, for these initiatives to be effective, policies must find a constructive way of differentiating between low- and high-income households (Department of Energy, 2016).

2.5 LPG STRATEGY, POLICY AND REGULATION

The World LPG Association was founded in Dublin, Ireland in 1987 to represent LPG use through the leadership of the industry globally and to unite the diverse interests of the enormous global LPG sector. The organisation developed an LPG policy document to guide governments worldwide and LPG stakeholders in developing appropriate governance structures which will enable LPG industries in their respective nations to thrive by developing solid enforceable LPG policies which are safe and sustainable (WLPGA, 2017).

According to the WLPGA (2017) policy document, the first step for a nation to utilise LPG for the first time or expand its use is to create a thorough overview of all the benefits that LPG can offer. This Roadmap can then be utilised as a resource and tool for formulating a policy framework. However, the policy recognises that the best course of action for each nation’s LPG strategy is determined by its unique national and regional conditions. These may include the stage of development of the LPG market; budget constraints that may limit available funding for promotional programs; the country’s international commitment to decreasing GHG emissions; the severity of local air pollution issues; the availability and cost impediments of fuel supply; and existing obstacles to fuel switching, including the local cost of transitioning and stringent restrictions.

If countries want to ensure that the value proposition for LPG, as seen from the perspective of the consumer, is improved, the World LPG Association's (2017) policy document advises policymakers to ensure that the rollout strategy is compelling and appealing. It should be predicated on the "four A's", which are awareness, availability, affordability, and accessibility.

2.5.1 LPG strategy

The SA LPG Rollout Strategy (2021) offers a framework for increasing the usage of LPG in the country, with a strong focus on residential markets. The aim of the strategy documents is to position LPG in the market as one of the best possible contributors to solving the nation's energy-supply problems. According to the Department of Mineral Resources and Energy (2021), numerous barriers impede the country's development of its LPG industry. These are said to be resolved by government. They include, but are not limited to, LPG pricing framework; structure of the market; LPG infrastructure; compliance, monitoring and enforcement; LPG negative perceptions; and cylinder management

2.5.2 LPG regulation in South Africa

In the context of SA, the Department of Mineral Resources and Energy (DMRE) serves as an economic regulator and policymaker in the liquid fuel industry. The department is responsible for drafting, implementing, monitoring, and enforcing policies and legislation in pursuit of energy security for the country (Department of Mineral Resources and Energy, 2021). LPG is regulated under the Petroleum Products Act, whereby petroleum products are defined as "any petroleum fuel and any lubricant used and unused and includes any other substance which may be used, for a purpose for which petroleum fuel or any lubricant maybe used" (Department of Mineral Resources and Energy, 2021). The DMRE mandate regulates the trade of petroleum products, which also includes the pricing of petroleum products under the Petroleum Products Act of 1977 (Act No. 120 of 1977). According to the LPG Rollout Strategy (2021), LPG pricing is controlled mainly by the regulation of exrefinery pricing, which includes the Maximum Retail Price (MRP) of LPG and Maximum Refinery Gate Price (MRGP).

The liquid fuel sector was first licenced in 2005 with the objective of facilitating an efficient, conducive, and commercially viable investment; promoting efficient retailing, wholesaling, and manufacturing industries; creating small businesses and employment opportunities for the sector; and advancing historically disadvantaged individuals (Department of Mineral Resources and Energy, 2023). The licencing framework is detailed in the Petroleum Products Amendment Act 2003, Act 58 of 2003.

2.5.3 South Africa's Policy framework for LPG

According to the Department of Energy (2016), the 1998 Energy Policy White Paper was the main policy document guiding all subsequent energy strategies, policies, and legislation (Department of Energy, 2016). LPG is identified in the Energy White Paper as a viable alternative source of energy, and it forms part of the Department of Energy's 2011/2012 and 2015/2016 Strategic Plan (Competition Commission SA, 2017), as well as the recent LPG Rollout Strategy (2021) by the DMRE.

According to the Integrated Energy Plan report (2016), the Energy White Paper highlights five key objectives which form part of the foundation and development of SA energy and remain relevant to this day. Some of the main energy policies factoring LPG are listed below (however, this list is not exhaustive);

- The Integrated Resource Plan 2010 (IRP2010)
- Free Basic Alternative Energy Policy (2007) which includes LPG subsidy to indigent households
- The White Paper on Renewable Energy of 2003 (Renewable Energy White Paper)
- The National Energy Efficiency Strategy of 2008

2.5.4 Northern Cape Local Government Policy framework for LPG

The local government in the Northern Cape Province presently does not have a policy document specifically addressing the rollout strategy of LPG as a viable alternative source of energy for household use for domestic use in urban, peri-urban, rural areas and informal settlements, particularly as an energy poverty alleviation 'tool'.

The JTGDM Integrated Development Plan (2022) is an important strategic document for district municipalities. This plan was produced according to the Municipal Systems Act and its accompanying rules, with particular attention paid to Municipal Planning and Performance Management Regulations, which came into effect in 2001. Because the strategy document is a legislative requirement with legal status, it takes precedence over any and all other plans that are used to direct development in this municipality.

The JTGDM IDP (2022) outlined the following 5-year strategic agenda and key performance areas for local governments: investment in basic service delivery, community participation and good governance, local economic development, institutional development and municipal transformation, and robust financial management and financial viability.

2.6 THEORETICAL FRAMEWORK

Numerous theories have explained household energy transition patterns (Israel-Akinbo *et al*. 2018). However, the two common energy theories used to determine household fuel choices and energy transition patterns particularly for developing countries are called the "energy ladder model" and "energy stacking model" as depicted in Figure 2.4. These energy models link the different energy consumption patterns of a household to its economic standing (Leach, 1992).

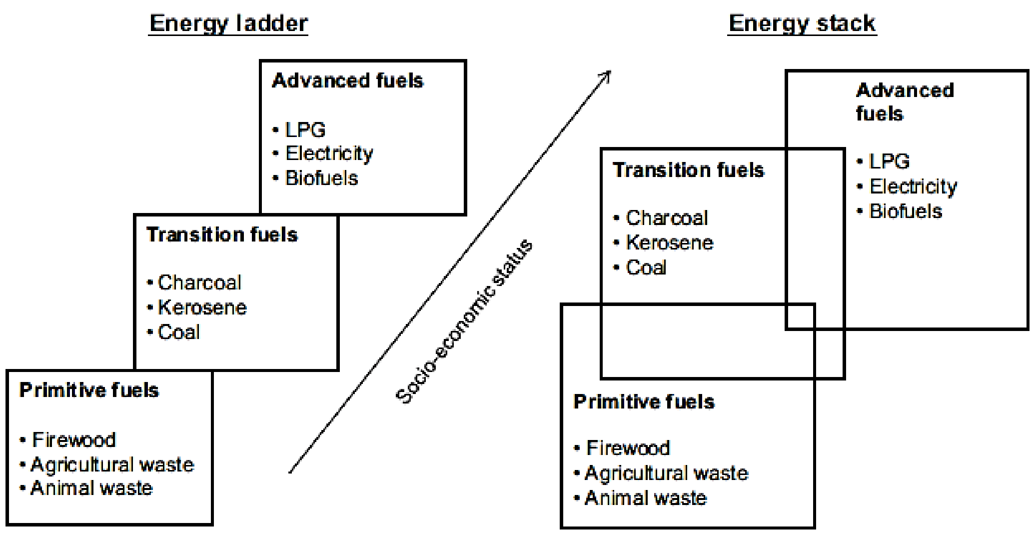

Figure 2. 4: Energy Transition Process

Source: Van der Kroon *et al*. (2013)

A more contemporary framework by Van der Kroon *et al*. (2013), as adapted from Bruntrup and Heidhues (2002), is discussed in Section 2.5.3. More recent studies from Israel-Akinbo (2018), with the objective of evaluating energy use patterns and trends among low-income South African households, and Alananga and Igangula (2022), are significant for this research.

2.6.1 Energy ladder model

A key idea in the energy transition process is "fuel switching”, which refers to the substitution of one fuel for another (Van der Kroon et.al., 2013). A linear movement with three separate phases is used to represent the process of climbing up the energy ladder (as depicted on the left side of Fig. 1.4) to obtain more efficient and cleaner fuels. Based on this model, households migrate from a universal reliance on biomass fuels (e.g. firewood, animal, and agricultural waste) to transition fuels such as kerosene/paraffin, coal, and charcoal (as depicted in the second phase) as their socioeconomic standing improves. As households continue to reject inefficient, less expensive, and more polluting fuels, they begin to migrate to improved technologies, such as LPG and electricity, as depicted in the last and third phases (Heltberg, 2004). Therefore, this model suggests a strong correlation between income and fuel selection. Traditional biomass fuels and coal are gradually being phased out in favour of fuels that are cleaner, more energy-efficient, and more user-friendly. According to the World Health Organization (2006), this is the result of rising prosperity. They reported that as the majority of low- and middle-income households employ a variety of fuels to satisfy their cooking requirements, progressing up the energy ladder is typically a slow and steady process.

At the external and macro levels, a comparison between countries also reveals a positive correlation between economic growth and the consumption of modern fuels (Van der Kroon *et al*., 2013). This also correlates with the research by Hosier and Dowd (1987) which argues that ‘‘as a country progresses through the industrialization process, its reliance on petroleum and electricity increases and the importance of biomass decreases’’.

Earlier empirical research at the micro level has proven the correlation between household income and the choice of fuel in households (Davis, 1998; Farsi *et al*., 2007; Gupta *et al*., 2006). However, empirical evidence indicates that the links between fuel choice and income level are rarely as strong as the energy ladder assumes (Van der Kroon *et al*., 2013). Therefore, it is important to note that research conducted in developing nations has shown that, notwithstanding household income levels, fuelwood can still be a significant energy source for urban as well as rural households [Brouwer & Falcao, 2004; Mirza & Kemp, 2009). For example, Hiemstra-van der Horst and Hovorka (2008) discovered that in Maun, Botswana, households with different income levels used fuelwood, despite the widespread use of commercial alternatives. The aforementioned gaps implies that it is oversimplified to refer to wood energy as the "fuel of the poor." (Van der Kroon *et al*., 2013).

While there is a significant difference in the patterns of energy use between the rich and poor, there are also a large number of low-income households who make use of advanced contemporary fuels, such as electricity and LPG (Campbel *et al*., 2003; Mirza & Kemp, 2009). This implies that a wider range of influential factors, outside wealth and income, should be considered. Recent research has shown that as affluence increases, traditional fuels are not completely abandoned, but are instead used in a mix with other energy sources, and that income does not influence the amount of fuel that households use (Mishra & Behera, 2016; Hossain *et al*., 2018). These recent findings further exposed the limitations of the energy ladder model.

2.6.2 Energy stacking

Several studies have discovered that households in developing countries typically employ a combination of fuels instead of completely abandoning one fuel for the other, as in the case of fuel ladder theory. According to Kayode *et al*. (2016), the stacking model proposes partial switching as households progress up the energy ladder; therefore, this model offers a helpful tool for explaining the cooking energy consumption pattern of households in developing countries, such as SA. This phenomenon is known as "energy stacking", which is in contrast to the energy ladder idea of one fuel substituting the other (Heltberg, 2003; Joon *et al*., 2009). According to the energy stacking theory, after a household switches to a modern fuel, it keeps its conventional fuels and equipment, meaning that they only partially convert from one fuel type to another (Van der Kroon *et al*., 2013; Mgimba *et al*., 2017). This implies that as income increases, households can afford a wider variety of energy appliances and are likely to opt for multiple fuel types simultaneously without having to replace traditional energy sources, such as firewood, with cleaner and more modern energy, such as LPG (Liao *et al*., 2019; Obrumah *et al*.,2019). Furthermore, contrary to Energy Ladder theory, energy transition does not occur as a sequence of clear, discrete stages (Van der Kroon, 2013) which leads to a more diverse energy mix.

Alananga and Igangula (2022) found in a recent study, that other factors, beyond cost and household income, have an impact in the energy choice of households. They argue in their study that factors such as access to LPG, awareness of benefits, gender dynamics, and a moderate ability for households to pay can influence energy transition. According to Choumert-Nkolo *et al*. (2019), other factors contributing to energy stacking include impediments caused by inconsistent and unreliable supply of modern energy, such as LPG and electricity. D'Agostino *et al*. (2015) in their study found that an upgrade in new appliances to accommodate the transition to newer and advanced energies is impeded by financing constraints.

Some critiques of the model (Masera *et al*., 2000; Alananga & Igangula, 2022) point out the limitations of the model by taking things a step further by disputing the existence of fuel switching and proposed a multiple fuel model in which households choose to employ a portfolio of energy options at various rungs of the energy ladder rather than switching fuels. Masera *et al*. (2000) draw a crucial contrast from Foley's energy demand model, which discovered that multiple fuels are used in households based on specific purposes like cooking or lighting.

2.6.3 Conceptual framework: household energy choice

Van der Kroon *et al*. (2016) used the Bruntrup and Heidhues (2002) framework to explain household energy choice (See Figure 2.5). Researchers discuss a decision-making environment for farm households in emerging and developing economies. The option between subsistence and market orientation, or the level of market integration, is the main focus of their framework, where subsistence orientation refers to a farmer who primarily produces for the consumption of his own family. The choice between self-sufficiency and market dependency in a developing country environment also affects the choice of energy carriers. The energy ladder illustrates how homes at the bottom of the ladder rely on biomass resources, which are typically gathered by households themselves, especially in rural areas. Commercial fuels are higher up the ladder and must be purchased in the market. Hence, climbing the energy ladder requires a transition from self-sufficiency to market dependence. Given that households primarily rely on markets as consumers of energy carriers, although many farm households are both consumers and producers in agricultural goods markets, there is a clear distinction between market dependency for agricultural products and energy carriers.

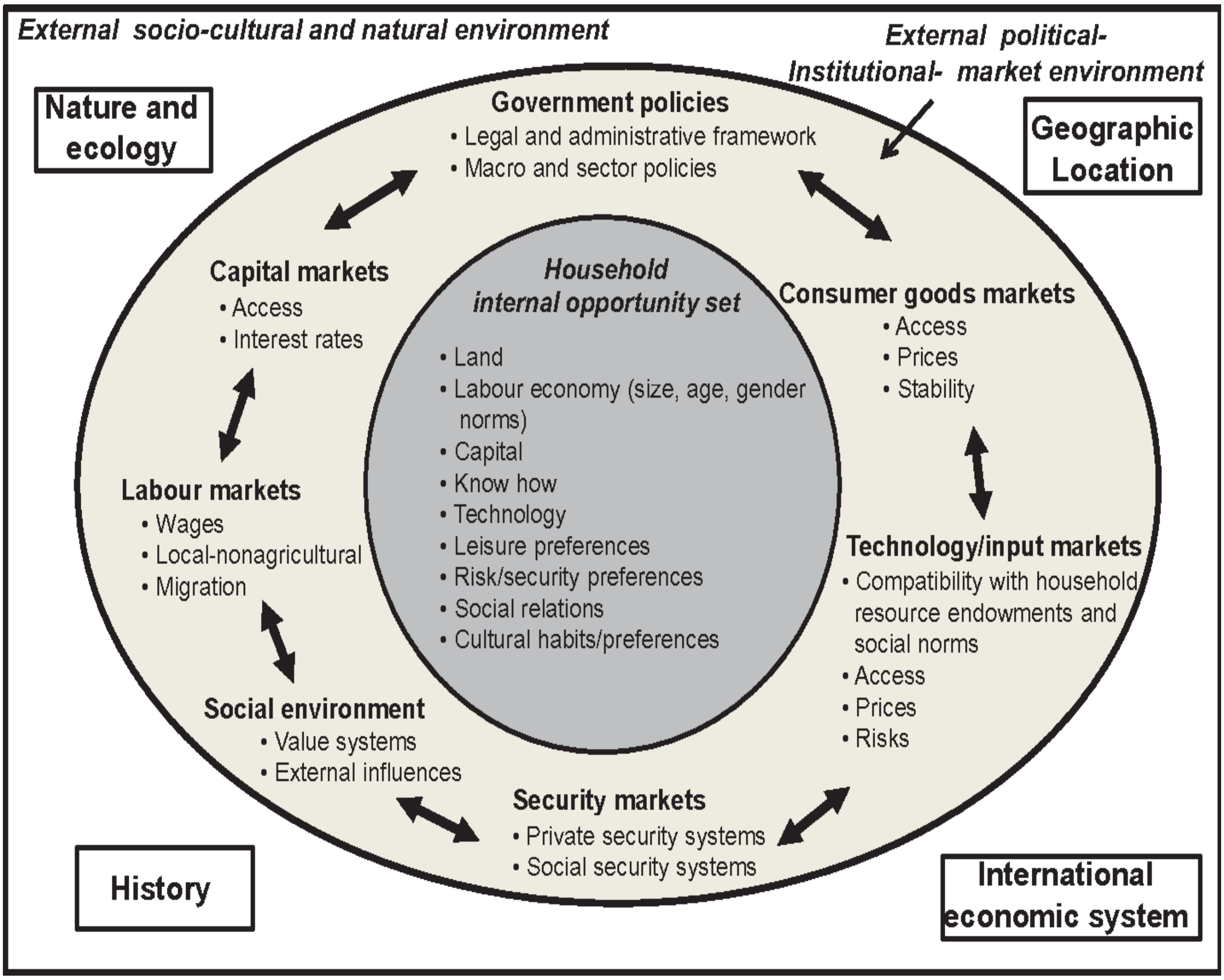

Figure 2. 5: General conceptual framework for explaining household energy choices

Source: Van der Kroon *et al*., 2013, Adapted from Bruntrup and Heidhues' (2002)

The framework distinguishes between three main categories of influencing factors:

1. A country's external environment defines the confines within which a society must operate, such as nature and ecology, location, and the international economic system.
2. The decision context expresses household external and country internal elements, based on the market, political, and institutional conditions of a particular location. These variables include government policies, technology or input markets, social environment, consumer markets, etc.

3. The household internal opportunity set comprises a collection of internal factors specific to the home based on its traits and factor endowment. The decision environment, which is specific to each household, is determined by the interaction between factors from several categories.

The foundation of a household's livelihood plan is the household’s opportunity set. It establishes a household's capacity and limits or improves its chances of success. Human capital is believed to be crucial in the energy decision-making process (Gupta and Kohlin, 2006; Farsi *et al*., 2007). This covers both education and knowledge, as well as aspects of household composition, including household size, age, and gender. Several studies have found that women’s income is a significant factor in determining the type of contemporary fuel they choose (Israel, 2002; Gupta and Kohlin, 2006; Alanang and Igangula, 2022). Additionally, household choices based on customs and cultural beliefs affect fuel choices (Masera *et al*. 2000; Murphy 2001; Israel 2002; Gupta and Kohlin 2006).

The choice of fuel is influenced by supply reliability, network structure, and distributor count (Farsi *et al*., 2007; Mirza & Kemp, 2009). It has also been discovered that the transaction costs associated with obtaining fuel, such as the effort required by households for transportation and distance to markets, have an impact on a household's access and choice (Mirza & Kemp, 2009; Alanang & Igangula, 2022).

Some academics contend that costs are the primary barrier preventing households from switching to modern fuels, while others show that fuel costs rarely influence fuel choices (Hiemstra-van der Horst and Hovorka, 2008). Sathaye and Tyler (1991) made the intriguing observation that, when comparing relative fuel prices, lower-income households actually seem to spend more per unit of energy for their fuels than households with higher incomes. According to Leach (1992), households that already utilise a variety of fuels are more frequently encouraged to switch to new fuels based on energy prices. According to Masera *et al*. (2000) and Campbell (2003), fluctuating prices, a lack of appropriate equipment, and households that possess the required equipment can climb the ladder forward and backward which implies that new fuel equipment, rather than the cost of fuel, causes an impediment towards energy transition to modern fuels.

2.7 CONCLUSION

The guiding principle of this research is based on the premise that LPG consumption can be understood based on behavioural and socioeconomic factors serving as the foundation of the study's theoretical framework. The relevant behavioural and energy models this study uses to analyse the different factors influencing the energy transition to LPG includes the energy ladder model, energy stacking model and the Conceptual framework on household energy choice developed by Van der Kroon *et al*. (2016) as adapted from the Bruntrup and Heidhues' (2002) framework. The following chapter will unpack the research methodology and design guiding this study in detail.

CHAPTER 3: RESEARCH METHODOLOGY AND DESIGN

3.1 INTRODUCTION

The methodology chapter will be used to discuss the study's population and sampling design alongside research procedures, data collection, and analysis methods in detail. The chapter includes additional information on the administration of data collection instruments, sampling procedures, and data analysis, ensuring that the proper reliability and validity measures and ethical considerations were factored into consideration during data collection.

This chapter provides an in-depth account of how the research problem regarding the energy choices of rural households leading to the slow energy transition to LPG was approached and addressed. Following the research approach of prior scholars (e.g. Murthy & Bhojanna, 2009:32), the research methodology was a systematic method of collecting data to resolve a research problem through the application of research techniques, data interpretation, and providing conclusions and recommendations. To develop the study, the researcher relied on the key elements of research methodology and design, as depicted in the Saunders *et al*. (2009) research onion model presented in Figure 3.1. The research onion model depicts three research methodology choices as being either: mono-methods, mixed methods, or multi-methods. This study identified a mono-method approach using a quantitative research technique to gather numerical data and apply it across the target population in the Northern Cape to explain the phenomenon of slow energy transition towards LPG in rural households in the JTG District Municipality.

In the following sections, the stratum is explained from the outer strata, and then inward. Each stratum was described and contextualised in the current study.

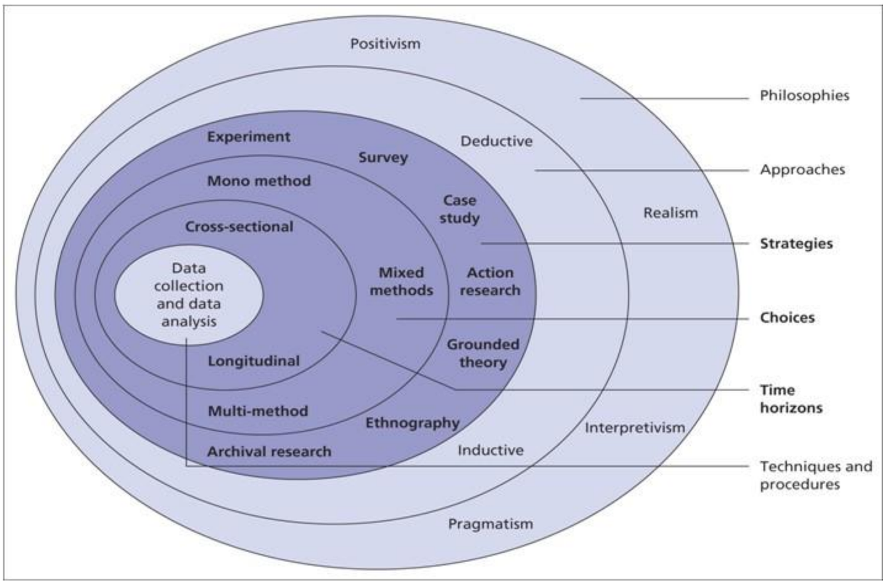

Figure 3. 1: The Research Onion Model (Saunders *et al*., 2009:138)

3.2 RESEARCH METHODOLOGY

Research methodology is defined as a systematic method of collecting data to resolve a research problem by applying different research techniques, interpreting data collected, and then providing conclusions (Murthy & Bhojanna, 2009:32). As previously mentioned, the research problem for this study was the existing phenomenon of slow energy transition towards LPG as an alternative source of energy in rural households. Therefore, this study aimed to determine the various factors contributing to this phenomenon across rural households in South Africa, with a specific focus on the Northern Cape Province.

3.3 RESEARCH PARADIGM

The research paradigm refers to a logical framework for conducting research in various social realities. According to TerreBlanche and Durrheim (1999), it encompasses a system of interrelated practices, along with what defines the type of research based on three main dimensions: epistemology, ontology, and methodology.

To determine the various factors contributing to this phenomenon, the researchers applied the onion model (Saunders *et al*. 2007). In this study, the guiding philosophy was positivism, given that the researcher's aim was to examine a social phenomenon and objectively explain the social world (Saunders *et al.*, 2007). According to Wilson (2010), positivist researchers consider themselves to be detached from their work and are able to conduct completely impartial research. With interpretivism/constructivism, qualitative research is guided by a theoretical framework that views the world as something formed, experienced, and interpreted by individuals in the context of their own personal interactions with one another and broader social structures. (Neuman, 2003). According to Farzanfar's (2005) model, the very nature of enquiry is interpretive, and the goal of the research is not generalisable to a population but rather to gain an understanding of a particular occurrence. Positivists find that empirical facts are derived independently from one's personal beliefs or ideas, wherein facts are regulated by the relationship between cause-and-effect and social reality.

The research approach followed was a deductive reasoning approach, whereby the researcher explored a known theory called the Energy Theory (i.e. Energy Ladder and Energy Stacking) and the existing phenomenon of low LPG consumption in low-income households. Whether this theory was valid in the given circumstances of rural households in JTG District Municipality was tested. The deductive approach follows a path of clear logic, whereby reasoning starts with a theory that then leads to a new hypothesis. This hypothesis will then be tested by challenging it with observations that will either confirm or reject that hypothesis (Dudovskiy, 2011). This study adopted a quantitative research approach primarily as it follows the confirmatory scientific method because its focus is on hypothesis testing and theory testing, unlike qualitative research which uses inductive reasoning which primarily follows the exploratory scientific method.

The research strategy used was a survey, as the researcher employed scientific sampling and used a questionnaire (see Appendix C) to measure population characteristics with statistical accuracy (Sukamolson, 2007). According to Saunders *et al*. (2000), this research is appropriate for studies on social sciences, especially those pertaining to psychology. Deductive research methods such as surveys are frequently used in business and management research. A large number of questionnaires form the basis of this survey. In a village, the sizable population can range from a small number to a sizable one. It is easily comparable and seen as authoritative by most people. The survey-based research is suggested because it is understandable, for this reason. Survey-based research provides a good level of control over research processes.

The researcher used a mono-method approach of utilising the quantitative research method to gather numerical data and apply it across the target population to explain the phenomenon (Babbie, 2010). According to Sukamolson (2007), quantitative research is used to explain a phenomenon by collecting quantitative data which are then analysed using mathematically based methods. When a researcher measures the outcomes and exposures of the study participants during the same time period, the time horizon is considered cross-sectional (Dermatol, 2016). The following sections provide additional information on the research methodology.

3.4 RESEARCH DESIGN

The research design of a study refers to the methods and processes the researcher was guided by in resolving the study's fundamental research problem using data collection techniques and data analysis measures (Grand Canyon University, 2021). According to Creswell (2017) research design is a strategy and framework for conducting an inquiry that is created in such a way as to yield responses to research questions. A descriptive research design is suitable for collecting descriptive data, particularly if the study defines the present events (Zikmund *et al*., 2013). This study used a descriptive research design, as its aim was to identify characteristics, trends, frequencies, and categories (McCombes, 2022) from data collected in the rural villages of JTG about their energy choice of LPG. Data was gathered without controlling any variables. A cross-sectional study is ideal for examining frequent phenomena during a particular period (Thomas, 2022). The time horizon of this study was cross-sectional because the research measured outcomes in the same period as data were collected (Dermatol, 2016).

This study employed a quantitative research design strategy. Using the recommended research methodology, the researcher was able to collect a large amount of data from a sizable population in a highly competitive setting. This study technique made it possible to collect data by administering questionnaires to participants.

3.5 POPULATION AND SAMPLING

The population is the entire spectrum of characteristics from which the study participants will be drawn. According to Quinn and Keough (2002), the population comprises potentially interesting observations. Whenever any researcher is working on a study with a large population group which is unreachable, a random selection of the sample may be used; otherwise, a selection can be drawn from a smaller part of the population on which the study is based (Bhandari, 2022). The sample consisted of rural households from the district municipality of JTG in the Northern Cape Province. Through probability sampling, the findings were generalised to a broader population of rural households in SA. The specific sampling method used was convenience non-probability sampling which uses non-random criteria, such as geographic location, expertise about the population, or availability (Nikolopoulou, 2022). By using the convenience sampling technique, the researcher approached residents in their households and places of public gathering which included community halls and the Tribal Council Office or 'Lekgotla'. Considering the sampling technique, no prior appointments were made with the participants. The sample size comes into being after there has been a demand for an effective representation of statistical data in research (Morgan, 1989). Morgan (1989) further emphasized there is a need to have an effective sample size that will comfortably represent the given population and the researcher will be able to infer or refer easily.

The sample size was determined using a survey system software calculator, Creative Research Systems (2021), from the JTG population size of 242 264 (Statistics SA, 2016). The researcher determined the sample size using the following values: expectation of a 5% margin of error, with confidence levels of 95%. This calculation yielded a sample size of 384 participants. Given time and geographic constraints, only 301 participants took part in the survey between 14 October 2022 and 10 January 2023. Subjects excluded from the study included households in townships and suburbs in the towns of Kuruman and Kathu.

3.6 DATA COLLECTION

Data collection involves the process of gathering the required information for the study from different respondents, either directly or indirectly, to obtain information according to the research questions (Mukesh, 2013). According to Mugenda and Mugenda (2003), the characteristics of the subject, research question, data, and anticipated findings all play a major role in instrumentation choice during data collection. Questionnaires are among the most popular data collection methods in business studies. In line with the specific objectives of the study, a questionnaire was developed and developed (see Appendix C). This was done to demonstrate the relevance to the topic of the study. A complex technique was used to ensure that the distribution of the questionnaires occurred at the appropriate and determined timeframe so that the respondents had enough time to accurately complete the surveys. Research assistants were required to conduct the study. Three assistants, residing in Joe Morolong, Gasegonyana, and Gamagara, respectively, were carefully chosen and provided appropriate training and were given the task of administering the questionnaire to the chosen respondents.

Primary data were collected from residents of the villages of JTG District Municipality using a self-administered questionnaire. Primary data, as defined by Polit and Beck (2004), are the first-hand information that the researcher obtains from the participants through the use of tools such as questionnaires, observational checklists, and schedules. Data were collected from 301 participants from three villages in Gasegonyana local municipality, three villages in Joe Morolong, and two villages in Gamagara. Household energy use was not predetermined, and the house building type included brick and mortar, mud houses, and shanty/shacks. The researcher adapted a questionnaire used by the Journal of the Geographical Association of Tanzania (2020). The instrument comprised 50 closed-ended questions. The items were anchored on a 5-point Likert scale ranging from strongly agree to strongly disagree. To accommodate the different literacy levels of all participants and the language barrier, the researcher translated the instrument into the predominantly spoken local language of Setswana.

3.6.1 Pilot Study

A pilot study of 10 randomly selected participants from the village of Gamotlharo (also known as Batlharos Village) was conducted. The pilot study revealed the need for the research instrument to be translated into the local language of Setswana which is the first language of most residents in the rural villages of JTG District Municipality.

3.6.2 About John Taolo Gaetsewe District Municipality

JTG District Municipality is one of five district municipalities in the province of Northern Cape, with the others being Frances Baard, Pixley Ka Seme, ZF Mgcawu and Namakwa. This district municipality, with its local municipalities of Gasegonyana, Gamagara, and Joe Morolong, has a total population size of 261 363, which accounts for 19.4% of the province’s total population estimated at 1.293 million (Statistics SA, Mid-Year Population Estimates, 2019 & 2020). The province’s population density is comparatively low, as it has the smallest population size in the country, but the largest land size of all provinces (Northern Cape Provincial Government, 2021).

Between 2011 and 2016, in terms of local population dynamics, the population of JTG was the smallest of all five districts, with a population growth of approximately 7.8%. According to the Northern Cape Provincial Government (2021), this was largely attributable to mining activities in the district. The migration statistics roughly indicate that most economic activities are concentrated in the two local municipalities of Gasegonyana and Gamagara, and people have migrated there in search of jobs and better livelihoods.

With an unemployment rate of 47% (JTGDM IDP, 2022), according to the Northern Cape Provincial Government (2021), in 2018, JTG had the second largest percentage of people living in poverty at 61.2% and the lowest Human Development Index (HDI). It is worth noting that there has been some improvement in HDI from 0.55 in 2010 to 0.63, which indicates an improvement in development and a positive change in the lives of the people within the district and province.

3.7 DATA ANALYSIS

Data analysis involves examining the collected data, drawing conclusions, and making judgments about the findings. For data analysis, a statistical software package called Statistical Package for Social Scientists (SPSS) version 28.0 was used. The completed questionnaires were carefully analysed to ensure that the acquired data were correct and compatible with other information gathered. To analyse the data, the researcher performed three statistical analyses in line with the objectives. First, the researcher performed descriptive statistics to analyse the profiles of the participants and determine the frequencies of each of the variables constituting the factors. The results are presented in the form of tables, graphs, pie charts, bar charts, cross tabulations, and other figures for the quantitative data collected. Second, factor analysis was performed to determine the factors that could address the research problem. Prior to the factors, two tests were analysed: the KMO test and Bartlett's test of sphericity to test the sampling adequacy to perform factor analysis. Exploratory factor analysis was performed, and varimax rotation was used to refine the factors. Finally, correlations were performed to determine the correlation between the factors and household LPG consumption in the Northern Cape.

3.8 VALIDITY AND RELIABILITY

Validity refers to the degree to which a test or other measuring device or instrument truly measures what is intended. This is defined as the extent to which a concept is accurately measured in a quantitative study. Three forms of validity (Heale and Twycross, 2015) are relevant to this research. First, construct validity refers to the nature of the psychological construct or characteristic being measured. Content-related validity refers to the content and format of the instrument. Finally, criterion-related refers to the relationship between scores obtained using an instrument and scores obtained using one or more instruments or measures. A content-related method was used to test the validity of the research instruments used in this study.

Although a precise estimation of reliability is not always possible, the three reliability traits can be examined using various methods to approximate reliability (Heale and Twycross, 2015). They include stability, which is the consistency of results using an instrument with repeated testing, followed by equivalence which is the consistency among responses of multiple users of an instrument, and homogeneity which is the extent to which all items on a scale measure one construct. For this study, a reliability coefficient of 0.50 or higher, was considered as “acceptable” for a newly developed construct.

3.9 ETHICAL CONSIDERATIONS

The study considered the Belmont Report's basic ethical guidelines, which include the inclusion of two ethical principles: recognising people as independent agents and granting them protection they are entitled to, beneficence which refers to not causing harm to others, and justice which entails the treatment of respondents in an equal manner.

The study also ensured that participants completed the IIE MSA Ethics Consent Form (see Appendix D) with an accompanying explanatory information sheet (see Appendix A), and participation was voluntary. The goal of this study, as well as the possible risks and benefits, were all covered by informed consent and expressed to the participants. This information was provided in the local language and in English. According to Denzel and Lincoln (2011), "informed consent" is the bedrock of ethical research since it consists of two significant components, each of which must be carefully considered before being implemented: the terms are "informed" and "consent." Respondents are required to be informed of what is requested from them, the manner in which information obtained is going to be utilised, and whether there are other concerns that might be (if any) important for them to be aware of. Researchers did not collect data from vulnerable groups and did not involve children or younger people under the age of 18 years. The questions were not sensitive and did not cause any deception or misleading participants. It was very important that the information and consent forms were robust, clear, and well written to ensure that the best quality of data was collected. Given that the data collection was conducted in rural settings, the study also adhered to the requirements of submitting a risk assessment. The collected data were securely stored using password-protected and secure cloud storage technology.

3.10 CONCLUSIONS

This chapter covers the research methodology, which is a detailed description of the study's process. The research method was explained in terms of research design and methodology, data collection and analysis tools, and ethical considerations. The chapter enabled the researcher to ensure that the appropriate choice of methodology and methods were considered to best address the research questions and study objectives. The next chapter presents the results of the questionnaires, which will be analysed and interpreted, followed by a discussion of the findings.

CHAPTER 4: RESULTS, INTERPRETATION AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the results and discusses the findings obtained from the questionnaires used in this study. The questionnaire was the primary tool used to collect data, and was distributed to 301 participants from rural households in the JTG District municipality, NC, SA. Quantitative data were collected from the respondents and analysed using the statistical software SPSS version 28.0. The descriptive statistical results are presented in the form of tables, graphs, and other figures. The use of inferential techniques included the chi-squared test and correlation values. These were interpreted using p-values, and a significant result is indicated as "$p < 0.05$".

The aspects covered in the chapter are organised as follows: reliability and exclusions, biographical data of respondents, factor analysis and identified trends, followed by conclusions

4.2 THE SAMPLE

In total, 326 questionnaires were despatched and 301 were returned, giving a 92% response rate.

4.3 PROFILES OF PARTICIPANTS

The following sections provides a summary of the biographical characteristics of participants.

4.3.1 Gender distribution by age

Table 4.3 below provides a description of the high level gender distribution by age of the respondents.

Table 4. 1: Gender Distribution

		Gender		Total
Age (years)		Male	Female	
18 - 20	Count	13	16	29
	% within Age (years)	44.8%	55.2%	100.0%

	% within Gender	10.5%	9.0%	9.6%
	% of Total	4.3%	5.3%	9.6%
21 - 30	Count	33	48	81
	% within Age (years)	40.7%	59.3%	100.0%
	% within Gender	26.6%	27.1%	26.9%
	% of Total	11.0%	15.9%	26.9%
31 - 40	Count	31	50	81
	% within Age (years)	38.3%	61.7%	100.0%
	% within Gender	25.0%	28.2%	26.9%
	% of Total	10.3%	16.6%	26.9%
41 - 50	Count	16	21	37
	% within Age (years)	43.2%	56.8%	100.0%
	% within Gender	12.9%	11.9%	12.3%
	% of Total	5.3%	7.0%	12.3%
51 - 60	Count	12	16	28
	% within Age (years)	42.9%	57.1%	100.0%
	% within Gender	9.7%	9.0%	9.3%
	% of Total	4.0%	5.3%	9.3%
> 60	Count	19	26	45
	% within Age (years)	42.2%	57.8%	100.0%
	% within Gender	15.3%	14.7%	15.0%
	% of Total	6.3%	8.6%	15.0%
Total	Count	124	177	301
	% within Age (years)	41.2%	58.8%	100.0%
	% within Gender	100.0%	100.0%	100.0%
	% of Total	41.2%	58.8%	100.0%

The study found that more women than men participated, with an overall ratio of males to females being approximately 2:3 (41.2% : 58.8%) ($p = 0.002$). Within the age category of 31 to 40 years, the most participation was from females at 61.7%, followed by the age group 41 to over 60 years participating at an average of 57.2%. The participation of more females than men was significant for this study as research would show that more women than men participate in the household energy choice. In a study by Israel-Akinbo (2018) measuring the energy use patterns and trends of low-income households in SA, the results found that most respondents are female because many households are run by women. This is likely because it is mainly women making choices about food preparation methods. Within the context of the economy of the household, particularly in less developed nations, women are typically the ones in charge of both the preparation of meals and the gathering of firewood (Van der Kroon *et al*. 2013). It is to be noted that the age distributions are not similar as there are more respondents younger than 40 years ($p < 0.001$).

4.3.2 Racial composition

Table 4.4 below indicates the racial composition of the sample.

Table 4. 2: Racial composition

	Frequency	Percent
African	280	93.0
Coloured	16	5.3
Indian	2	0.7
White	3	1.0
Total	301	100.0

The sample was comprised with a majority of African respondents (93.0%), with Coloureds forming 5.3% of the sample ($p < 0.001$). This is consistent with the racial group predominantly residing in the villages of JTG district municipality.

4.3.3 Type of house

Figure 4.1 below represents the type of house that respondents lived in.

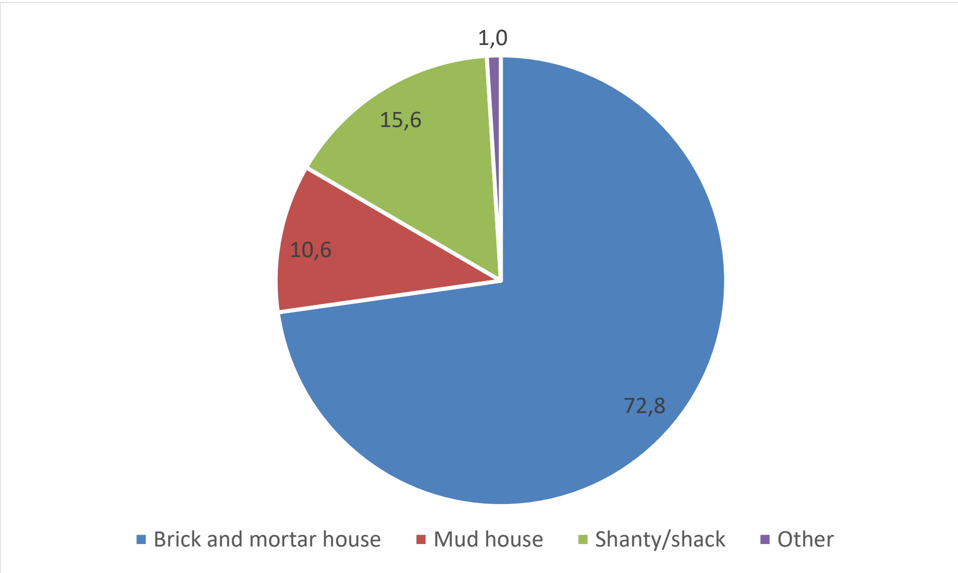

Figure 4. 1: House types

A little less than three-quarters of the respondents (72.8%) indicated that they lived in brick houses, with similar but smaller numbers living in shacks or mud houses ($p < 0.001$). It is important to note that 91.7% (see Figure 4.5) of households have access to electricity. Any other energy source in an electrified household will constitute an energy mix of either primitive, transitional, or advanced energy such as LPG, with a possibility of a combination of all fuels.

4.3.4 Number of people living in dwellings

The number of people living in the dwellings is shown below in Figure 4.2.

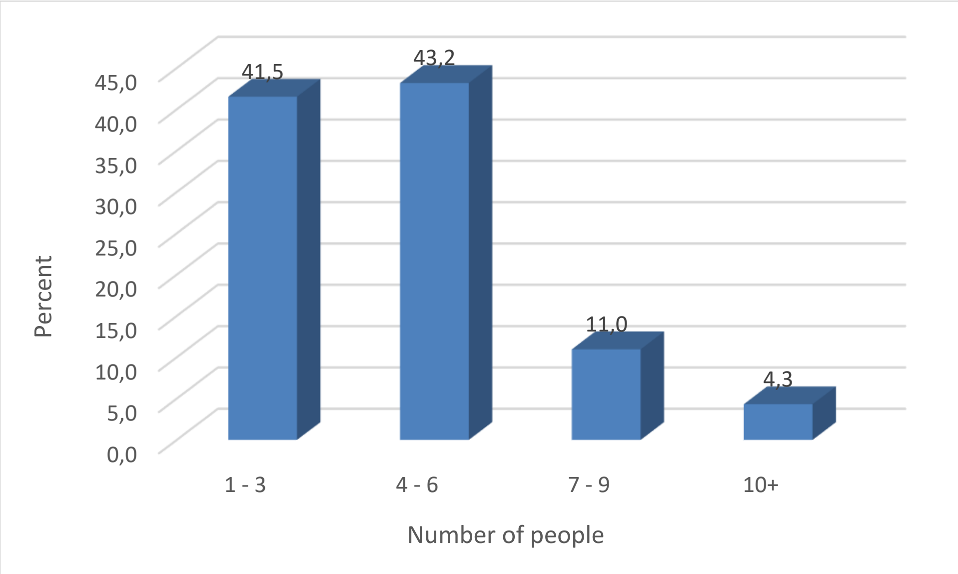

Figure 4. 2: Household number of people

Approximately 85% of the respondents indicated that there were at most 6 people living in the houses (including both children and adults). Eleven percent of the respondents indicated that there were between 7 to 9 people living in a dwelling, with 4.3% indicating that there were ten or more people living in a dwelling ($p < 0.001$).

4.3.5 Education level of respondents

Figure 4.3 below indicates the education levels of the respondents. The majority of respondents (91%) had at most a school qualification. Nearly half of these (48.8%) had completed part of Secondary School. Less than 2% of the respondents had a university education ($p < 0.001$). Recent literature finds that households headed by individuals with basic education are likely to remain in the lower energy ladder or using only a single energy source (Obrumah *et al*., 2019; Zou & Luo, 2019). However, depending on the energy demand for specific household function, there is likely going to be evidence of energy mix. The higher level of education is also associated with a higher and better awareness of the benefits of cleaner and modern energy sources and higher income (Mgimba *et al*., 2017; Sustainable Energy Authority of Ireland, 2018).

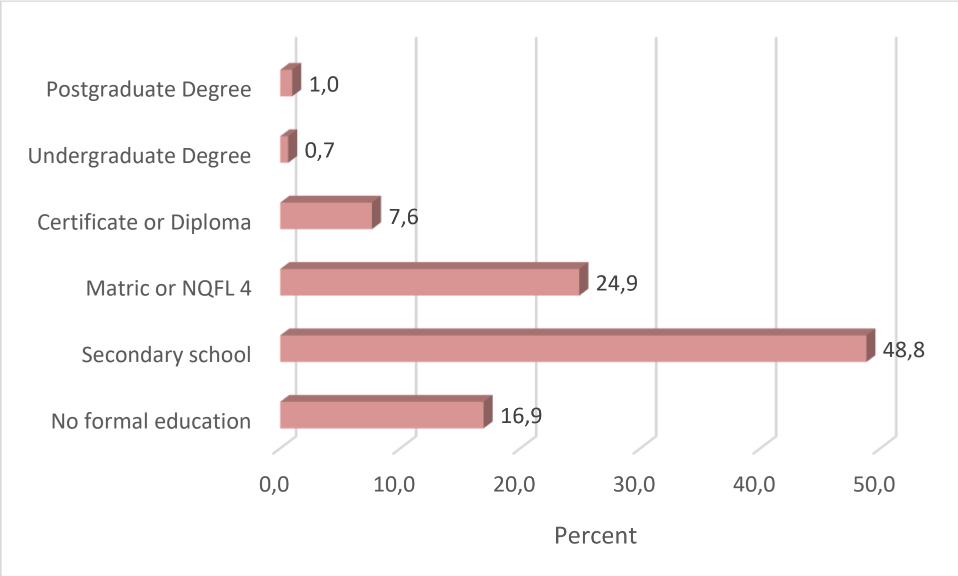

Figure 4. 3: Education level

4.3.6 Household monthly income

Figure 4.4 below indicates the monthly household income of the respondents.

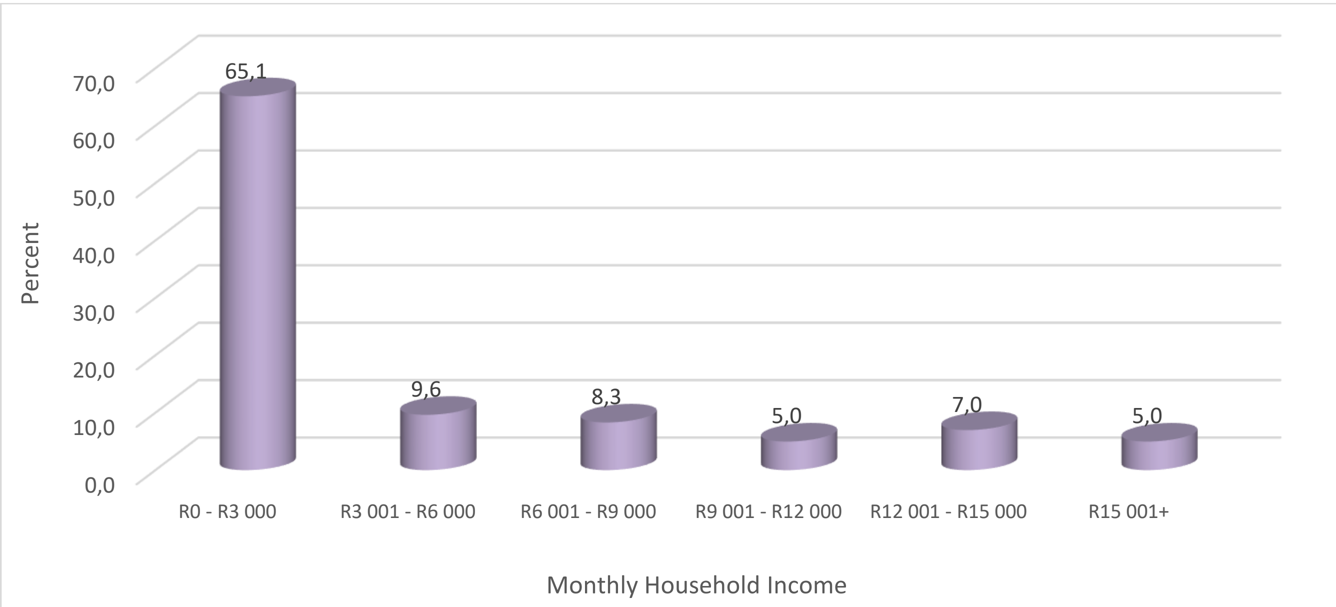

Figure 4. 4: Monthly household income

Two-thirds of the respondents (65.1%) indicated that the households earned less than R3 000 per month. There were similar and lower numbers of respondents in each of the remaining categories ($p < 0.001$). Empirical research has found a correlation between household income and their choice of household fuel (Farsi et al., 2007; Gupta et al., 2006). This low-income levels of the respondents is expected to have a negative impact on their ability to transition to cleaner more efficient modern energy such as LPG.

4.3.7 Source of household energy

Table 4.5 below indicates the source of household energy. Multiple responses were permitted, indicating that there was more than one source of energy.

Table 4. 3: Household energy mix

	No		Yes		Chi Square
	Count	Row N %	Count	Row N %	p-value
Eskom	26	8.6%	275	91.4%	< 0.001
Candle	205	68.1%	96	31.9%	< 0.001
Paraffin	251	83.4%	50	16.6%	< 0.001
LPG	203	67.4%	98	32.6%	< 0.001
Solar	295	98.0%	6	2.0%	< 0.001
Firewood	201	66.8%	100	33.2%	< 0.001
Generator	295	98.0%	6	2.0%	< 0.001
Charcoal	300	99.7%	1	0.3%	< 0.001
Other	299	99.3%	2	0.7%	< 0.001

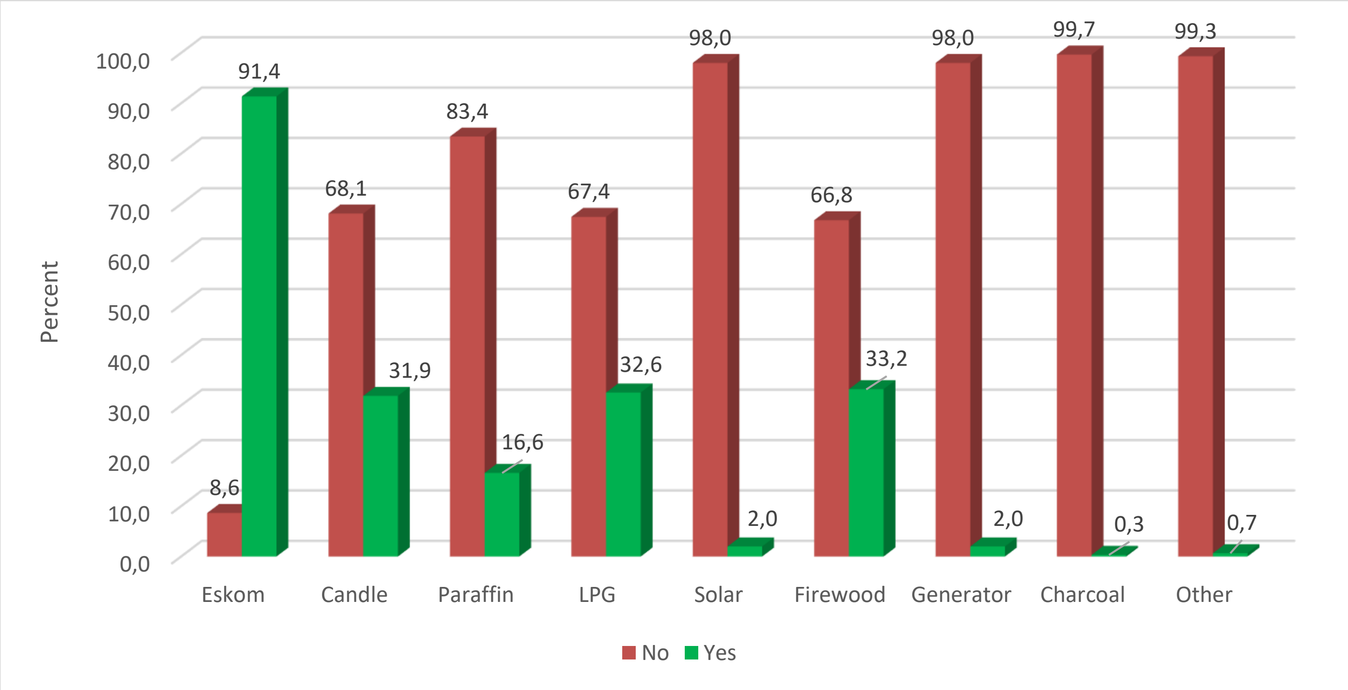

Figure 4. 5: Household energy mix

The majority of respondents (91.4%) were connected to the Eskom grid. However, a third of the respondents indicated that they each used candles, LPG and firewood as energy sources. Approximately 17% also used paraffin ($p < 0.001$). There are clear patterns of energy mix in households whereby some households uses more than one energy source, of which some are a combination of traditional or primitive fuels (firewood), transitional fuels (charcoal and paraffin), advanced fuels (electricity and LPG). Accordingly, the energy profile of the rural households identifies with energy stacking (Kayode *et al*., 2016; Mgimba *et al*., 2017; Quinn *et al*., 2018; Choumert-Nkolo *et al*.,2019; Alananga & Igangula, 2022).

4.3.8 LPG purchasing location

Figure 4.6 below indicates the different location at which respondents using LPG purchase LPG.

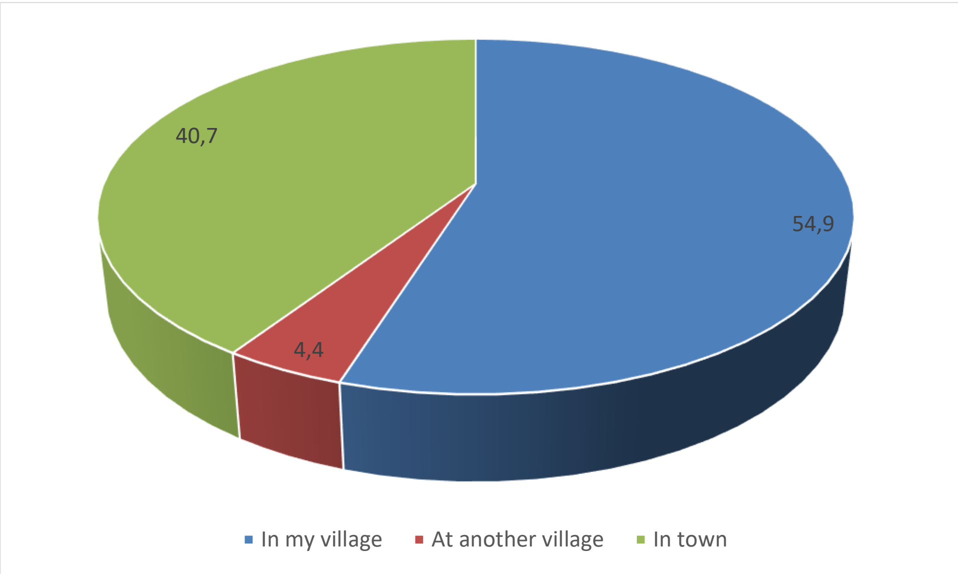

Figure 4. 6: LPG purchasing location

A little more than half of the respondents (54.9%) indicated that they purchased gas from their village, with 40.7% obtaining the gas from the local town ($p < 0.001$). A small number (4.4%) travelled to neighbouring villages to purchase LPG. There is an additional financial burden for over half of the respondents when accessing LPG markets. This will have a direct negative impact on LPG adoption and transition patterns.

4.3.9 Size of cylinder purchased

Table 4.6 below indicates the size of the cylinders of the LPG purchased.

Table 4. 4: Cylinder size patterns

	No		Yes		Chi Square p-value
	Count	Row N %	Count	Row N %	
1.4 kg	272	90.4%	29	9.6%	< 0.001
7 kg	256	85.0%	45	15.0%	< 0.001
9 kg	150	49.8%	151	50.2%	0.954
19 kg	243	80.7%	58	19.3%	< 0.001
48 kg	297	98.7%	4	1.3%	< 0.001

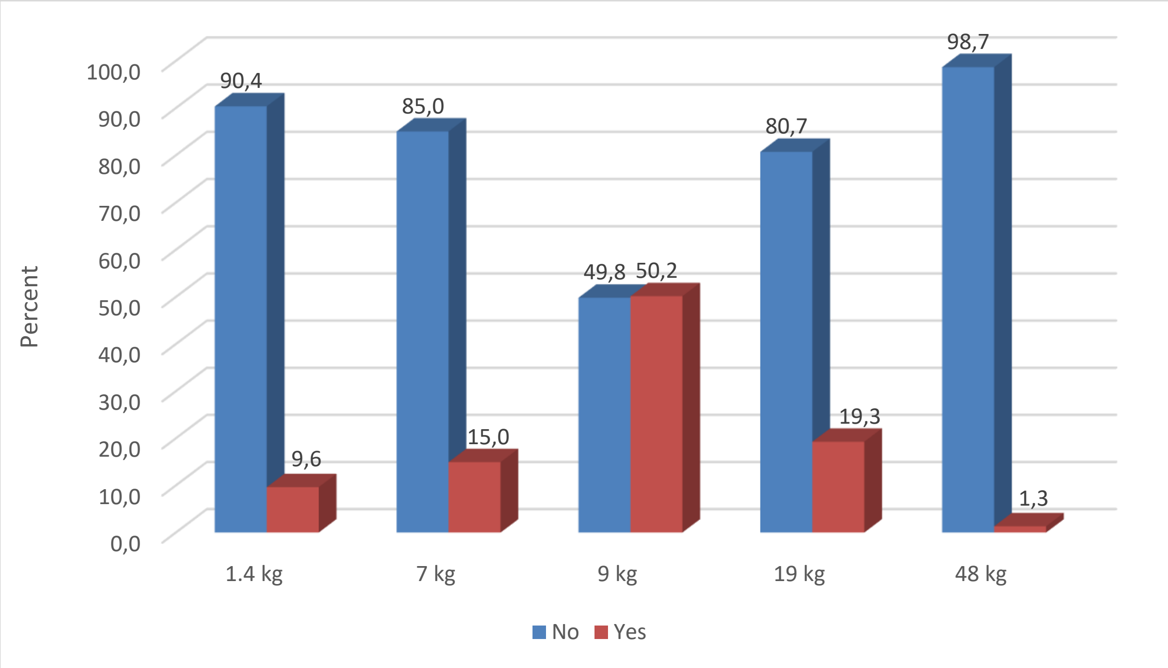

Figure 4. 7: Cylinder size

The most common size of cylinder purchased was a 9 kg, with similar but lower numbers buying 7 kg or 19 kg ($p < 0.001$). The size of the cylinders purchased is proportional to the number of people living in the house (See Annexure E. line 1343 under Crosstabs – Biographical in the Excel file).

4.4 THE RESEARCH INSTRUMENT

The research instrument consisted of 65 items, with a level of measurement at a nominal or an ordinal level. The questionnaire was divided into 12 sections which measured various themes as illustrated below:

A	Biographical data
B	Size of the Cylinder
C	Household Income
D	Household Size
E	LPG Availability
F	Awareness
G	Level of Education
H	Dwelling Status
I	Food Preparation
J	Safety
K	Cost of LPG
L	LPG Usage

4.5 TESTING FACTORABILITY

The matrix table/s is preceded by a summarised table that reflects the results of KMO and Bartlett's Test. The **KMO and Bartlett's Test** table below (see Table 4.2) indicates that the data is suitable for the detection of a structural form. If the value is found to be less than 0.50, then the results of the factor analysis are generally not considered to be useful, however higher values closer to 1.0 are acceptable as they in all probability indicate a factor analysis that is useful with the data. For the **Bartlett's test of sphericity** tests, smaller values of less than 0.05 of the significance level, are considered as the factor analysis is likely to be useful with the data.

Table 4. 5: KMO and Bartlett's Test

		Kaiser-Meyer-Olkin Measure of Sampling Adequacy	Bartlett's Test of Sphericity		
	Section		Approx. Chi-Square	df	Sig.
B	Size of the Cylinder	0.500	63.310	1	< 0.001
C	Household Income	0.500	4.415	1	0.036
D	Household Size	0.544	14.977	3	0.002
E	LPG Availability	0.508	18.720	3	< 0.001
F	Awareness	0.500	87.582	1	< 0.001
G	Level of Education	0.500	0.700	1	0.403
H	Dwelling Status	0.543	96.840	3	< 0.001
I	Food Preparation	0.489	7.143	3	0.067
J	Safety	0.556	57.229	10	< 0.001

K	Cost of LPG	0.534	109.850	10	< 0.001
L	LPG Usage	0.675	339.598	10	0.403

All of the conditions are satisfied for factor analysis, except the sphericity tests for sections G, I and L. That is, for these sections, the variables are not orthogonal.

That is, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value should be greater than 0.500 and the Bartlett's Test of Sphericity sig. value should be less than 0.05.

In many sections, there were a minimum number of statements that made up each dimension. Some statements were bidirectional. Reverse coding and dropping of redundant statements were done to attempt factor analysis. The results are shown below.

4.5.1 Rotated Component Matrix

The rotation method (Varimax with Kaiser Normalization) and extraction method was used for the principal component analysis. This was used to simplify the interpretation of the factors for the Likert scale items. This is captured below using the rotated component matrix tables.

B	Component
	1
At home we prefer large cylinders	0.849
Buying small cylinders ultimately becomes expensive as it finishes quickly	0.849

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

C	Component
	1
LPG is for the rich not poor people	0.771
At home we buy LPG only when we have enough money	0.771

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

D	Component
	1
We are a big household, so LPG does not last	0.543
If we were a small household, we would use LPG	0.685
Other sources of energy are better for cooking for a big family	0.756

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

E	Component
	1
There are many suppliers of LPG in my village	0.267
We travel long distance to buy LPG	0.777
Sometimes, the suppliers run out of stock	0.763

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

F	Component
	1
I know the benefits of LPG	0.868
I know the different places that sells LPG	0.868

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

G	Component
	1
It is mostly educated people who use LPG	0.724
It is NOT easy to learn how to use LPG	0.724

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

H	Component	
	1	2
At home, we prefer to cook outside	0.029	0.973
Our kitchen is so small that we cannot use LPG	0.829	0.310
LPG is not good for an informal house structure like mud-house or shanty	0.885	-0.182

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

I	Component	
	1	2
Food tastes better when other sources of energy like firewood is used	0.763	-0.191
At home, we do not use LPG when preparing traditional foods	0.754	0.200
We use LPG to cook food during load-shedding	0.003	0.968

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

J	Component	
	1	2

I am aware of the safety requirements when using LPG	0.090	0.801
LPG is safer to use in a formal structure house like a brick-and-mortar house	0.736	-0.048
Children younger than 18 years should not use LPG	-0.066	0.773
I know of someone who was badly affected by LPG	0.615	0.204
LPG is not safe	0.650	-0.091

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

K	Component	
	1	2
Distance to retail shop makes it expensive to buy	0.713	0.130
LPG is more expensive than electricity	0.773	-0.125
Only rich people can afford LPG	0.603	-0.048
The smaller cylinders are more affordable	-0.011	0.839
LPG appliances like stoves are expensive to buy	-0.026	0.838

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

L	Component
	1
At home we use LPG during winter to warm up the house	0.387
At home we use LPG to cook food	0.824
At home we use LPG to heat water	0.746
LPG is important during load-shedding	0.644
At home we save electricity when we use LPG for cooking	0.764

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

The statements in sections B, C, D, E, F, G and L loaded perfectly along a single component. The implication is that the statements in these sections measures perfectly what the study sets out to measure.

Whereas the variables in sections H, I, J and K have sub-themes which is an indication that they loaded along 2 components. This implies that respondents are influenced by other potential trends in the section which may fall out of scope. Therefore, for the purposes of this study, Sections H and I were excluded.

4.6 TESTING RELIABILITY

For precision, the aspects of reliability and validity were considered. For this study, reliability was computed through the process of taking a number of measurements from the same subjects. For this newly developed construct, it was determined that reliability coefficient of 0.60 and higher is measured as “acceptable”.

Cronbach’s alpha score for all items in the questionnaire is presented in Table 4.1 below.

Table 4. 6: Cronbach’s Alpha Score

	Section	Number of Items	Cronbach's Alpha
B	Size of the Cylinder	2	0.602
C	Household Income	2	0.633
D	Household Size	2	0.638
E	LPG Availability	2	0.585
F	Awareness	2	0.671
G	Level of Education	2	0.692
H	Dwelling Status	2	0.655
I	Food Preparation	2	0.567
J	Safety	4	0.553
K	Cost of LPG	5	0.609
L	LPG Usage	5	0.644
All items included		38	0.606

The reliability scores for all sections exceed or approximate the recommended Cronbach’s alpha value. This indicates a degree of acceptable, consistent scoring for these sections of the research.

4.7 FACTOR ANALYSIS

The following section analyses the score patterns of respondents for each variable, for each section.

4.7.1 Section B: Size of the cylinder

This section deals with the variable ‘size of the cylinder’. The researcher examined whether this variable had any influence or impact on the energy choice of LPG on rural households in the villages of JTG District Municipality, in the Northern Cape. Table 4.7 below summarises the scoring patterns.

Table 4. 7: Size of cylinder patterns

		Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree		Chi Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
LPG is sold in small cylinders that are more affordable	B1	31	10.5%	223	75.9%	13	4.4%	20	6.8%	7	2.4%	< 0.001
At home we prefer large cylinders	B2	25	8.5%	208	70.7%	11	3.7%	33	11.2%	17	5.8%	< 0.001
Buying small cylinders ultimately becomes expensive as it finishes quickly	B3	33	11.1%	226	76.1%	17	5.7%	11	3.7%	10	3.4%	< 0.001

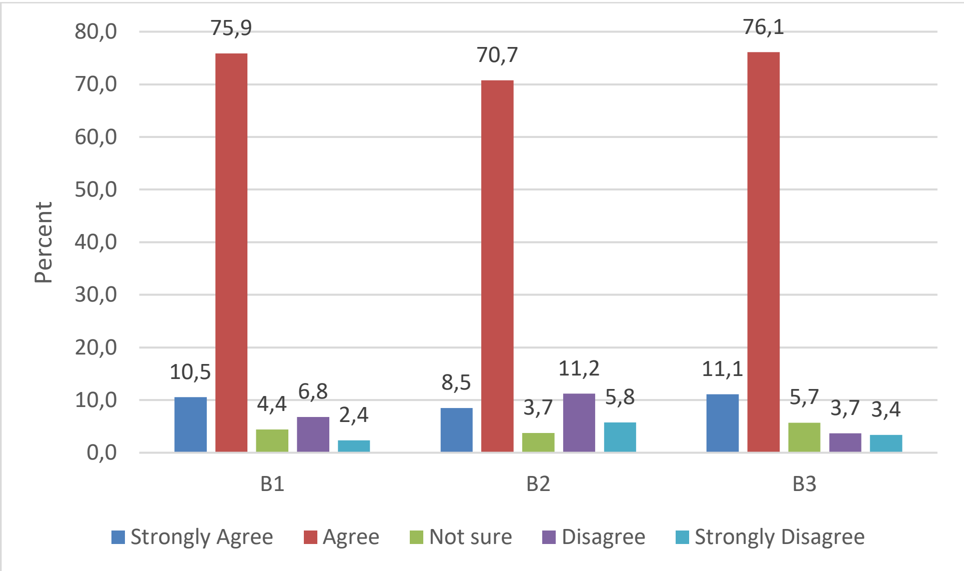

Figure 4. 8: Size of cylinder

General trends identified:

There appears to be a strong perception with over two-thirds (75%) of respondents agreeing that smaller cylinders are more affordable. The impact is that there is a likelihood that a higher number of rural households have a preference for smaller cylinders. This likely due to cost constraints or affordability, income levels, ease of transportation. However, when asked whether respondents prefer a large cylinder, a little over two-thirds (70.7%) of respondents had in fact a preference for larger cylinders. Whereas 75% believe that smaller cylinders are more affordable, 70.7% still prefer larger cylinders. Therefore, there is a strong likelihood that, due to cost constraints, some households would have to settle for smaller cylinders, whereas they prefer larger cylinders. Furthermore, over 76.1% of respondents believe that smaller cylinders ultimately become more expensive because the fuel depletes quickly. This further supports the findings that there is a strong preference for larger cylinders (as they do not deplete as fast). However, due to cost implications, respondents are likely to select or buy a smaller cylinder.

4.7.2 Section C: Household Income

This section deals with the variable ‘household income’. The researcher examined whether this variable had any influence or impact on the energy choice of LPG on rural households in the villages of JTG District Municipality, in the Northern Cape. Table 4.8 below summarises the scoring patterns.

Table 4. 8: Household income patterns

		Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree		Chi Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
Our monthly income is low, so we use other energy sources like firewood or electricity	C4	28	9.4 %	230	77.4 %	7	2.4 %	27	9.1 %	5	1.7 %	< 0.001
LPG is for the rich not poor people	C5	6	2.0 %	33	11.2 %	5	1.7 %	223	75.9 %	27	9.2 %	< 0.001
At home we buy LPG only when we have enough money	C6	7	5.6 %	92	73.6 %	1	0.8 %	22	17.6 %	3	2.4 %	< 0.001

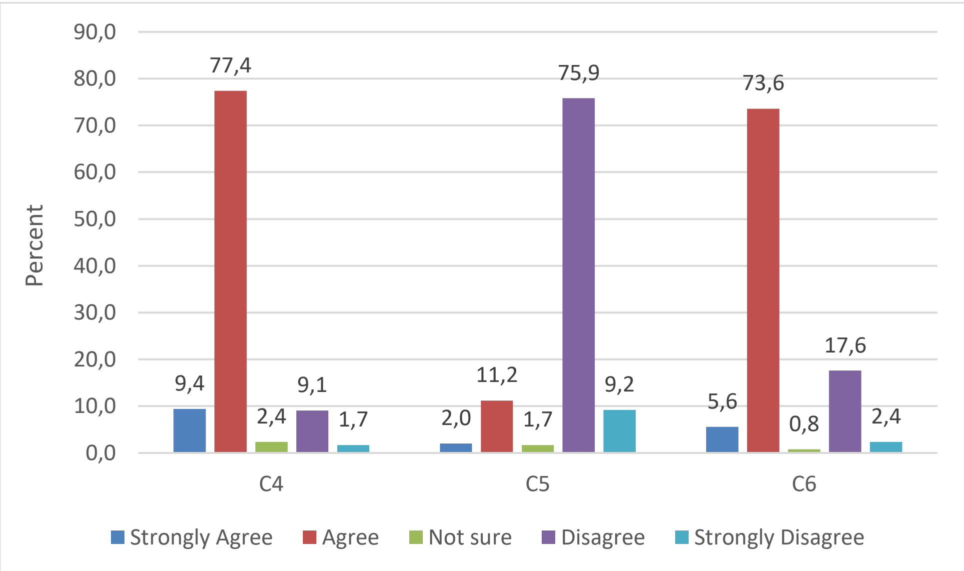

Figure 4. 9: Household income

General trends identified:

The statement about whether the respondent prefers to use other sources of fuel (not LPG) such as electricity or firewood due to low household income, a significantly higher number of respondents (77%) agreed with the statement. The statement about whether respondents believed that LPG is only for high-income households, majority of respondents (75.9%) disagreed with the statement. This implies that, without the impediment of affordability, low-income households believe that LPG is for all (whether rich or poor). This will have a positive impact on the adoption of LPG. It is noted that 73.6% of respondents agreed that they would only buy LPG when they have enough money (or income). Therefore, income and cost remain a major impediment. Factors such as finances, cost and availability of LPG impacts on the transition to LPG (Quinn *et al*., 2018). Therefore, income and cost remain a major impediment.

4.7.3 Section D: Household Size

This section deals with the variable 'household size'. The researcher examined whether this variable had any influence or impact on the energy choice of LPG on rural households in the villages of JTG District Municipality, in the Northern Cape. Table 4.9 below summarises the scoring patterns.

Table 4. 9: Household size patterns

		Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree		Chi Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
We are a big household, so LPG does not last	D7	8	2.7%	31	10.3%	29	9.7%	169	56.3%	63	21.0%	< 0.001
If we were a small household, we would use LPG	D8	17	9.9%	112	65.5%	12	7.0%	23	13.5%	7	4.1%	< 0.001
Other sources of energy are better for cooking for a big family	D9	29	9.8%	237	79.8%	9	3.0%	19	6.4%	3	1.0%	< 0.001

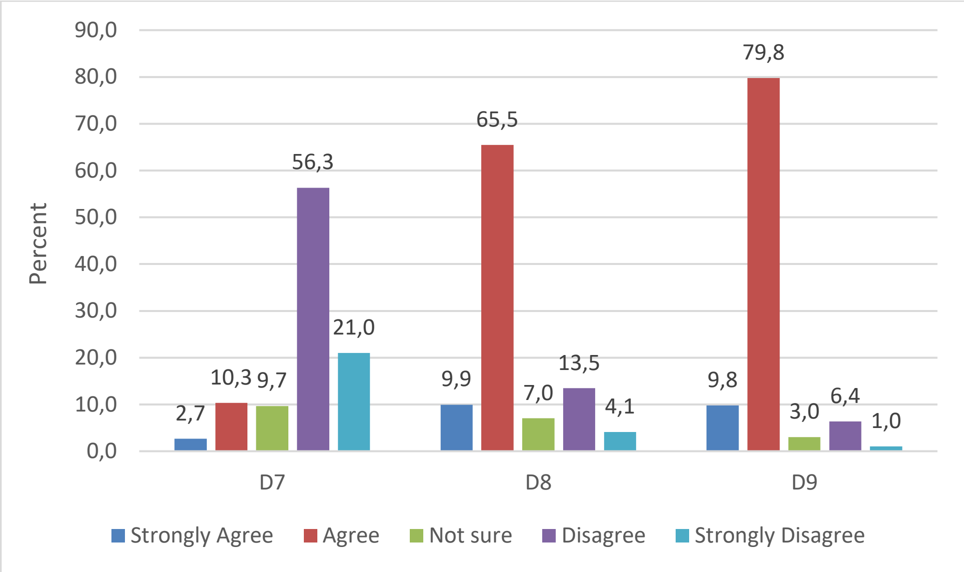

Figure 4. 10: Household size

General trends identified:

77.3% of respondents disagreed that LPG does not last long for a big household (i.e. 7 or more residents in a household). This is likely to have a positive impact on the fuel choice of LPG. However, the chance of LPG being adopted as a household fuel appears to be greater for a smaller household (0 - 6 household residents), because 75.4% of respondents agreed that they are likely to buy LPG of the household is smaller. Therefore, household size has a direct impact on the fuel choice of LPG. Furthermore, majority of respondents (79.8%) agreed that other sources of energy (not LPG) are better for cooking for a big family/household.

Therefore, the inference the researcher can make is that household size doe have an impact on household energy choice of LPG. That is, the larger the family, the smaller the chances of household transitioning or adopting LPG. For a larger household, more dirty energy is expected to be used more than cleaner fuels particularly in rural areas (Obrumah *et al*., 2019; Liao *et al*., 2019; Mwaura *et al*., 2014).

4.7.4 Section E: LPG Availability

This section deals with the variable ‘LPG availability’. The researcher examined whether this variable had any influence or impact on the energy choice of LPG on rural households in the villages of JTG District Municipality, in the Northern Cape. Table 4.10 below summarises the scoring patterns.

Table 4. 10: LPG availability

		Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree		Chi Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
There are many suppliers of LPG in my village	E10	20	6.7%	124	41.5 %	25	8.4%	100	33.4 %	30	10.0 %	< 0.001
We travel long distance to buy LPG	E11	18	6.1%	57	19.2 %	9	3.0%	207	69.7 %	6	2.0%	< 0.001
Sometimes, the suppliers run out of stock	E12	18	6.1%	55	18.6 %	17	5.8%	197	66.8 %	8	2.7%	< 0.001

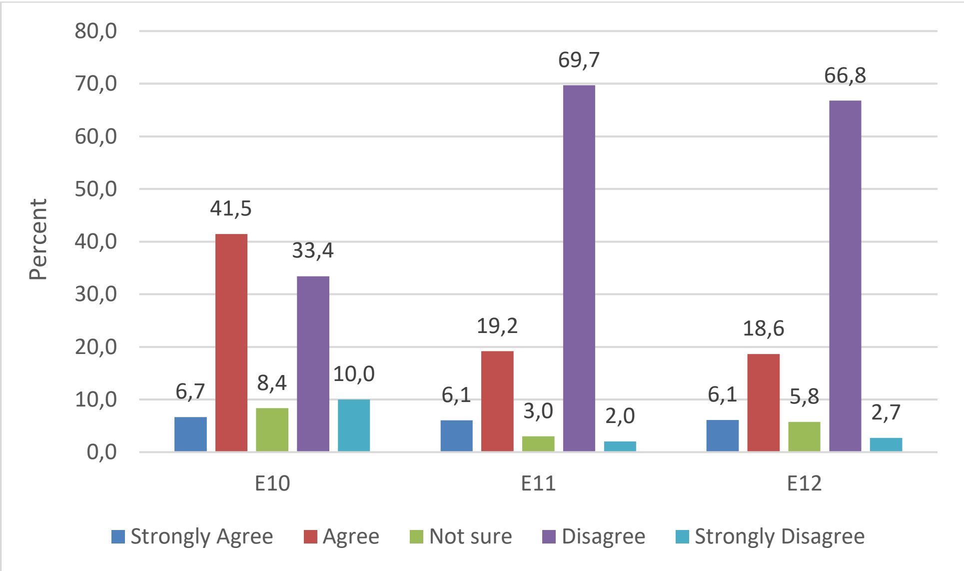

Figure 4. 11: LPG availability

General trends identified:

Responses about whether there are many suppliers of LPG in the village, were not significantly different. 48.2% of respondents agreed that there are many suppliers of LPG in their village and 43.4% disagreed with the statement. 8.4% were not sure. This implies that, there is an almost equal proportionate of villages with LPG supply, as compared to villages without LPG supply. The availability/unavailability of LPG in a village will have a direct impact on household energy choice of LPG. The statement about whether respondents have to travel long distance to buy LPG, about two-thirds (69.7%) of respondents disagreed with the statement. This implies that LPG suppliers are generally not too far from the villages. It is to be noted however that 69.7% is not significant enough.

However, both statements (E10 and E11) are supported by Figure 4.6 which demonstrated that just over half (54.9%) of respondents have to travel longer distance to town to access LPG outlets/markets and 40.7% households travel shorter distances as they have access to LPG within their respective villages. According to findings by Quinn *et al*., (2018) limited access modern fuels drives up the demand for primitive and dirty fuels. Two-third (66.8%) of respondents disagreed with the statement that sometimes LPG suppliers run out of LPG. Whereas this is not a significantly high enough, this nonetheless points to a supply network which operates fairly smoothly. However, a greater footprint of LPG outlets is necessary for a more positive impact on LPG fuel choice. Therefore, it is to be noted that LPG available has an influence on LPG adoption. Ultimately, energy transition is influenced by reliable supply, enough distributors and a strong supply-chain network (Farsi *et al*., 2007; Mirza & Kemp, 2009).

4.7.5 Section F: Awareness

This section deals with the variable ‘Awareness’. The researcher examined whether this variable had any influence or impact on the energy choice of LPG on rural households in the villages of JTG District Municipality, in the Northern Cape. Table 4.11 below summarises the scoring patterns.

Table 4. 11: LPG awareness patterns

		Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree		Chi Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
I do not know how to use LPG	F13	11	3.7%	85	28.3%	9	3.0%	179	59.7%	16	5.3%	< 0.001
I know the benefits of LPG	F14	19	6.4%	243	81.3%	12	4.0%	21	7.0%	4	1.3%	< 0.001
LPG is only used for cooking	F15	17	5.7%	85	28.7%	9	3.0%	173	58.4%	12	4.1%	< 0.001
I know the different places that sells LPG	F16	22	7.4%	236	79.5%	6	2.0%	28	9.4%	5	1.7%	< 0.001

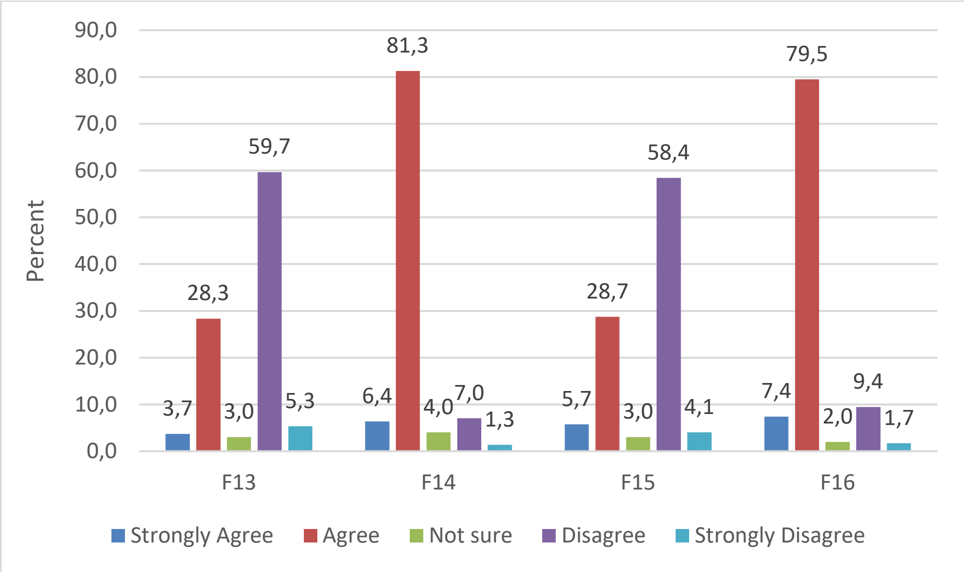

Figure 4. 12: LPG awareness

General trends identified:

Response to the statement "I do not know how to use LPG", yielded the following responses: 65% disagreed, whereas 32% agreed with the statement. This is implies that about two-third of respondents are comfortable with their knowledge of how to use LPG. However, what remains a concern is that a significantly high rate (35%) of respondents does not have the knowledge of how to effectively use LPG for household use. This will have a direct impact on the energy choice of LPG by rural households. Majority of respondents (81%) agree that they are aware of the benefits of LPG. This will have a significant positive impact on the energy transition to LPG. When there is more awareness about the benefits of LPG, households will gradually adopt the use of LPG (Ronzi *et al*., 2016). In direct support of the statement above, a little less than two-third (62.5%) respondents disagreed with the statement that "LPG is only used for cooking". However, this is not significant enough as a fairly large population of 34.4% respondents agreed that LPG is used only for cooking, whereas 3% are not sure at all. This will have a direct negative impact on the promotion of LPG adoption as the benefits are not fully understood by one-third of the respondents. 79.5% of respondents agreed that they are aware of the different places selling LPG. This will have a direct positive impact on the adoption of LPG.

4.7.6 Section G: Level of Education

This section deals with the variable 'Awareness'. The researcher examined whether this variable had any influence or impact on the energy choice of LPG on rural households in the villages of JTG District Municipality, in the Northern Cape. Table 4.12 below summarises the scoring patterns.

Table 4. 12: Education level patterns

		Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree		Chi Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
It is mostly educated people who use LPG	G17	12	4.0%	31	10.3%	9	3.0%	223	74.3%	25	8.3%	< 0.001
Anyone can use LPG	G18	36	12.2%	225	76.0%	5	1.7%	26	8.8%	4	1.4%	< 0.001
It is NOT easy to learn how to use LPG	G19	9	3.1%	138	47.4%	12	4.1%	124	42.6%	8	2.7%	< 0.001

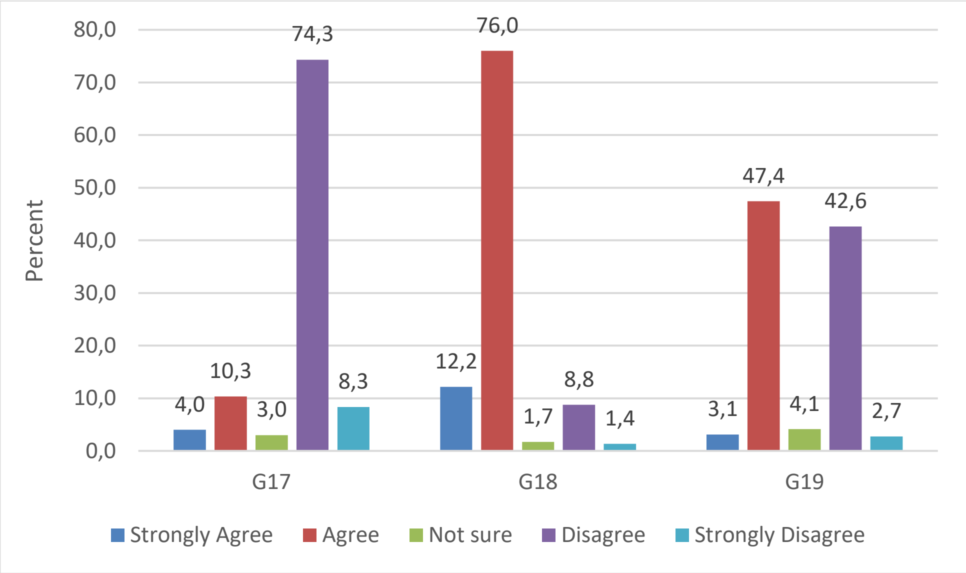

Figure 4. 13: Education level

General trends identified:

74.3% of respondents disagreed with the statement that it is mostly educated people who use LPG. This will have a positive impact in the adoption of LPG by both educated and less educated users, as this myth or perception is not highly entrenched. The above results are further supported by 76% of respondents agreeing with the statement that “anyone can use LPG”. However, it is clear that there is a perception that educational background contributes towards the ability to learn how to use LPG as 47% of respondents agreed with the statement “it is not easy to learn how to use LPG.” Therefore, education or educational background does have an impact of the fuel choice of LPG. Education, like awareness, influences energy usage at household level (Sustainable Energy Authority of Ireland, 2018; Mgimba *et al*., 2017).

4.7.7 Section L: LPG Usage

This section deals with the variable 'LPG usage'. The researcher examined whether this variable had any influence or impact on the energy choice of LPG on rural households in the villages of JTG District Municipality, in the Northern Cape. Table 4.13 below summarises the scoring patterns.

Table 4. 13: LPG usage patterns

		Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree		Chi Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
At home we would like to use LPG during winter to warm up the house	L36	14	4.8%	152	51.9%	8	2.7%	105	35.8%	14	4.8%	< 0.001
At home we would like to use LPG to cook food	L37	19	6.4%	256	85.9%	5	1.7%	14	4.7%	4	1.3%	< 0.001
At home we would like to use LPG to heat water	L38	19	6.4%	252	84.8%	6	2.0%	15	5.1%	5	1.7%	< 0.001
LPG is important during load-shedding	L39	94	31.4%	195	65.2%	2	0.7%	6	2.0%	2	0.7%	< 0.001
At home we would save electricity if we used LPG for cooking	L40	47	15.7%	238	79.6%	6	2.0%	5	1.7%	3	1.0%	< 0.001

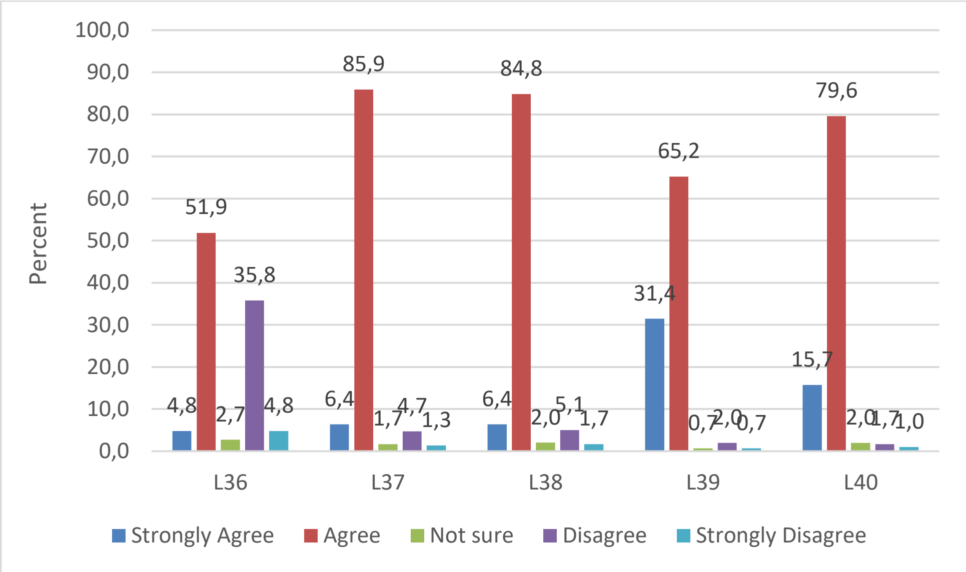

Figure 4. 14: LPG usage

General trends identified:

Just over half of the respondents (56.7%) agreed that they would like to use LPG for space heating during winter and 40.6% disagreed. The high rate of respondents not interested in using LPG for household heating signifies cost constraints and an affordability factor. A clear majority (92.3%) of respondents would like to use LPG for cooking, whereas a significant rate (91.2%) of respondents would like to use LPG for boiling water. Regarding whether "LPG is important during load shedding" (electricity blackout) load shedding), an overwhelming majority of 96.6% agreed with the statement. Energy security has direct impact on LPG adoption. Lastly, the majority of respondents (95.3%) agree that they would save electricity if they used LPG for cooking. Thus, the many uses of LPG has a direct positive impact on the interest levels of rural households to transition to or adopt LPG into their household energy mix.

4.7.8 Section B: Safety

This section deals with the variable 'safety of LPG'. The researcher examined whether this variable had any influence or impact on the energy choice of LPG on rural households in the villages of JTG District Municipality, in the Northern Cape. Table 4.14 below summarises the scoring patterns.

Table 4. 14: LPG safety

	Strongly	Agree	Not sure	Disagree	Strongly	Chi

		Agree								Disagree		Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
I am aware of the safety requirements when using LPG	J26	26	8.7%	250	83.9 %	5	1.7%	12	4.0%	5	1.7%	< 0.001
LPG is safer to use in a formal structure house like a brick-and- mortar house	J27	26	8.7%	145	48.5 %	14	4.7%	110	36.8 %	4	1.3%	< 0.001
Children younger than 18 years should not use LPG	J28	28	9.4%	225	75.8 %	12	4.0%	22	7.4%	10	3.4%	< 0.001
I know of someone who was badly affected by LPG	J29	17	5.7%	59	19.8 %	12	4.0%	201	67.4 %	9	3.0%	< 0.001
LPG is not safe	J30	34	11.8 %	184	63.7 %	14	4.8%	52	18.0 %	5	1.7%	< 0.001

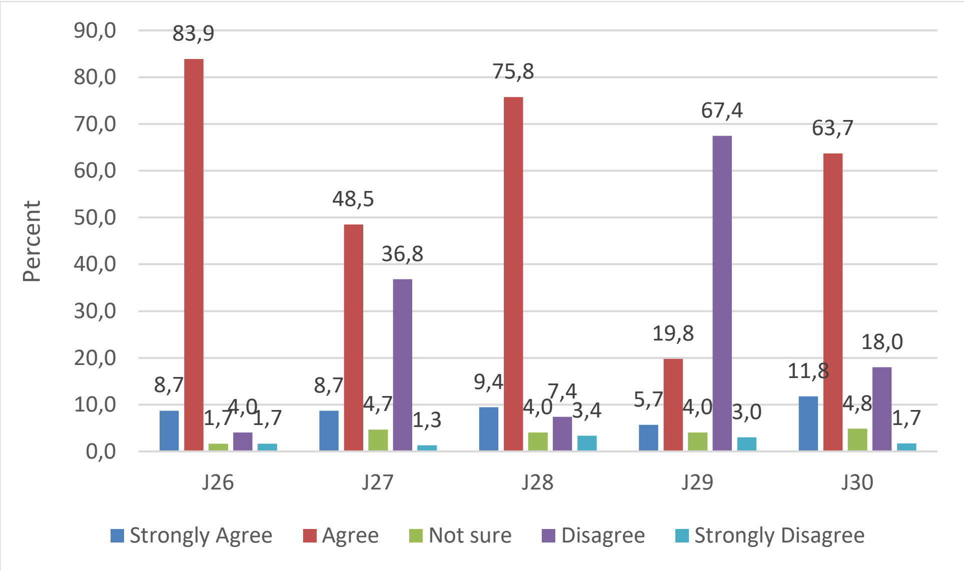

Figure 4. 15: LPG safety

Note: There are 2 sub-themes in this section.

The following statements form a sub-theme:

- I am aware of the safety requirements when using LPG
- Children younger than 18 years should not use LPG

There are similar levels of agreement relation to this sub-theme, that is “Age and the Use of LPG”. Respondents have an understanding of the impact of age in relation to the ability to operate LPG and LPG appliances such as stoves, heaters and cylinders.

General trends identified:

A clear majority of respondents (92.6%) agree that they are aware of the safety requirements when using LPG. Regarding the statement that LPG is safer to use in a brick-and-mortar house type, the views are divided almost equally with just over half (57.2%) of respondents agreeing and 28.1% disagreed. The implication of almost half of respondents associating house type with the safe use of LPG is very significant on the impact of LPG adoption. This creates a negative perception about LPG safety for rural household users dwelling in either a mud-house or shanty/shack. Another strong perception about LPG safety is the believe that children under the age of 18 years should not use LPG. This implies that majority of respondents (85.2%) believe that users below the age of 18 years should not use LPG and its appliances. This will have a direct negative impact on the adoption and/or regular usage of LPG. Over two-thirds (70.4%) of respondents disagreed with the statement that they know someone badly affected by LPG. This may imply that the safety concern about LPG appliances amongst respondents is exacerbated by rumours. A direct statement further probing the perception about LPG safety, the response rate agreeing with the statement “LPG is not safe” was a clear majority with well over two-thirds of respondents (75.5%) agreeing; compared to 19.7% believing that LPG is safe. It is clear from the responses that the safety factor has a strong impact on the energy choice of LPG.

4.7.9 Section B: Cost of LPG

This section deals with the variable ‘Cost of LPG’. The researcher examined whether this variable had any influence or impact on the energy choice of LPG on rural households in the villages of JTG District Municipality, in the Northern Cape. The table below summarises the scoring patterns.

Table 4. 15: Cost of LPG

		Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree		Chi Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
Distance to retail shop makes it expensive to buy	K31	24	8.1%	103	34.6 %	11	3.7%	158	53.0 %	2	0.7%	< 0.001
LPG is more expensive than electricity	K32	24	8.0%	44	14.7 %	8	2.7%	215	71.9 %	8	2.7%	< 0.001
Only rich people can afford LPG	K33	14	4.7%	27	9.1%	7	2.3%	229	76.8 %	21	7.0%	< 0.001
The smaller cylinders are more affordable	K34	21	7.0%	240	80.5 %	10	3.4%	21	7.0%	6	2.0%	< 0.001
LPG appliances like stoves are expensive to buy	K35	19	6.5%	236	80.3 %	15	5.1%	19	6.5%	5	1.7%	< 0.001

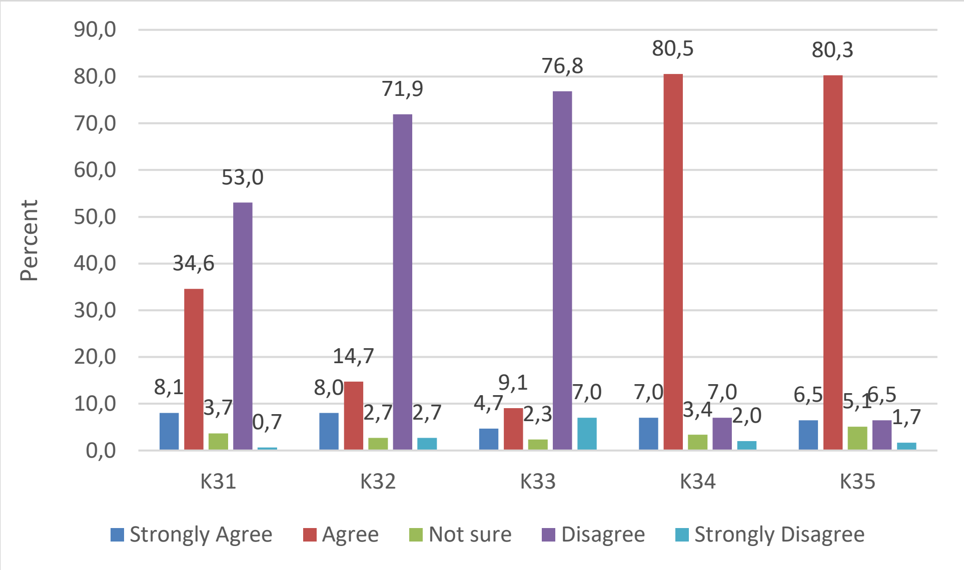

Figure 4. 16: Cost of LPG

The following statements form a sub-theme:

- The smaller cylinders are more affordable
- LPG appliances like stoves are expensive to buy

There are similar levels of agreement relation to this sub-theme “LPG appliances and the cost of LPG”. Respondents have an understanding of the cost implications of LPG appliances in relation to the size and type of appliance.

General trends identified:

Just over half of respondents (53.7%) disagreed that the distance users have to travel to retail shops to buy LPG makes it expensive to buy LPG. Whereas just under half (42.7%) agreed that traveling to buy LPG makes it more expensive to consume. This implies that the respondents without the concern about cost of travel are likely buying LPG within their village (40.7%) as opposed to the 54.9% respondents having to travel to town (or 4.4% buying it from neighbouring villages) to buy LPG (see Figure 4.6). Majority of respondents (74.6%) disagreed with the statement that “LPG is more expensive than electricity”, compared to 22.7% who believe that LPG is more expensive than electricity. Therefore price of LPG (as compared to electricity) has a strong impact on the adoption of LPG. Another positive perception is that majority of respondents (83.8%) disagee with the statement that “only rich people can afford LPG”. This will have a positive impact on the adoption and fuel transition to LPG. 87.5% of respondents agree that smaller cylinders are more affordable. This will have a positive impact on households considering fuel transition or adoption of LPG. Majority of respondents (86.8%) agree that LPG appliances are expensive to buy. This will have a negative impact on the adoption of LPG.

4.8 CONCLUSIONS

This chapter outlined the results from data collected from the questionnaire. A reliability score exceeds or approximated the recommended Cronbach's alpha value which indicated a degree of acceptability and consistent scoring for the sections of the research. The quantitative data was analysed and interpreted with the descriptive statistics presented in the form of graphs and other figures for the quantitative data that was collected. The following chapter will provide recommendations and conclusions.

CHAPTER 5: RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

This study aimed to determine the various factors that contribute to the slow energy transition towards LPG in rural households in South Africa, with a specific focus on the Northern Cape Province. The chapter provides a summary of key findings from both the primary study and the literature review, as well as the limitations of the study. This is followed by recommendations for further research, conclusions, and policy recommendations.

5.2 SUMMARY OF FINDINGS

The various contributing factors which the study revealed are discussed below.

5.2.1 Demographics characteristics influencing households' energy choice

The study revealed that the majority of rural households (91.4%) were electrified, which included all house types, with the majority being brick-and-mortar, followed by shanty/shacks, and mud houses. The electrified profiles of rural households influenced the energy choice of households; for the majority of households, any additional fuel source is based on household energy functions. This study, like others, found that education level influences household energy choices. The educational profile of rural households revealed a mostly undereducated population. The impact is found to be on the level of awareness of the benefits of LPG and various household applications. Another key finding is that the family size influences the choice of cylinder size proportionately.

The income of rural households in the JTG has a direct impact on the energy choice of LPG. This study revealed that income contributed to the size of the cylinder, access to LPG markets, acquisition of LPG equipment, and affordability. The energy profiles of the households revealed a mixed energy profile. At the bottom of the energy ladder, households were not connected to the grid (8.6%); however, the study also revealed that some households without electricity depended on a single source of energy or multiple sources along the three phases of the energy model (see Figure 2.4). Households can transition up or down along a linear line. For instance, some unelectrified households may use a combination of advanced fuels (for example, LPG) and primitive fuel (e.g. firewood) for cooking, and also use a transition fuel such as paraffin for their lighting needs. This study found that the energy profile of rural households in the JTG district municipality is consistent with the energy stacking hypothesis and more contemporary energy models.

5.2.3 Other drivers of household energy choice

The study revealed that the majority of households are likely to buy smaller cylinders owing to cost constraints, whereas the majority of households prefer larger cylinders as they perceive them as adequate for the size of the family. Although there is a clear interest in adopting LPG as an additional source of energy, the household income level is a barrier to transition. Households are aware of the benefits of LPG, but affordability is a major impediment. Safety is a great concern for households, but studies have revealed that this does not have a strong negative influence on energy transition. This is likely because the majority of households consider LPG to be more affordable than electricity and that it is a good alternative source of power during electricity blackouts (Eskom load shedding). The latter is likely to have a strong positive impact on the adoption of or energy transition to LPG.

The study also found that household size influenced energy choice. There is a perception among households that LPG is not an effective source of energy for large families. Another finding is that proximity to the market has a direct influence on the energy choice of rural households; the closer the market is to the consumer, the more attainable and affordable the energy source (the inverse is true).

5.4 RECOMMENDATIONS

This study sought to fill a knowledge gap about the various factors contributing to the energy choices of rural households. LPG has been proven to provide health and environmental benefits to users, particularly in low-income households that are more exposed to primitive and harmful fuels. The transition of the energy ladder towards cleaner and more efficient fuels must be supported through strategic rollout strategies developed at the local level by the local government. The strategy document can be informed by the national LPG rollout strategy, the World LPG Association policy guide, and the national energy policy and be directed at the local policy level. Local governments must identify and partner with strategic energy industry partners, LPG industry players, and other stakeholders interested in matters of energy security, health promotion, and environmental sustainability.

According to the Municipal Systems Act, every new council that comes into office after the local government elections is required to draft its own IDP, which will serve as a roadmap for council members during their term of office, which lasts for a total of five years. This can be utilised to consider a strategy for the promotion of LPG in low-income households to eradicate energy poverty. This can be considered the first KPA of Basic Service Delivery and Infrastructure Investment.

Other key policies which the local government can take advantage of are the two policy instruments that promote electricity provision for indigent households: Free Basic Alternative Energy (FBAE) and Free Basic Electricity (FBE). Accordingly, the objective of these policies is to supply a specified amount of basic energy to indigent households, not necessarily for the provision of other modern energy sources. However, lessons have been learned from the municipalities that utilised the subsidy fund to promote the adoption of LPG in low-income households:

The City of Tshwane Metropolitan Municipality took advantage of the subsidy fund in 2006 by implementing an LPG programme through its Public Works & Infrastructure Development Department, wherein 13,300 (and not 20,000 as intended) households benefitted. Kimemia and Annegan (2016) evaluated the impact of subsidised LPG intervention and found that over 70% of recipients still using LPG seven years after the LPG intervention. Beneficiaries indicated that LPG enhanced their well-being, with tangible benefits, such as fast cooking and electricity bill savings. Recommendation was that in order for implementing agents to ensure greater project success, there was a need for a more stringent beneficiary selection criteria, improved community involvement, a long-term LPG distribution and maintenance plan and the addition of recurring monthly LPG subsidies for low-income households.

In another pilot programme, the Western Cape Province implemented an LPG intervention project supported by the Department of Energy and Eskom (in the Western Cape). This initiative was implemented when the province experienced protracted electricity blackouts in 2006. In response to this energy crisis, the utility Eskom launched an aggressive Demand Side Management (DSM) initiative with the intention of saving electricity and lowering the need to lose household customers. The initiative included an ‘energy equipment exchange’ and subsidy programme in Khayelitsha, City of Cape Town Metropolitan Municipality. Residents were urged to switch their two-plate electric stoves to Liquid Petroleum Gas (LPG) stoves. Residents in low-income neighbourhoods enthusiastically embraced LPG burners. Mohlakoana and Annecke (2009) found that up to 89% of the households surveyed still used LPG for cooking.

Such case studies can be explored further by the local government to maximise the value of subsidy funds and ensure that the scaling up and mainstreaming of LPG interventions are based on research evidence. Other funds that local governments can take advantage of include decarbonisation funds, carbon credits, SLP funds, and a strategy to participate in South Africa’s Carbon Offsets programme. The statistical data in this study can be used as a framework for rural household transition patterns. It is important to note that the development and application of clean cooking technology for low-income households has significant promise for advancing at least five UN Sustainable Development Goals (SDGs) which are “3. Good health and wellbeing; 5. Gender equality; 7. Accessible and clean energy; 13. Climate action; 15. Life on land.”

5.5 LIMITATIONS

The following limitations are noted in this study: Firstly, the need to translate the data collection instrument to the local language of Setswana some useful detail might have been ‘lost in translation’. In some instances, participants from Gamagara local municipality were only comfortable interacting with Afrikaans. Second, the study included non-decision makers which may have caused cross-comparisons, particularly on some socioeconomic and safety variables. Lastly, due to time constraints, the researcher was limited in examining whether there was a strong correlation between some identified factors and rural household energy choices of LPG. This limitation can be addressed through further analysis of the statistical reports generated from the collected data.

Notwithstanding these limitations, this study contains useful statistical data and energy use patterns that contribute to the provision of energy security to rural households in South Africa.

5.6 RECOMMENDATIONS FOR FUTURE RESEARCH

To better understand the implications of these results, future studies could address consumer behaviour in detail using qualitative research methodology. Further research is required to understand the effects of external factors influencing energy consumption from the perspective of retailers, and wholesalers will provide further insights.

5.7 CONCLUSIONS

Given the significance of energy poverty alleviation in South Africa, this study sought to identify the drivers of energy choices within the context of LPG adoption in low-income rural households. This chapter concludes the study by highlighting the key findings related to the research aims and questions. Notably, access to markets, household income, safety (particularly in relation to age), and awareness were found to act as the primary antecedents, while family size and dwelling type were found to act as secondary antecedents. On the basis of these findings, actionable recommendations were made. This chapter concludes with a review of the overall limitations, from which future research recommendations are derived. It is envisaged that this research will assist the LPG industry, policymakers, and government in developing strategies to address energy poverty in these communities through the promotion and adoption of LPG.

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