Investigating the current and future roles of paraffin in South Africa

LOUISE TAIT

BRUNO MERVEN

MAMAHLOKO SENATLA

ENERGY RESEARCH CENTRE
University of Cape Town

Contents

List of abbreviations used

BAU	Business as usual
CFL	Compact fluorescent light bulbs
DoE	Department of Energy
DoH	Department of Health
DRMC	Disaster Risk Management Centre
DSH	Department of Human Settlements
FBAE	Free Basic Alternative Energy
FBE	Free Basic Electricity
HESASA	Household Energy Safety Association of South Africa
GJ	Gigajoule
IDP	Integrated Development Plan
IEP	Integrated Energy Plan
LPG	Liquid Petroleum Gas
NMDC	National Disaster Management Centre
NRCS	National Regulator for Consumer Standards
PASASA	Paraffin Safety Association of South Africa
SANEDI	South African National Energy Development Institute
SAPIA	South African Petroleum Industry Association
SATIM	South African TIMES model
SWH	Solar Water Heater
VAT	Value added tax

Executive summary

This research was undertaken to explore the current and future role of paraffin in South Africa for PASASA. The domestic use of paraffin carries many health and safety concerns including the risks of fires and burns, unintentional ingestions of paraffin, indoor air pollution associated with use of cheap appliances and contamination of the fuel. In South Africa it is difficult to garner political support to adequately regulate the safety of this fuel. The Department of Energy's policy approach to energy has been dominated by a focus on promoting access to grid-based electrification. There have been comparatively fewer programmes to address access to other household fuels. The major players in paraffin safety to date have been the petrochemical companies through their funding of the Paraffin Safety Association (PASASA). This situation has changed, however, with the decision of the petrochemical companies in 2012 to discontinue funding PASASA.

This research investigates what the future of paraffin could and should be in South Africa, in particular whether this could be envisioned as transforming paraffin into a safe fuel for households. Alternatively, might South Africa look to assist households with a transition towards other modern fuels.

The research involved interviews with a range of stakeholders including government departments and representatives from the petrochemical sector, as well as academics and development practitioners in the household energy sector. It also included focus groups with consumers of paraffin in informal settlements in Cape Town to explore the use of paraffin from a consumer perspective. Finally, a modelling exercise was undertaken to estimate the future consumption of paraffin under different policy scenarios. These included a business as usual scenario, a government liquefied petroleum gas (LPG) programme scenario, a least cost scenario, and a safe stove scenario.

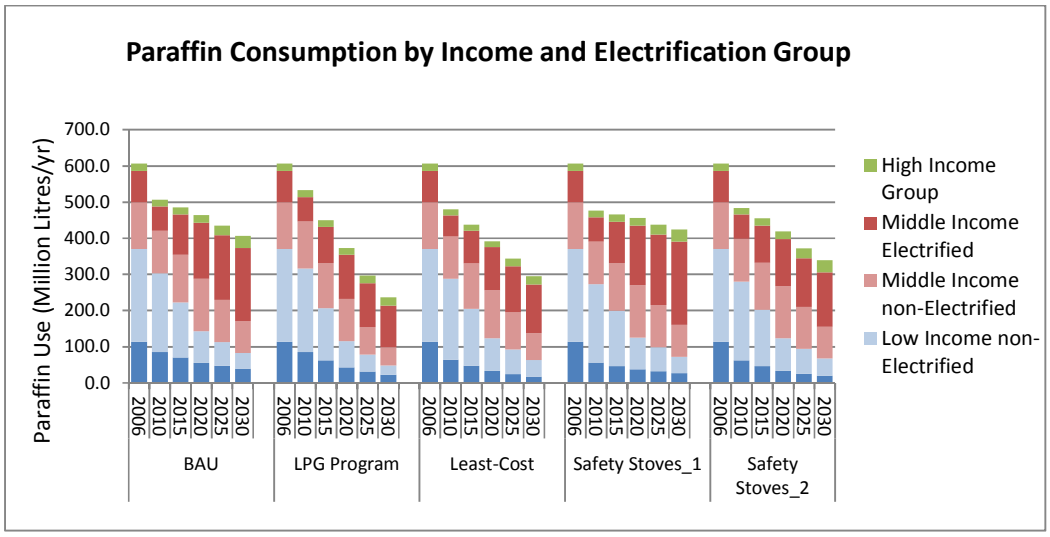
The focus groups revealed that households see paraffin as an important part of their overall energy mix. Among its major attributes are its perceived affordability compared to LPG or electricity, as well as being the preferred fuel for cooking certain meal types. However, consumers also registered much dislike of the negative safety implications of the cheap and unsafe stoves, as well as symptoms associated with the indoor air pollution. None of the households from the focus groups had ever seen or heard of the safe and compliant stoves. Many had however stopped using the illegal wick stoves because of their safety risks and switched to using paraffin heaters for cooking instead. These are seen to be safe, reliable and good value for money. Evidence from the focus groups suggests that market penetration of safe stoves may not be succeeding, but that households themselves in some instances are finding market solutions for safer appliance alternatives.

The focus group discussions also gave insight into the inadequacy of the electrification programme to address households' energy needs and transition them away from unsafe fuels. Electricity supply in informal settlements is often unreliable, with blackouts a frequent feature of people's lives. This requires that households have 'back-up fuels' and thus necessitates the on-going use of candles and paraffin. The practice of selling electricity amongst neighbours is common but typically means that one connection cannot support more than one household cooking at a time, again requiring the use of other fuels. There are also issues with low-cost electrical appliances that make them unsuitable for cooking all meal-types. Widespread and deeply entrenched misperceptions relating to different energy sources among consumers also serve as barriers that keep households from transitioning to safer or more affordable alternatives. There is a firm belief that electricity is more expensive than paraffin and beyond the affordability levels of many households, although research studies comparing the relative cost to cook with different fuels and their appliances show that electricity is significantly cheaper than both paraffin and LPG. A major barrier to increased LPG use is fear that it is not safe, particularly that cylinders may explode, which ironically keeps many households continuing to use paraffin, a fuel with comparatively greater safety risks.

The stakeholders interviewed saw the lack of political will as the principal barrier to improved paraffin safety in South Africa. Greater regulation of appliances and packaging is seen as a vital

part of a solution. Most stakeholders were sceptical of overcoming the challenges around paraffin safety in South Africa. Phasing this fuel out and transitioning households to other modern alternatives such as LPG and electricity was seen to be more socially desirable. There was, however, acknowledgement that both of these fuels face supply constraints and are unlikely to be able to absorb the displaced demand from paraffin. In the absence of any direct intervention to phase out paraffin, most stakeholders expect that it will continue to retain a presence in the household market although consumption levels are likely to continue to decline. The petrochemical sector did not indicate that an active phase-out of paraffin is likely to happen and they will continue to respond to market demand for this product. The Department of Energy (DoE) too said that they have no intentions of actively phasing this fuel out. Their focus for the residential sector is on the continuation of the electrification programme, expanding the off-grid solar programme and, in the future, driving growth of LPG. Whilst expansion of both of these programmes (electrification and LPG) would contribute to the declining market share of paraffin, they would probably not result in paraffin's eradication from the fuel mix entirely. Therefore, without a proactive phase-out of this fuel, its presence in the South African market will continue for the foreseeable future.

The modelling exercise modelled four scenarios that are informed by assumptions about the adoption of different government programmes. The *LPG Programme* describes a scenario where government drives the uptake of domestic LPG use. This would entail programmes to overcome current demand barriers related to cost of the fuel and/or intiial high switching costs, and education to overcome fears of its safety. The scenario predicts a steeper decline in paraffin consumptions as more households switch towards LPG. The *Least Cost* scenario shows the impact on paraffin consumption were household energy choices based on choosing the least cost options. There are currently many misperceptions around the relative cost to a household of an energy service provided by different fuels. Misperceptions could be influenced through education and awareness programmes, for example. This scenario indicates reduced consumption of paraffin as households switch to using electricity for cooking, which is than paraffin. *Safety Stoves 1* describes a scenario where households use safer appliances and looks at the impact were households to switch to other existing technology. Safer non-pressure stoves have lower efficiencies than the illegal variant and this scenario therefore indicates greater paraffin consumption (although still long term decline) than the BAU scenario. *Safety Stoves 2* describes a scenario of high-end aspirational products, which are initially supported by subsidies and phased out over time. As a result paraffin consumption under this scenario initially rises but eventually declines more steeply over time as households transition to other cheaper options when the subsidies are phased out. All scenarios predict a gradual long-term decline in total consumption. Paraffin is estimated to decline from around 600 million litres in 2006 to approximately 400 million litres in 2030 in the *BAU* scenario.



Paraffin safety is a cross-cutting issue and requires involvement of a diverse range of stakeholders, in both public and private sectors. The petrochemical companies consider that their role in the safety aspects of the fuel has greatly diminished over time. They are no longer involved in the marketing and distribution of paraffin, which is where they suggest packaging initiatives should be directed. Going forward, it seems that is little further strategic value that they would derive from continuing to enhance the safe image of this product. In the absence of any regulatory requirements, it is unlikely that the petrochemical industry will play a significant role in paraffin safety. However the DoE, the principal governmental stakeholder, does not currently play a proactive role in supporting paraffin safety as its strategies are focused on other fuels. This makes the planning of a safe future for this fuel in South Africa extremely challenging, particularly around safe packaging and garnering further support and resources around appliance issues. In the absence of support from the DoE, there are, however, various other government stakeholders who could actively play a role in paraffin safety. The National Regulator for Consumer Standards (NRCS) has and will continue to play a defining role around appliance issues. The South African National Energy Development Institute (SANEDI) has also shown interest in supporting appliance safety. Whilst their primary focus is on efficiency, they support an integrated approach to energy interventions that address multiple objectives, including for example both efficiency and safety.

There is also potential to engage with various other departments to grow and develop education and awareness raising campaigns around safety. However, to achieve this would require active engagement and lobbying from energy stakeholders to grow awareness about paraffin safety. This would benefit from the inclusion of an organisation like PASASA, with its institutional expertise around paraffin safety, in capacitating governmental programmes. Unfortunately, with the closure of PASASA during 2012, due to a lack of funding it is unclear who could take a leading role in this regard. PASASA does intend to develop a new organisation with a wider mandate covering all fuels, a Household Energy Safety Association of South Africa (HESASA). But this is dependent on funding such an initiative.

The stakeholders interviewed expressed widespread support for the idea of developing a national household energy strategy. Such a strategy could enable a more balanced approach to household energy and to facilitate a move beyond the dominance of electrification in policy. Again, this would require active lobbying but could be facilitated by coordinating stakeholders in this sector to present a unified sectoral voice. Lobbying would also need to be supported by targeted research and an evidence base to justify key lobbying fronts.

1. Introduction

This study was undertaken by the Energy Research Centre for the Paraffin Safety Association of South Africa (PASASA) to investigate the current and future role of paraffin use in low-income households in South Africa. Despite relatively high rates of electrification in South Africa, paraffin usage in both electrified and un-electrified households remains significant. This is problematic, as there are a number of continuing health and safety concerns associated with the use of this fuel. These include indoor air quality (or pollution), unintentional ingestions, the risk of burns and fires from unsafe appliances and contamination with other fuels. There have been insufficient programmes and interventions to date to address these challenges. This research investigate the role of government and policy in addressing these going forward.

The research explores trends and challenges associated with the use of paraffin in South Africa from a stakeholder perspective. A wide range of stakeholders were interviewed, including government, the petrochemical sector and academic and development practitioners. This was supported by focus groups with paraffin users in informal settlements in Cape Town. A normative approach has been applied here by exploring what an ideal or socially optimal future for paraffin use and household energy in South Africa should be. This is analysed from the context of the current challenges and how they could be overcome to achieve an optimal future. This optimal future is defined in terms of either achieving the transformation of paraffin into a safe fuel or transitioning away from this fuel to alternative energy sources. Policies and other interventions which would be required to achieve either of these future states, with the underlying objective of enhancing the wellbeing of the poor, are identified. The goal necessitates the provision of energy services that meet certain criteria in terms of health and safety, affordability and convenience for poor people.

Section 2 of the report gives an overview of the methods used for the research study, while section 3 presents an overview of the policy framework governing energy in South Africa with reference to the household sector. Section 4 presents findings from the focus groups and perspectives of paraffin users in low-income settlements. Sections 5, 6 and 7 present the perspectives of other stakeholders interviewed in relation to particular issues, and section 8 shows the results of a modelling process undertaken to estimate future trends in consumption of this fuel. Finally, section 9 explores how to plan for paraffin going forward.

2. Methods

The purpose of this study was to gain insight into the issues related to household energy in general and paraffin in particular in South Africa. To achieve this, a range of qualitative and quantitative methods was underataken to explore the issue in greater depth, including stakeholder interviews, focus groups with paraffin users and a quantitative modelling exercise investigating consumption of paraffin up to 2030.

2.1 Stakeholder interviews

Interviews were undertaken with a wide range of potential stakeholders including government, private sector, development practitioners and academics. This was to gain an independent understanding from experts, private sector, government, etc, as to their position on this fuel, central issues and concerns, as well as potential policy and other solutions to address some of the challenges related to the safe usage of paraffin in South Africa. Interviews were held over by telephone or in person. Discussion topics were prepared in advance, but interviews themselves were designed to allow for general discussion and for new information to emerge. The following government institutions were interviewed as part of this project.

- Department of Energy;
- South African National Energy Development Institute (SANEDI);
- Department of Health;
- Disaster Risk Management Centre for City of Cape Town;
- Department of Human Settlements in the Western Cape; and
- National Regulator for Consumer Standards (NRCS).

Representatives from the petrochemical sector were also interviewed including:

- The South African Petroleum Industry Association (SAPIA);
- Shell; and
- Kayagas.

Finally, experts from academia with a particular interest in the energy sector were interviewed, including people from:

- Energy Research Centre, University of Cape Town;
- Sustainable Energy Technology and Research (SeTAR) Centre, University of Johannesburg;
- Cape Peninsula University of Technology;
- University of Twente (in the Netherlands); and
- Sustainable Energy Africa.

A detailed interview schedule is included in Appendix A.

2.2 Focus groups

Focus groups were undertaken with low-income households in peri-urban informal settlements in Cape Town. Focus groups are a useful qualitative research tool to explore particular issues in more depth. A focus group method uses the group interaction to explore and initiate insights and information that might not otherwise emerge during individual interviews (Kitzinger, 1995). Attitudes and perceptions are developed in a social context, and it can be useful to explore such issues in a group dynamic. Group methods often help participants to explore and clarify viewpoints and issues and the interaction can often bring greater validity to the findings as viewpoints can be confirmed, reinforced or contradicted within the discussion (Webb and Kevern, 2000).

Three focus groups were undertaken in low-income settlements in Cape Town, Imizamo Yethu in Hout Bay, and two areas in Khayelitsha (Site C and Kuyasa). These focus groups were designed to explore why and how people use paraffin and other energy sources, exploring their perceptions and preferences relating to different fuels and appliances. Each focus group had eight participants who were paraffin users, and efforts were made to select a mix of people who lived in formal dwellings and shacks, and those with legal, illegal and no electricity connections.

2.3 Modelling paraffin use in the domestic sector in South Africa

A modelling exercise was undertaken as part of this study to estimate trends in future consumption of paraffin in the household sector. The Residential Sector Module of the South African TIMES model (SATIM 2012) developed at the ERC was used to develop scenario projections. Three scenarios were developed to explore a range of possible evolution of the demand for paraffin in the residential sector:

- a BAU scenario – based on a continuation of existing trends;
- an LPG programme scenario – based on an assumed government initiated LPG programme which encourages greater use of LPG by low-income households;
- a least cost scenario – based on an assumed education and awareness programme educating households about the relative costs of different fuels, which encourages fuel use based on least-cost.

3. Context for household energy in South Africa

3.1 An overview of the development context and energy poverty in SA

South Africa remains an economically deeply divided society, and still suffers a legacy of poverty and inequality rooted in its socio-political history. Despite the country having many features of an advanced economy, poverty is still widespread and remains concentrated among rural and black citizens (Mensah and Benedict, 2009). Since the democratic transition in 1994, however, the ANC government has embarked on various policies to redress inequality and poverty. This has included a system of social grants and provision of free basic housing and services. Apartheid was based on the notion of separate development and the non-white population was excluded from many of the services and amenities that the white population enjoyed. The extension of basic services such as water, energy and sanitation to the previously marginalised and excluded non-white populations was seen as one of the major objectives of the new democratic government in 1994. South Africa adopted a rights-based and a 'universal service' approach to basic services (Jaglin, 2008) that rises out of the South African Constitution, which frames such services as basic rights. Whilst energy is not specifically included in the constitutional understanding of basic rights, access to electricity as a right is often implied in policy terms. It is, for example, treated in the same manner as water and sanitation in the free basic services package (Dugard, 2008). Dugard notes that 'arguably, the allocation of the Free Basic Electricity (FBE) subsidy to qualifying households … alongside Free Basic Water, is an implicit acknowledgement of a right to "sufficient" electricity along the same lines as the constitutional right of everyone to "access to sufficient food and water"'.

The discourse on energy poverty as a policy problem only started to emerge with the demise of the apartheid regime (Bekker et al, 2008). Although ideally electrification should be one subset of an energy access programme, it has dominated the approach to access in the country. This was influenced to a large extent by the key role that Eskom played in defining and running the electrification programme in the early 1990s (Bekker et al, 2008). This electrification programme has in many respects been a significant success in extending services and energy access to previously un-serviced households. The programme electrified some 2.5 million households between 1994 and 1999 (Prasad, 2006). However, in more recent years the pace of implementation has slowed and the costs have risen. The bulk of the remaining backlog is now in rural areas (DoE, 2011) which entails much greater investment in bulk infrastructure and supply networks. The programme now faces major challenges in funding constraints as well as human capacity constraints. particularly in some constrained rural local municipalities who are under-spending on their electrification roll-out (DoE, 2011).

Despite the electrification programme, reliance on other fuels including those with health and safety implications, is still fairly widespread amonng low- and even middle-income households. This singular policy approach of grid electrification is based on assumptions about household energy transitions that have little substantive evidence to support them. Firstly, there seems to be an implied assumption that access to an electricity connection will fully displace the usage of other fuels, with the only barriers being economic, or a lack of affordability. Secondly, the policy assumes low-income households will be single-fuel users of electricity only. In reality, however, households choose to use different fuels for a wide variety of reasons, such as affordability, preferences and perceptions about the utility of different fuels, traditions, and misinformation about relative costs and safety of different fuels. Multiple-fuel use is a common and widespread phenomenon in low-income households, both in South Africa and internationally.

There have been few programmes targeting other household fuels in South Africa. The then Department of Minerals and Energy did introduce the South African National Low Smoke Fuel Programme to reduce smoke emissions by introducing the Basa Njengo Magogo [1] lighting technique for coal fires. Firewood has not really been addressed. The only other ongoing

[1] This is an alternative fire ignition method for coal fires using braziers or 'imbaula's which reduces smoke and pollutants (Le Roux et al, 2009).

significant policy programme that deals with other fuels is the Free Basic Alternative Energy (FBAE) subsidy which subsidises the consumption of energy sources such as paraffin, LPG, gel fuel etc. However, this subsidy is generally poorly implemented by municipalities in South Africa.

There are very few initiatives that have linked energy and health. Paraffin and health has in fact seen the most focus and indeed appears to be unique internationally as well (Matinga, 2010). This focus on the health aspects of paraffin has not however been led by government for the most part. The principal actors in this energy safety sphere are petroleum companies through the funding of the Paraffin Safety Association of South Africa (PASASA). Initiatives such as safety campaigns and appliance standards that have been run by government have largely been a reactive response to promotion and lobbying efforts by PASASA (Matinga, 2010). Other government-led initiatives around paraffin have focussed mainly on affordability through efforts to regulate pricing and an indirect subsidy through the removal of VAT.

In 2012, however, PASASA announced that the organisation would be closing during 2013. This move was reportedly catalysed by the discontinuation of funding from the oil companies. As a primary actor in the energy safety sphere since 1996, the closure of PASASA leaves a significant gap in the realm of energy safety and makes the question of understanding the future of paraffin in South Africa all the more pertinent.

3.2 Energy policy related to the household sector in SA

This section briefly outlines some key pieces of legislation in the energy sector with respect to the household sector. It pays particular attention to the scope and mandate established in respect of issues such as a range of fuels, respective energy consuming technologies, health and safety, affordability, etc.

White Paper on Energy of 1998

The governing policy document for the energy sector in South Africa is the 1998 White Paper on Energy (DME, 1998). A white paper outlines a government's policy stance on a particular subject from which legislation can be enacted. As stated in the document: 'The White Paper takes a broad approach, but provides specific policy statements on what Government intends for the energy system as a whole. It does not attempt to deal with strategies for implementation' (DME, 1998: 3-4). The White Paper makes provision for lower-level programmes and regulations to be enacted and thus it is relevant to note firstly its scope and the principles it promotes in relation to energy governance.

Its overarching objectives include increasing access to affordable energy services; improving energy governance, stimulating economic development, managing energy-related environmental and health impacts and securing supply through diversity. Health is seen as an important underlying driver behind interventions around energy provision for poor households. The document expands on this objective of environmental and health by stating certain actions that government will undertake in this regard:

- Government will promote access to basic energy services for poor households, in order to ameliorate the negative health impacts arising from the use of certain fuels.
- Government will work towards the establishment and acceptance of broad national targets for the reduction of energy-related emissions that are harmful to the environment and to human health. (DME, 1998:9)

Throughout the document, it makes provision for an integrated approach to household energy and the emphasis is on *energy services*, including a range of fuels and technologies beyond just electricity. It promotes a demand-led rather than purely supply-led approach to energy planning and notes that energy is a cross-cutting issue that should be coordinated with other sectors and poverty alleviating goals.

Energy Act 2008

The Energy Act elaborates on and makes specific mandates to develop programmes in relation to various aspects of energy supply. Some relevant parts of the act are outlined below:

The objects of the Act that are relevant to households and safety include:

> (e) promote appropriate standards and specifications for the equipment, systems and processes used for producing, supplying and consuming energy;…
>
> (g) provide for optimal supply, transformation, transportation, storage and demand of energy that are planned, organised and implemented in accordance with a balanced consideration of security of supply, economics, consumer protection and a sustainable development;
>
> (h) provide for certain safety, health and environment matters that pertain to energy:
>
> (i) facilitate energy access for improvement of the quality of life of the people of Republic;
>
> (j) commercialise energy-related technologies. (DME, 2008:6)

The Act gives the Minister powers to 'adopt measures not contemplated in any other legislation, to minimise the negative safety, health and environmental impacts of energy carriers' (DME, 2008: 8) after consultation with relevant departments of Trade and Industry, Labour and Environmental Affairs and Tourism. This Act therefore clearly places the responsibility for safety of different forms of energy under the jurisdiction of the Minister of Energy and gives the Minister a mandate to promote standards for appliances involved in the consumption of energy. Again, as laid out in the White Paper (DME, 1998) the Energy Act refers in all instances to energy and not specifically to electricity.

Integrated energy plan 2003

In 2003 the DME launched the Integrated Energy Plan (IEP) for the energy sector. This plan is currently in the process of being updated. The IEP is intended to fulfil various technical functions, which include:

- analysing energy needs in terms of how their fulfilment will contribute towards attaining national economic and social goals;
- analysing the potential of energy supply systems and demand side management to meet current and potential future energy needs. This would include analyses of individual supply sub-sectors and the linkages between sub-sectors.

The IEP includes objectives to promote universal access to clean and affordable energy, and coordinating household energy supply with provincial and local integrated development programmes. The plan also notes that it intends to 'balance energy demand with supply resources in concert with safety, health and environmental considerations'. Despite the requirement to balance consideration of demand and supply, the plan is dominated by supply-side considerations and does not adequately analyse future trends in demand for the household sector.

Electricity Basic Service Support Tariff Policy (Free Basic Electricity)

In recognition of pervasive poverty and a lack of affordability directly impacting electricity consumption levels among poor households, the government introduced the Free Basic Electricity (FBE) policy. This subsidy was developed in line with government's broader policy approach of free basic services and is funded by the national government. The subsidy is set at 50kWh per month and is meant to provide households with electricity for lighting, media, limited ironing and water heating.

Free Basic Alternative Energy Policy

In recognition that the FBE policy could not target households not connected to the grid, the government developed the Free Basic Alternative Energy Policy (FBAE). Beneficiaries are indigent households in areas 'where no electricity infrastructure exists' (DME, 2007: 9). Municipalities are required to identify applicable indigent households and maintain indigent

registers in order to obtain the subsidy from government. The funding is paid via the Equitable Share Grant to municipalities. This grant is paid by national government to municipalities to assist with the delivery of basic services. The policy states that municipalities are expected to also supplement this grant from their own income.

The stated objectives of this policy are:

- To facilitate the provision of basic energy needs to indigent South African households that do not have access to electricity;
- where possible, to address a whole suite of socio-economic issues that arise from inadequate provision of energy to households, inter-alia, job creation, etc;
- to minimise health risk by promoting safe use of these energy carriers;
- to ensure that energy carriers chosen are sustainable, safe and easily accessible to the indigent households; and
- to maximize efficient use of energy carriers for the benefit of all citizens. (DME, 2004:8)

The policy identifies common alternative fuels to electricity that it covers including paraffin, LPG, coal and bio-ethanol gel. Municipalities are required to choose a relevant carrier, taking certain defined criteria into consideration, one of which is the safety and environmental aspects of the fuel. The policy also requires that municipalities 'conduct awareness campaigns informing the beneficiaries on how best to apply the chosen energy carrier(s). The campaigns must include but not limited to safe use of the energy carrier, safe handling and storage to minimise health risk of such energy carrier(s)' (DME, 2007: 10)

Energy Efficiency Strategy (2008)

There are many synergies between energy efficiency in low-income households and energy poverty, health and appliances. This is noted in the Energy Efficiency Strategy which includes as its overarching goals to:

- Improve the health of the nation;
- Job creation;
- Alleviate energy poverty;
- Reduce environmental pollution;
- Reduce CO_2 emissions.

The residential sector is a key sector of interest in the strategy and one of the efficiency measures outlined for this sector includes the development of standards for appliances, including non-electric appliances. Again, this strategy supports the overall sector's responsibility for health and the development of appliance standards.

National Development Plan

The Presidency of South Africa launched the National Planning Commission whose role it is to develop a long-term vision and strategic plan for South Africa. This resulted in the development of the finalised National Planning Document, whose overarching goals aim to reduce poverty and inequality by 2030. The plan considers various aspects such as infrastructure, the transition to a low-carbon economy, environmental sustainability, rural development, education, health and human settlements. Energy access is discussed in the chapter relating to infrastructure and in respect of energy for low-income households the document states the following under the heading of 'National electrification and energy poverty':

> The energy needs of poor households are still inadequately met. Between a fifth and a quarter of South Africans still have no access to the grid. The electrification programme has slowed (annual connection rates are now half of those a decade ago) and the original goal of universal access by 2014 is not feasible. The following interventions are proposed:
>
> - A thorough review of targets, planning, technology choices, funding and implementation.
> - Subject to costs, South Africa could aim for at least 90 percent grid connection by 2030, with alternative off-grid options offered to the remaining households for whom a connection is impractical.

> Develop integrated programmes to tackle energy poverty by building on research done since the 1990s around household energy use. Even poor households with access to electricity can afford to use only modest amounts and rely on other sources such as paraffin, gas and fuel wood. An integrated programme could include sustainable production of fuel wood and its safe combustion in efficient stoves in rural areas. (National Planning Commission, 2012:171)

In the final National Planning Document, despite reference to other fuel sources used by households, the activities and targets outlined refer to electrification only. The document appears to perpetuate the view that electrification will displace other fuels and that affordability is the only real constraining factor in this regard. The NDP's approach is aligned with supply-side planning and a large infrastructure-driven approach to energy. The discussion on energy access takes place within the context of provision of suitable infrastructure to provide the basis for social and economic development. Such an approach can however overlook the issues around the demand and consumption of energy at its end use and potential synergies with health, environment, and other social development goals. Attempts were made by a group of concerned stakeholders in the public submissions process to push for the inclusion of the need for a household energy policy to provide an overarching framework to direct initiatives in the household energy sector (PASASA et al, 2012b). However, this recommendation and comments were unfortunately not incorporated into the final strategy document.

3.3 Conclusion

What the preceding section has indicated is that theoretically a framework exists to support an integrated approach to energy use in the household sector that deals with access to a range of commonly used fuel types. Importantly, the legislative framework in the energy sector also clearly establishes a mandate for safety aspects of fuel usage that lies with the Minister of Energy. From a policy perspective there is the potential to create a future for a safe future for paraffin usage in South Africa. There is, however, evidently a gap between stated policy objectives and implementation thereof in terms of strategies and programmes. There has been very little implementation in the energy-health nexus at the behest of the DoE to date.

4. Insights from the focus groups into household energy usage

Focus groups as a research tool are used to explore specific issues in greater depth with a limited number of participants. Whilst the predominant topic of interest in the focus groups was paraffin, energy usage in general and a range of fuels were also discussed. The main objective was to better understand household energy choices and the usage of paraffin in particular. These discussions aimed at gaining insights into the factors influencing household energy choices and usage of different fuels such as accessibility, affordability and relative costs of fuels and appliances, cultural traditions, personal preference, safety, etc. The focus group discussions also aimed to explore the key advantages and disadvantages that people experienced with different fuels and appliances. The discussions provided users' perspectives on paraffin and are useful way to contextualise and support the ensuing discussion on policy responses in the rest of this report. This section presents an overview of some of the key themes that emerged from the discussions. A more detailed write-up of the focus groups can be found in Appendix B.

4.1 Overview of the focus group discussions

Three peri-urban low-income settlement locations in Cape Town were chosen for the focus groups. The first location was Imizamo Yethu, a settlement in the suburb of Hout Bay in Cape Town and the following two were held in different parts of Khayelitsha: Site C and Kuyasa. All participants were selected on the basis of being paraffin users and to get a range of housing types and access to electricity. Focus groups included shack dwellers living in proclaimed and unproclaimed areas as well as residents living in formal RDP housing, as well as people with their own formal electricity connections, informal connections from neighbours and those who had no access at all.

Living in formally declared/proclaimed areas is a highly relevant factor in the discussion on energy access and service delivery. Those households living on private land or other areas not proclaimed for housing are not eligible for their own services. The Western Cape has a very high rate of electricity access, with more than 90% of households having access to electricity for lighting in 2011 (Statistics South Africa, 2012). A significant number of households, however, remain ineligible for electricity and other services because of their informal or illegal status. Backyard dwellers, for example, have notoriously remained outside of the Department of Energy's and municipal service delivery plans. However, in a notable shift in policy, the City of Cape Town in 2011 acknowledged the need to address the living conditions of backyard dwellers and is implementing pilot service delivery projects in a settlement called Factreton.

Participants in the focus groups used a combination of electricity, paraffin, LPG, candles and wood. No one reported using coal. The academic literature on the determinants of household fuel usage often tends to focus on factors such as affordability and accessibility, but the focus group discussions here presented a much richer picture of household energy choices in the context of social, economic and cultural and personal factors. Fuel use is intricately interwoven into people's lifestyles, behaviour patterns and modes of socialising. It is interesting to note the common threads running through the discussions but also the diversity in the perceptions and behaviours of different individuals. Multiple fuel use remains a pervasive feature of household energy profiles. Energy choices are influenced by affordability, perceptions about costs, personal preferences, reliability and availability of alternatives and attitudes to risk. The discussions on how and why participants choose different fuels revealed that people regard each fuel as having its own particular attributes that were important to them.

All participants from all focus groups, except for two in Site C in Khayelitsha, had some form of access to electricity, either through their own legal connection or an informal connection buying electricity from neighbours using extension cords. These households pay a (often significant) premium for their electricity, as the primary household adds a mark-up to the electricity they sell to neighbours. Electricity is, however highly desired and most people seem willing to tolerate the higher prices, rather than not have it. Paraffin forms an important part of people's energy use. It is the preferred fuel for cooking certain types of meals, is seen as being the most affordable fuel and

plays an important role as a back-up fuel when there are electricity cuts. Cooking on paraffin appliances also heats the house at the same time, providing a highly valued money-saving co-benefit that neither electric nor LPG appliances offer in the same way. LPG was not as widespread as either electricity or paraffin, although there was at least one participant in each focus group who used it. Those who used it found it convenient and easy to use, and enjoyed the safety of this fuel in comparison to paraffin. Wood was used only infrequently by participants in Imizamo Yethu and Kuyasa. where it was viewed as a poor man's fuel to be used only as a last resort. In Site C, however, wood plays a central role in socialising and communal gatherings around outdoor fires in the evenings. It carries little of the connotations of poverty found in the other areas (the custom of communally gathering around outdoor wood fires was not reiterated in either of the other focus groups).

Each fuel also registered negative aspects for users as well. Electricity supply in informal settlements is extremely unreliable and blackouts are a frequent feature of people's lives, causing inconvenience, and additional costs when appliances break due to power surges when the power is turned back on. Low-cost electric stove appliances are also problematic. Their heat settings frequently malfunction, which means that the stove is only capable of being on at full power. This makes these appliances unsuitable for slow-cooked meals that must be prepared over a low heat setting. Households, therefore, use paraffin instead for meals such as samp and beans or steamed bread. Many households that buy electricity from neighbours cannot use electricity for cooking at all or must time it around the primary household's cooking times as the connection cannot support more than one household cooking at a time. It is evident that, for these various reasons, access to an electricity connection is not sufficient to displace the use of other fuels.

Paraffin had many negative attributes for people relating to issues with exploding appliances, poor quality of these appliances, indoor air pollution causing respiratory issues and headaches, the smell of paraffin and general safety concerns. Participants reported that there was often intermittency in the supply of paraffin as well and periods when they would not be able to obtain it from spaza shops. LPG was widely disliked and there are deeply entrenched fears about the risks of cylinders exploding. LPG was also seen to be an expensive option. Imbaulas[2] are generally disliked, especially for use indoors, because of their smokiness and blackening of walls. There is much awareness of the dangers of using an imbaula inside – with descriptions of them causing headaches and dizziness and perhaps even death.

The focus group discussions revealed many misperceptions about different energy sources relating to the costs, safety and utilities of different fuels. These often serve as a significant barrier to using cleaner or safer energy sources. For example, fear of LPG is a significant barrier to its increased take-up. Those participants who did use this fuel often had had some exposure to it elsewhere, for example at a place of work, which had served to familiarise them with its ease and safety.

The picture of household energy use painted during the focus group discussions was also characterised by a significant degree of uncertainty. This uncertainty stems from affordability constraints and the unreliability of supply (of both electricity and paraffin). Uncertainty also stems from the safety risks that lie beyond a household's control, such as dangerous stoves. Multiple fuel use serves as a risk mitigation strategy to deal with uncertainty, by having more than one option to rely on when, for example, you run out of money for electricity or when there are electricity blackouts. When participants in the focus groups were asked about what their 'ideal energy mix' would look like, some said electricity would be their optimal choice, the major benefit being they could use one fuel for everything. However, the majority described the same mix of fuels as they currently use. It is interesting that these participants did not conceptualise a response where they would have perfect and reliable electricity supply but rather that paraffin would always be needed for those times when there was no electricity. Perhaps the ability to influence electricity supply lies so beyond the frame of reference of a resident in an informal settlement that it does not even appear to register as an imagined scenario of 'what things could look like'.

[2] Imbaulas are devices used for the combustion of biomass, they are typically paint containers or half drum barrels that are punched full of holes and sometimes have a grate inside as well.

None of the participants in any of the focus groups had ever seen or heard of the safe and compliant non-pressure stoves, nor were they aware that the ubiquitous unsafe ones were illegal. There were interesting differences, however, in what appliances were used for cooking in the different areas. Use of the illegal wick stoves was widespread in Imizamo Yethu. Although participants were very aware of their dangers and had stories to share of stoves exploding, they generally felt they had no alternative. In contrast, none of the participants in the two Khayelitsha focus groups used these stoves anymore and had switched to using paraffin heaters instead to cook with. This choice was directly influenced by their concerns about the safety of the illegal stoves and their poor quality. Participants in these two focus groups were very vocal about their dislike of the unsafe stoves and said that they would never use them again. They expressed admiration for their heaters, which they described as being safe, reliable and long-lasting. They felt these to be much better value for money than the other appliances.

Individual responses to risk were interesting to observe and are worth doing further research into. For example, it was interesting to note how participants in the two Khayelitsha focus groups had changed their behaviour in response to the risks presented by the use of flame stoves – switching to using heaters exclusively instead. And yet Imizamo Yethu participants, despite having many anecdotal experiences of the dangers of flame stoves and access to paraffin heaters, still used the unsafe flame stoves. Some participants did indicate that the paraffin heaters are more expensive to cook with and this may be a strong determining factor, but several Imizamo Yethu participants owned paraffin heaters as well. It is not clear how the running costs of the different appliances compare and this would be worth investigating further.

Another interesting example of behaviour change in response to risk is a woman in the Site C focus group who had come home one day and found her child had been playing with the paraffin in her house and was covered in it. The woman described that it was difficult to hide the paraffin in a one-room shack and in response to this incident she decided that paraffin was not safe to be used around her children anymore. Since she could not use electricity to cook with (because her neighbour who she bought it from did not allow her to cook with it) she decided to switch to LPG instead. This event with her child appeared to serve as a trigger in readjusting her personal acceptable risk-benefit trade-off. The benefits of using cheaper paraffin were no longer seen to be worth the risk it posed to her family. It would be interesting to engage with more households who do not use paraffin to explore other experiences of transitioning away from this fuel in response to risks it poses.

The focus groups revealed many differences in perceptions, behaviours and social connotations even within households of similar socio-economic and cultural backgrounds. This highlights the mistake of trying to identify the ‘typical energy consumptive patters’ of a low-income household. Instead one can start to better understand the range of behaviours and attitudes that exist. It is important to be cognisant of the limitations of generalising the findings from these focus groups. Specific issues or findings could, however, inform the design of a randomised survey that could better establish the wider confidence of determinants of household fuel choices, safety practices, etc. The issues raised here nonetheless open up a much wider range of discourse of certain aspects of energy use and do reveal interesting insights into the limitations of the current policy approach to energy access.

4.2 Investigating the comparative costs of different cooking fuels

Focus groups are not an appropriate way to gather quantitative information regarding consumption and spending on different fuel types, which itself is highly variable between households. Whilst some consumption and spending information was discussed, different participants’ usage varied depending on their habits and mix of different fuels. What was particularly interesting to discuss, however, were the perceptions about affordability. The cheapness of paraffin and its greater affordability is an oft-cited reason for the continued reliance on this fuel and thus it is pertinent to understand this issue when exploring the value of its role for poor households. Affordability can be viewed in terms of affordability of appliances and affordability of the energy service itself (e.g. cooking) using different fuels.

In terms of appliance costs, the difference in the prices of the legal and illegal variants of the non-pressure stoves is fairly small. Legal stoves retail for about R100 whereas the illegal ones appear to range between R85 and R100 (based on participants' reports). Furthermore, many participants actually use paraffin heaters with which to cook, which cost about R400. This is more than either an electric two-plate or an LPG stove. Lack of affordability of appliances does not seem to be a major constraining factor. Of more interest, perhaps, is the issue of affordability of the actual energy service: for example, is it cheaper to cook on paraffin or electricity? Paraffin was widely regarded by all participants to be the cheapest fuel (compared to electricity and LPG). This section will explore issues around affordability of cooking energy service.

The issue of affordability and comparative costs of using different fuels is interesting and appears to be mired in much misinformation and myths. Determining the comparative costs to cook with different fuels is complex. Few actors, either consumers or other stakeholders interviewed, were able to definitely say what these comparative costs are. This is understandable, particularly for a household, for whom it is difficult to make direct comparisons between fuels that come in different units, such as litres, kWh and kg. The costs of a cooking service can also depend on many factors such as type of appliance and efficiencies, type of meal, user practices and behaviour (Cowan, 2008). When measuring electricity use, the concurrent use of multiple appliances drawing electrical energy at the same can make it difficult to isolate the cost of any one energy service. Fuel prices also change over time and households may not be aware of the impact of changes in relative terms across different fuel types.

Several research studies have been undertaken estimating the relative cost to cook with different fuels. There are different ways of estimating costs to cook, and two studies are presented here that were undertaken in the South African context. The first study (Lloyd, 2010) undertook laboratory testing of various fuel and appliance types using the water boiling test. This method used was to bring 1.5 litres of water and 1kg of maize meal to the boil, boiling for five minutes and then reducing power and simmering for 30 minutes. This study made use of fuel prices as at January 2010, and the table below shows the results updated to 2012 prices. The results reveal that electricity is the cheapest fuel to cook with, followed by paraffin on a pressure stove, paraffin on a wick stove, and then LPG.

Table 1: Costs of cooking from Lloyd (2010) and updated to 2012

Fuel	*Appliance*	*2010 Original calculations*		*2012 Updated calculations*	
		Cost to boil (cents)	*Cost to cook (cents)*	*Cost to boil (cents)*	*Cost to cook (cents)*
Electricity	Not specified	16.9	29.6	23.1	40.5
Paraffin	Wick stove	35.5	68.4	36.6	70.4
Paraffin	Pressure stove	22.9	49.2	23.6	50.7
LPG	Not specified	61.2	132.3	68.1	147.2

Source: Lloyd, 2010 and based on 2010 prices. Updates for 2012 using same assumptions except for cost of fuel using 2012 prices.

There can be limitations in relying solely on laboratory testing that cannot factor in unaccounted-for variables that only emerge in real life settings, such as user behaviour, environmental factors, preparation of different meal types (Kipruto, 2011). It is useful therefore to compare these results with other experiments using different stove testing methods conducted in the field. Another study was undertaken by Cowan (2008) estimating the costs of cooking with paraffin, LPG and electricity using 2008 prices. This study undertook experiments conducted in low-income settlements using local residents to cook a range of typical meals, including staple starch meals (mealie meal, rice and pasta), quick-to-medium stews (liver, chicken and vegetables) and longer-cooking meals (beef stews, samp and beans). The study was undertaken using 2008 energy prices that included a range which were R11/litre of paraffin; R20/kg for LPG; and R0.6/kWh of electricity (Cowan, 2008). Appliances used in the experiments were those that 'commonly used' in settlements. These results have also been updated with 2012 prices and indicate that electricity

is cheaper by a significant margin for all meal types. However Cowan (2008) notes that despite these findings the commonly held perception amongst all the residents in the local settlement where the study took place was that paraffin was the cheapest.

Table 2: Costs of cooking from Cowan (2008) and updated to 2012

Fuel	*Appliance*	*2008 Original calculations*			*2012 Updated calculations*		
		Simple starch meals	*Med length stews*	*Longer cooking meals*	*Simple starch meals*	*Med length stews*	*Longer cooking meals*
Electricity	Spiral hotplate (1000MW)	R0.15 - R0.31	R0.28	R0.51 – R0.73	0.21– 0.44	0.39	0.73-1.03
Paraffin	Panda wick stove	R0.49 - R1.00	R0.96	R1.72 - R2.50	0.50-1.01	0.97	1.74-2.53
LPG	Cadac single burner	R0.57 - R1.26	R1.19	R2.07 – R3.55	0.63-1.40	1.32	2.30-3.94

Source: Cowan, 2008, and based on 2008 prices. Updates for 2012 using same assumptions except for cost of fuel using 2012 prices.

There are also other factors to take into consideration for future research in this area. The first is the space heating co-benefit that paraffin stoves and heaters offers households. It means that spending on fuel for space heating is reduced, compared to if a household were using electricity or LPG, neither of which offer such a co-benefit. Further research into practices and spend on heating would need to be conducted to understand the extent of this saving in winter and the running costs of electric or LPG heating appliances. The second issue that requires further investigation is factors that might influence the electricity price, for example FBE (which would make the average unit price of electricity cheaper, or the higher premium that backyard dwellers and other un-electrified households pay for their electricity because of higher prices charged by neighbours.

Although affordability was an oft-cited reason for fuel choices by focus group participants, affordability itself is a subjective notion. In economic terms it assumes a household of rational actors, but notions of what a household can 'afford' entail a much more complex interplay of different factors that includes both rational and irrational reasons (Matinga, 2010). For example, as households, particularly those in urban and peri-urban areas, come into contact with a range of different modern consumptive goods and services, the increased cost of a stove or of cooking with LPG must now compete with the cost of getting a new cell phone or a television, for example (Matinga, 2010). The subjectivity of affordability is, therefore, influenced by perceptions on other attributes of the goods as well as personal priorities. The case of the woman in Site C using LPG, for example, is illustrative: although she complained about the expense of LPG she had obviously made the decision she could 'afford' this fuel based on her priority of minimising the risks of paraffin for her child.

The research findings presented here are interesting in that they do not substantiate the commonly held perceptions by users (and many of the other stakeholders interviewed) of the cheapness of paraffin. Why the belief that paraffin is the cheapest fuel prevails despite evidence to suggest otherwise is not clear, but is likely influenced by the historic cheapness of the fuel and the complexity of measuring and comparing costs of energy services for end users. These findings, therefore, call into question the validity of the notion that paraffin has an continuing future role to play in household energy for the poorest of the poor. The margin of cost differentials between electricity and the other fuels also suggests that electricity prices could rise quite significantly and still not affect this overall picture. It would be useful to investigate at what price points for the different fuels this picture of the comparative costs could change. These findings also highlight the extent of the misperceptions that exist and the need for more consumer awareness and education around the costs of household energy to maximise the welfare of poor households.

5. General stakeholder perceptions about paraffin

This section presents stakeholder perceptions around paraffin and other household fuels. It aims to provide insight into the broader thinking around South Africa's energy future and paraffin's role therein. It therefore explores perceptions about the desirability of this fuel for poor households, perceptions about historic and future trends, as well as safety and pricing. This section also explores the implementation of the Free Basic Alternative Energy subsidy and its role in paraffin and the health and safety thereof.

5.1 The prevalence and desirability of paraffin as a household fuel

The discourse around modern energy access generally traces the movement of households away from traditional fuels towards modern fuels such as electricity and LPG. Paraffin holds a somewhat unclear middle ground. Whilst regarded as a modern fuel and better for health than solid fuel use, it nonetheless still carries its own health and safety concerns, which make its use problematic in many developing countries. Perceptions about the desirability of paraffin as a household fuel in South Africa were explored to contextualise the discussion around whether this fuel should ideally form part of South Africa's future household energy mix. Only one stakeholder saw the viability of paraffin being transformed into a safe fuel in South Africa. Virtually all the others felt strongly that, if it were an option, policy should be transitioning households towards other energy sources instead. This sentiment was shared not only by expert and academic stakeholders but many of the institutional stakeholders interviewed as well, including DRMC, NRCS, SAPIA and DHS, as well as both Shell and SAPIA. There seemed general consensus that phasing this fuel out would be more beneficial for the welfare of poor households.

The prevalence of this fuel in a developing country such as South Africa is interesting especially in the context of considerable access to other modern fuels that could displace it, such as LPG and electricity. Some academic stakeholders suggested that the presence of the oil refineries themselves probably plays a role in the high consumption. The original establishment of PASASA was seen as a strategic move by oil companies to legitimise their product with the new government in 1994. This enabled them to ensure that paraffin would remain a feature of the new energy supply landscape and essentially afforded them a measure of control in the policy approach towards this fuel. Following this line of logic, the recent decision by oil companies to discontinue their support of PASASA may well be reflective of the current government lack of interest in paraffin. There might be seen to be little further strategic or political advantage to be gained by enhancing the image of the product and their own socially responsible behaviour. SAPIA agreed that without any government interest or support for paraffin, oil companies do not see a strategic need to plan for its safe future use. Some stakeholders were of the opinion that the funding of PASASA by the oil companies discredited the independence of the organisation.

5.2 Perceptions about trends in paraffin consumption in South Africa

The total consumption of paraffin in all sectors in South Africa is declining, as reported in various national statistics. Data from SAPIA on paraffin sales volumes show a steady decline in total sales of almost 50% from 1999 to 2009 (SAPIA, 2011). The Department of Energy's energy balance statistics also show a decline in paraffin being consumed by the residential sector from 1999 to 2009 of almost 40% (DoE, 2009). What is less clear and more difficult to differentiate from the available data is in which sectors the bulk of this decline has been happening. It is difficult to accurately estimate the volumes going to commercial versus residential sectors. The sales statistics recorded by the petrochemical companies do not capture the sector that consumes the fuel, due to a fairly diverse distribution system and the multiplicity of players and the. The sector sees the practice of bulk distribution and on-selling of the product by distributors to different sectors which is then not recorded in sales statistics only recorded at the upper end of the distribution chain by petrochemical companies. However, this is then sold on to a wide array of distributors who may themselves on-sell it to another distributor before it meets The most significant sectors that use

paraffin are low-income households and industry, where it is used, for example, as a heating fuel in manufacturing. Insights from Shell suggest that both sectors have seen declines. Shell remarked that the industrial sector, in particular, has experienced significant decline and this is expected to continue due to the relative expense of paraffin, the emergence of cheaper alternatives and more efficient appliances. Shell therefore considers their core market for paraffin going forward to be low-income households. They see this market to be 'plateauing' rather than declining. Shell says that they have observed stable demand, particularly from rural areas, and even seen increases in some areas. Whilst Shell does not expect paraffin to become a boom product, they are aware that with increases in electricity prices there could be a potential for further growth in this market. However, they note that the price elasticity of electricity demand by poor households is not well understood and so is difficult to predict. Despite Shell's contention that household paraffin is a stable market for them, SAPIA remarked that the major players in the market do not, in general, regard paraffin as a growth fuel.

Illuminating paraffin (IP) is extremely similar in specification to jet fuel. It is produced in the refinery as a single product (dual-purpose kerosene), which is then diverted to either the IP or jet fuel markets, depending on demand conditions. Shell explained that the only major difference in the two products is the specifications for the way in which they are handled. He notes that market conditions determine how much of each is produced. Refinery gate prices of IP and jet fuel differ, depending on relative market conditions. SAPIA remarked that the jet fuel market is generally a high-volume, low-margin product. Establishing the competition from the jet fuel market or the viability of this as an alternative market was inconclusive from the interviews, as perceptions about the strength of the jet fuel market varied. However, it appears that competition from the jet fuel market for more product is not the prevailing factor behind declining paraffin sales, which is instead driven by declining demand.

Looking forward, many stakeholders feel that a continuation of the decline in paraffin consumption among households is probable, but remark that it is unlikely to ever disappear entirely. Indeed this sentiment was confirmed in the focus groups, which saw a strong role for paraffin in their household energy mix. The DoE stated that there will not be an active phase-out of paraffin but neither does it appear as if they intend to actively support or promote it either. Many of the stakeholders said that in their various interactions with the DoE there has been little interest in supporting paraffin – the predominant policy stance is electricity for household energy with indications of a growing interest in LPG. If more strategic support is given to LPG and programmes are developed to actively promote this fuel there may well be a greater reduction in the market share of paraffin. However, even then the perception amongst stakeholders is that paraffin is unlikely to disappear entirely and would probably still retain its place amongst the poorest income groups and in rural areas.

5.3 Health and safety concerns

All stakeholders agreed that the health and safety concerns related to paraffin usage were unacceptably high and urgently needed to be addressed. The lack of political will was seen as the principal barrier to enhancing paraffin safety. Several stakeholders noted the unresponsiveness of government to deal with paraffin, driven by a sentiment that it would be seen as 'going back' to combustible fuels, which are not compatible with the aspirations of a post-apartheid society. Hence to even support a safe stove initiative would be to admit that people are not going to get or use electricity.

Many stakeholders agreed that there is a need for regulation to play a greater role and for more stringent requirements to be placed on the supply chain. When asked about the potential role of legislation such as the Consumer Protection Act, most felt they did not have enough of a background with this Act to be able to comment, but that it was potentially useful and should be followed up on. It was agreed that a champion should take forward a test case, of unintentional ingestion for example, that could then serve as a precedent for others. PASASA was discussed as the most obvious player to take this forward. In the absence of this organisation it is unclear who else might take the initiative to do so. The following sub-sections section explore in more detail perceptions relating to two major health and safety issues, those of non-pressure paraffin appliances and safer packaging.

5.3.1 Non-pressure paraffin appliances

The issue of paraffin appliances is central to discussions around safety and the future of paraffin as a household fuel in South Africa. Currently, the market remains flooded with non-compliant and unsafe non-pressure stoves. The National Regulator for Consumer Standards is currently playing the key role in appliance enforcement and monitoring activities. The primary challenge they face is the illegal importation of non-compliant products. Monitoring activities now focus predominantly on border points of entry, manufacturers and huge distributors. They find this a more effective usage of resources than policing retailers. Previously the NRCS had no jurisdiction with importers but have now established a Memorandum of Understanding (MOU) with customs in Durban which has enabled them to focus on border monitoring activities. There are intentions to establish a similar MOU and intervention in the Western Cape region.

They note that working at a retailer level is challenging and does not necessarily address the root cause of the problem. Although awareness amongst retailers has grown about illegal products, the NRCS have found that, rather than necessarily helping to address the issue, it has instead driven the sale of illegal appliances 'under the counter'. Although NRCS has powers to enter any business premises and confiscate any non-compliant products found there, they are essentially taking money away from retailers and so they often encounter resistance or non-cooperation from them. They also have real challenges in communicating and engaging with the many non-English-speaking informal retailers from China and Somalia. The NRCS indicate that the challenge of removing illegal stoves from the market is still considerable and that informal estimates are that only one in five appliances in households are compliant products.

Issues around non-pressure stoves are not only around the use of unsafe illegal products but also relate to concerns about the quality of compliant products on the market. Academics who have been involved in stove research expressed reservations about the compliant stoves. They suggested it was not necessarily the standards that are problematic, however, but rather the products. Stove design needs to consider various aspects including functionality, quality, affordability, safety and aspirational value. The SANS safety regulations are therefore only one aspect of the design considerations that need to be included.

The second generation or 'new panda' compliant stove on the market includes more safety features, such as a lever mechanism to prevent re-filling the stove while alight, a snap-off feature to put out the flame if the stove is knocked over, and greater separation between the burner and the paraffin reservoir. However, these stoves are also problematic in terms of their construction and usability. They lack durability and are constructed out of flimsy materials – for example the metal pot supports are extremely thin and the external flipper for putting out the flame is weak. It was noted that stoves tend to malfunction and users often make their own modifications, which then prevent the safety mechanisms from working properly. In addition, the stoves are also not user-friendly and have little perceived value amongst buyers. They are, for example, reportedly difficult to light and do not produce a high enough maximum heat setting. One researcher who ran cooking tests and demonstration days several years ago in communities using different appliances, found that the compliant panda stoves were not user-friendly and in most cases did not manage to complete the cooking tasks. He says that people went home instead to fetch their own non-compliant stoves or heaters to use instead.

When asked about issues with the standards and a potential review thereof, the NRCS responded that they had noted there were some concerns but they had taken these to their technical department and in their view the current standards are adequate and have been tested against their required 500 hours. They did acknowledge, however, that if a product fails after 501 hours, it would still be compliant. If a problem is raised with products, the NRCS would obtain a sample from the market place and get SANS to test it against the current standard. If substantiated, they might then withdraw the product if necessary. They noted, however, that if there is a problem that is not within the scope of the standard's specifications that there is little they can do, and it would have to be addressed as part of the standards review process which happens every two years.

It is not clear from the interviews whether users' own perspectives and experiences with the compliant stoves are well enough understood. There seems to be little evidence-based research and only anecdotal evidence from researchers in this field, who suggest that households do not necessarily perceive value in these appliances. None of the participants in the focus groups had

ever used or were even aware of these stoves and so this topic could not be explored with them. The lack of general awareness about these products in the focus groups and low take-up of products could be taken as indicative of users' poor perceptions of them. Market penetration of new products is greatly facilitated and enhanced by positive user experiences and word of mouth. This may explain the wider use of paraffin heaters as a cooking appliance as word spreads that these appliances are versatile, safe and good value for money. If a product such as the compliant new panda stove is not user-friendly and breaks easily, for example, it has probably not benefited from such 'informal marketing networks'.

Researchers noted that safe and high quality appliances are possible to make and are in commercial use in other countries such as Japan and France. However, in a market such as South Africa cost is the determining factor. This gives rise to a trade-off between higher quality with improved safety design aspects and the cost of the appliance. Whilst it is easy to make an ultra-safe stove retailing for R1000, it is considerably more difficult to design and make a safe product that costs R100. Going forward, in terms of stove design, one suggestion was to stimulate a free-market competition to incentivise new designs. Such an initiative could involve the Department of Trade and Industry to support and develop local manufacturing capabilities. Others suggested that it might be better to focus effort and resources on existing working technology and ways to make existing stoves in the market work better through appropriate modifications.

There was also a suggestion that the high-end Japanese stove, the Toyitomi, be introduced in South Africa and marketed as an 'aspirational' product, although there was also scepticism about the viability of this. Such a move would require a market feasibility study to understand the viability which itself would be determined by poor people's own longer-term aspirations, and whether these lie in paraffin use, or whether they instead aspire to using electricity. Supporting the introduction of a high-end stove such as this would also need to be viewed in the context of the overall vision for low-income energy use in South Africa. Is it an appropriate use of resources, for example, to promote such an appliance, which is significantly more expensive than electric and LPG appliances, if the longer-term vision for this sector is to transition households towards LPG and electricity? Evidence from the focus groups suggest that heaters might also have a viable future in the cooking appliance market and that households have found their own market solution to the issues of unsafe stoves. If problems with the standards and product design of non-pressure appliances persist it could be more viable to investigate paraffin heater appliances further as an alternative.

5.3.2 Labelling and packaging

Introducing safe labelling and packaging was a key concern raised by many stakeholders in discussions around paraffin safety. Various suggestions with regards to pre-packaged packaging were raised, such as warning labels and childproof caps, the viability of disposable packaging versus investing in one container that gets re-filled. Although selling paraffin in packaging was seen as a method to mitigate the risks of ingestions and contamination, it was noted that improved safety is also reliant on behaviour change. Packaging will not necessarily ensure that the user will store it correctly in their home, and that as long as you can borrow a cup of paraffin, the risks may never really be fully addressed. Furthermore, several felt that packaging cannot necessarily address the issue of petrol contamination from using the same container to store multiple substances. There is still a need for government and industry to send an appropriate message that paraffin is a dangerous substance. Selling it only in certain packages with safety features and warnings could also influence people's perceptions about appropriate treatment. The current manner in which this fuel is freely dispensed into any container does not communicate an appropriate message of the risks of the substance. Most stakeholders felt that there was scope to increase the burden of safety on the supply chain. SAPIA suggested that government could send a more appropriate message through the way that the price is regulated, for example by regulating a retail price inclusive of packaging, instead of the way the current price is stated which is exclusive of packaging.

Addressing the packaging issue was seen to be critical if paraffin is to have a safe and viable future in South Africa, and yet stakeholders felt it would be very challenging to do so. Introducing packaging would ultimately increase costs for the end user, which some stakeholders saw as

removing the principal benefit of paraffin, i.e. its perceived affordability. They therefore felt that any initiative that would increase the costs would make it non-viable, especially politically. This argument, however, does not adequately reflect the true costs of using paraffin in relation to other fuels such as electricity. Furthermore, one might argue that the price of paraffin is artificially low at this point, as it is not inclusive of the costs of mitigating safety risks as LPG is, for example. The price of LPG incorporates the cost of the cylinders in which it is stored, and safe re-filling and distribution measures. The price of paraffin is also not fully reflective of the externalities associated with using it.

5.4 Pricing and subsidies

Paraffin is currently VAT-exempt in order to provide relief for the poor on what is considered an essential item. This VAT exemption is seen by most stakeholders to have been a politically motivated move. There has been little subsequent evidence-based research to investigate the impact of this indirect subsidy and whether it is actually fully passed through to consumers. Since 2003, government also sets a maximum retail price on a monthly basis, aimed at protecting consumers from exaggerated mark-ups in the supply chain and the overcharging of end consumers. Most stakeholders commented that they do not believe the controlled price is being adhered to and noted it is difficult to monitor and enforce, given the number and diversity of informal enterprises selling it. There is also little awareness among consumers about the regulated price giving them little power to question the prices that retailers charge. A survey of 330 retailers in six provinces was undertaken measuring adherence to the maximum retail price. The survey found that the majority of retailers, particularly those in rural areas, were not adhering to the regulated maximum retail price (PDC, no date).

Several stakeholders questioned the desirability of the VAT exemption subsidy and of having a pricing policy that promoted a fuel with negative health and safety externalities without addressing those as well. Although there is evidence to suggest that the cost reduction from the VAT exemption has not been passed through to consumers, theoretically making this fuel cheaper could incentivise households to use this fuel over other safer alternatives. Furthermore, if paraffin no longer holds its place as the cheapest fuel, as research presented in section 4.2 suggests, does the rationale for this subsidy still hold? It is also worth considering whether a subsidy programme might better be targeted at appliances rather than a fuel consumption subsidy. It was noted that priorities should lie rather in making this fuel safer as opposed to subsidising its consumption. Most stakeholders, however, considered that it would be extremely difficult from a political perspective to reinstate VAT on this product, which would be seen as negatively impacting the most vulnerable population segment. Such a move may only be possible as part of some bigger and broader shift in household energy policy, if at all.

5.5 Implementation of the Free Basic Alternative Energy subsidy

As described in section 3, FBAE was introduced to subsidise energy consumption for households not connected to grid electricity. FBAE is widely regarded by many energy stakeholders as being very poorly implemented at a local municipal level. To better understand the issues associated with this policy and any linkages to paraffin safety, an interview was undertaken with a researcher who is currently undertaking extensive research into the roll-out of FBAE and Solar Home Systems in the Eastern Cape.

National government provides general guidelines for the implementation of FBAE, but development of administrative systems is left up to the Department of Cooperative Governance and Traditional Affairs (COGTA), who leave targeting of beneficiaries up to individual municipalities. The subsidy is complex for municipalities to deliver and these institutions often have severe capacity and resource constraints. Often there are no personnel within a local municipality dedicated to energy specifically in comparison to other service delivery sectors such as health and sanitation, which have local personnel such as district officers. A municipality wishing to rollout FBAE needs to develop and keep up to date their indigent registers. Without registers that include verified names of beneficiaries, municipalities cannot apply for the subsidy

from government. However, developing and keeping an up-to-date indigent registers is, in itself, a huge administrative task and many rural municipalities do not have the resources to do even this. Municipalities have to balance limited resources amongst competing priorities.

Furthermore, national perspectives and priorities are, as one would expect, reflected in priorities for energy service delivery at a local level. As such the focus is predominantly on electrification. Local municipalities often lack any specific energy strategy and this is reflected only in IDP planning and electrification targets. Because targets on service delivery are set in terms of electrification, municipalities with higher electrification rates are commonly regarded as performing better off. National government does not therefore transmit the right incentives to adopt a wider approach to energy access. As a result, FBAE often gets overlooked. COGTA requires that municipalities report on a monthly basis on their free basic service delivery. However, unless there is dedication at a local municipal level to look at FBAE, there is little that COGTA does to enforce it. And so in municipalities who are not committed to alternative energy provision or have problems with combating corruption, FBAE often gets overlooked. Another challenge is the fact that the subsidy gets paid as part of the Equitable Share Grant. This is an unconditional grant that does not allow for this subsidy to be ring-fenced in municipal budgets. Thus the decision to pay this subsidy depends on a municipality's priorities as well as local politics, which affect many decisions at a local level. The budget allocated by National Treasury for FBAE is also reported to be insufficient to cover all households.

Fourteen of the thirty-eight local municipalities in the Eastern Cape are reportedly currently implementing FBAE. Of these, three are rolling out gel fuel, six paraffin and five solar. Paraffin is often preferred because it is a fuel that the population generally already uses and is familiar with, and the logistics of roll-out for the municipality are relatively simple. They do not for example have to consider sourcing new appliances as would be the case for gel fuel for example. The limited roll-out of LPG was regarded as being influenced by municipal representatives' concerns over safety and expense of this fuel. Those municipalities rolling out paraffin distribute 20 litres of paraffin per household on a quarterly basis, claiming they do not have enough money to disburse every month. The process typically involves municipalities putting a tender out to private companies to deliver paraffin to households. It is typically delivered in 20 litre containers on a truck or a 'bakkie' to villages. Households are expected to bring their own 20 litre containers, and often these might also be those that are also used for water by a household.

During her fieldwork this researcher had not observed any initiatives to address safety, either by the municipalities or the distributors. Municipalities do not therefore appear to be fulfilling the mandate as laid out in the FBAE policy that safety aspects of fuels are also addressed. Promoting access to a fuel such as paraffin without addressing the health and safety aspects thereof was noted as being problematic. One way this could be incorporated is to include safety specifications in municipal tenders for distributors, and to integrate safe appliances into the roll-out programme. Overall FBAE was seen as a necessary policy in terms of equity between electrified and unelectrified households, but there is a pressing need to reform the implementation mechanisms and to address the lack of capacity at a local level for implementation.

5.6 Conclusion

Without any active intervention, reliance on paraffin in the low-income household sector is expected to continue into the foreseeable future. Most stakeholders had a generally sceptical outlook, however, about overcoming the challenges of transforming it into a safe fuel. In theory, paraffin's safety issues are a direct function of inadequate safety standards and developing these could enhance the safety as has been done for electricity and gas. However, the practicalities of developing and enforcing appropriate standards in a developing country context are difficult, especially in South Africa where there is a lack of political will. No stakeholders were aware of other developing countries that had managed to successfully transform paraffin into a safe fuel. Although there were references to developed countries, these well-regulated contexts do not provide adequate insights into understanding the challenges in a developing country. These include political barriers, informal contexts that are difficult to monitor and control, government capacity constraints to enforce regulations, affordability constraints as well as issues of poor public education and awareness of risks.

6. The viability of alternative household fuels to displace paraffin

If a future of transitioning away from paraffin is to be investigated, it is necessary to understand the viability of modern alternatives such as electricity and LPG to replace it. These fuels are considered the most viable alternatives that can meet the same household energy services that paraffin provides access to in a clean and safe manner. As discussed in the previous section, many stakeholders felt it would be generally beneficial for the well-being of poor households if paraffin were to be phased out, but expressed reservations about the ensuing gap in the household fuel mix. This section briefly looks into the viability, from a supply perspective, of electricity and LPG as alternatives. The final part of this chapter explores the potential role that paraffin could play in national energy security in light of the electricity supply constraints that the country faces.

6.1 Electricity as an alternative

The likelihood of achieving universal access to electricity in South Africa is a challenging policy goal and one that appears unlikely to be achieved in the short to medium term. The universal access target by 2012 was originally set in 2004. The setting of this target was done in an un-transparent manner and it is not clear what evidence base was used for planning purposes to come up with this target date (Bekker et al, 2008). Indeed the 2012 date has proved to be untenable and the target was revised to 2014 and now most recently has been set at 92% of all households to be connected to the grid by 2014 (DoE, 2011). From a purely numbers perspective achieving this new 2014 target, using the backlog as at 2011 would require an additional 630,000 connections per year (Tait and Winkler, 2012). In comparison the planned roll-out for 2010/11 by the DoE was 199,561 (DoE, 2011). The electrification programme faces significant funding and capacity constraints (Bekker et al, 2008; DoE, 2011), which have dramatically curtailed the number of new connections per year as seen in Figure 1 below. Furthermore the wording of the universal access target itself appears to only refer to 100% of existing households when the policy target was set, as opposed to 100% of future households when the target is achieved (Bekker et al, 2008). This implies that even when the target is 'achieved' in policy terms there may still be a significant number of unconnected households in reality.

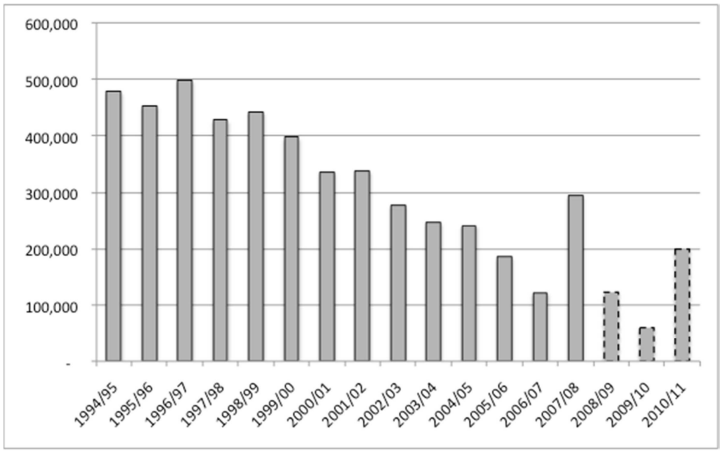


Figure 1: Annual new electrical connections
Source: Tait and Winkler (2012)

Many stakeholders interviewed remarked that electrification has not had as great an impact on displacing the use of other fuels in electrified households as was originally expected. The focus groups provided key insights into the inadequacy of electrification alone as a strategy to displace other fuels (see section 4). Perceptions of the cost of electricity, the poor quality and reliability of supply in informal settlements means that households cannot completely rely on electricity to meet all their household energy needs. The electrification programme also does not target all households, for example backyard dwellers (DoE, 2012). This not insignificant subset of

households may therefore never be reached by this policy. The viability of electricity to solely provide for the energy demands of a low-income household appears low. There is therefore a continuing need for the presence of other fuels to augment electricity in meeting household energy demand. For electricity to fulfil the gap left by a phase-out of paraffin would require at the very least a significant scale-up of annual connection rates, reforming the national policy approach to electrifying backyard dwellers and informal settlements, and addressing supply network capacity issues which contribute to unreliability of supply for poor households. It would also require addressing the poor quality of electrical appliances, which are inadequate to be used for all cooking requirements.

6.2 Liquefied petroleum gas

In many countries LPG is widely used as a household fuel in the low-income sector. South Africa in fact stands out as somewhat of an anomaly in its relatively low usage of this fuel (Kojima, 2011). Academic and petrochemical stakeholders commented that LPG's poor penetration of the domestic sector to date can be traced to various imperfections in LPG markets around pricing, regulation and supply and storage infrastructure. For example the price of LPG here is amongst the highest in the world (Kojima, 2011). Supply constraints have been one of the biggest challenges in LPG markets in South Africa. Security of supply of LPG is somewhat of a grey area in policy terms as there is no mandate for security of supply as there is for electricity. The supply constraints have derived both from inadequate import facilities and insufficient storage infrastructure. On top of these issues, Shell and Kayagas remarked on the recent unfavourable period for refining that the country experienced last winter. Virtually all refineries had some sort of output constraint due to breakdowns or shutdowns. Kayagas notes that supply constraints tend to hit the household sector first, rather than industry. This unreliability of supply understandably discredits the fuel in the eyes of consumers.

The low-income household LPG market in South Africa remains largely under-tapped. Kayagas is a distributor focussing on the low-income household market. They suggest that the messy realities of the low-income market are generally an unattractive prospect for the private sector. The challenges include the need to be cash-based, to deal with retailers that do not speak English and overcoming problems of obtaining permits for storage of cylinders in informal spaza shops. Kayagas have, however, developed a sustainable business model and have outlets in most low-income settlements around Cape Town. Whilst they are currently urban-based, Kayagas feel that cost-effective distribution networks in rural towns and nodes are also feasible. He notes that the major barriers from a demand perspective are the lack of understanding of the relative costs of different fuels and fears about the dangers of gas cylinders exploding. Kayagas have found that fears about safety can be easily and successfully overcome by increasing education and exposure to the fuel. Part of their business model therefore includes interactive demonstration/promotional cooking days in low-income settlements.

From a policy perspective there have been various statements from the DoE indicating their interest and support for the further growth of LPG. SAPIA, Shell and Kayagas noted that there are various plans and proposals to upgrade supply infrastructure over the next several years to address supply issues. A, much delayed, strategy document for the sector is reportedly being developed by the DoE. This strategy document intends to address development of supply infrastructure, a licensing regime for the regulation of prices and safety, dealing with uncompetitive behaviour, developing local production of cylinders, subsidies, and reviewing the approach to pricing (DoE, 2012b). There are also plans currently underway for import, storage and transport facilities for Saldanha and Richards Bay.

In a budget speech in May 2011, the Minister of Energy referred to the development of an LPG strategy that intends to divert households away from electricity to LPG for cooking and space heating (Peters, 2011). This intention for LPG was reiterated in the interview held with the DoE for this study. In a presentation to Parliament in 2012 the DoE indicated that LPG could serve to address energy supply shortfalls and was the preferred carrier to transition households away from coal and paraffin. There was discussion about the possibility of subsidies on appliances and cylinders to address affordability constraints. Details of any programmes or timelines however, remain unclear at this stage. There have been programmes in the past promoting LPG in the low-

income household sector. An Eskom programme was initiated in 2006 that involved swapping working electric appliances for a 2-plate LPG burner and 5kg cylinder. The programme was very successful in addressing the key barriers of the capital costs of switching as well as providing information and awareness to address safety concerns of households. However, it was ultimately undermined by the ensuing national LPG supply constraints. SANEDI commented that Eskom developed this programme without adequate consultation with the LPG industry. Thus the industry was not able to factor in the additional demand the programme produced. Several stakeholders commented that there was strong potential for similar programmes in the future to have a significant impact on increasing the use of LPG.

In terms of safety, LPG, currently benefits from a good system of well-designed cylinders and stoves. The number of households using this fuel and cylinders is also relatively low at this stage, however, and, as one stakeholder noted, should LPG be radically upscaled in terms of cylinders in households, there is the potential for the safety risks to also increase. A rapidly expanding market would open up potential for cheap and low-quality imports of cylinders; old and rusted cylinders remaining in the market, and illegal filling stations. Such risks would occur in the same context of poorly enforced regulation and the challenges of policing and intervening in informal settlement conditions. Whilst safety risks definitely have important fuel- and technology-specific considerations, they also relate to a large extent to the inadequacy of the regulatory and institutional setting in which they occur.

In conclusion, there does appear to be a strong potential for this fuel to grow its market and many stakeholders consider that LPG has a strong and viable future here. Growth in usage depends on government continuing to develop strategies to overcome current supply, distribution and pricing barriers. It may also benefit from targeted programmes at the household sector by the DoE (based on statements made) although details are unclear at this stage. It is also evident that, to create demand for LPG, any roll-out in the low-income sector would need to be accompanied by education and safety awareness programmes and potentially subsidies as well. Increased use of LPG in low-income domestic settings would also necessitate increased focus on its safety aspects.

6.3 Paraffin's potential role in national energy security

This section explores the potential for paraffin to serve as an option to ease electricity demand in the residential sector. South Africa currently faces an energy-constrained electricity system and removing capacity from the grid either through efficiency measures or using alternative fuels is a topical issue. One option in the residential sector is to explore the potential for alternative fuels such as LPG or paraffin to supply energy-intensive peak-time energy services such as cooking. Such an approach was launched by Eskom prior to the 2008 supply crises (discussed above). SANEDI indicated that Eskom, once again in a similar situation, is interested in trying to 'de-market' electricity for any end-use services that can be supplied by alternative options. Such an approach of assessing demand against a range of different supply options is, under normal circumstances, outside the DoE's paradigm of supply planning, and is only really considered in reaction to crisis situations. Although the DoE themselves did not comment directly on this issue in the interview, it appears likely as discussed in the previous section that LPG is the alternative energy carrier of choice to deal with energy security issues. Furthermore, in the current integrated energy planning process there is little mention of the role of paraffin in this regard.

From a stakeholder perspective, the potential of paraffin to contribute to national electricity security was generally perceived to be an undesirable option. It implies transitioning those households already using electricity, with its greater socio-economic and welfare impacts, away from this fuel and towards paraffin with its host of safety issues. Even with interventions such as safer appliances or better packaging, the notion of trying to transition people *towards* this fuel was seen to be socially sub-optimal. Stakeholders were also of the opinion that it would be unlikely to receive support in political circles. As was noted, if the safety aspects of the fuel are not simultaneously addressed, it would essentially be sacrificing the well-being of the most vulnerable parts of society to ensure security of electricity supply for the industrial sector.

Furthermore, from a household economic perspective, a household currently using electricity would be worse off moving to paraffin, which is more expensive. The viability of such an

intervention based on the aspirations and preferences of households themselves may also be questionable. The transition to electricity is often associated with modernity and a certain social status for households. Whether there would be market interest to move away from a modern fuel such as electricity to a 'poverty fuel' is unclear. One commentator also argued that it is not strategic to drive further household energy interventions that essentially support electricity-related objectives. The household energy discourse is already distorted by the over-emphasis on electricity and there is a need to promote household energy interventions that are driven from a safety or welfare perspective and not to save electricity.

6.4 Conclusion

From the discussions it was clear that actively promoting paraffin's role in household energy or to address energy supply constraints would not garner support from either government or other stakeholders in the sector. The prevailing perception is that the system of paraffin distribution and use has too many safety concerns and that it is preferable to focus on the expansion of other fuels such as electricity and LPG. Both electricity and LPG could play a greater role than they currently do in the household energy mix, but face both demand and supply barriers. Demand barriers stem from misperceptions about affordability and safety. While these could be relatively easily addressed, the more challenging constraints lie around supply, particularly in the short-to-medium term. For LPG, this supply-constrained picture is likely to change if government continues efforts to develop necessary infrastructure and an appropriate pricing and regulatory environment. Although they may not be able to fully displace paraffin, there is substantial opportunity to enhance the role of both of these fuels in the short term by educating households about the relative affordability of electricity and dispelling consumers' safety fears of LPG.

7. The role of government and the petrochemical sector in paraffin safety

This section presents an overview of the discussions with various government stakeholders and oil company representatives. Whilst this is not an exhaustive list of potential government departmental stakeholders, it aims to give some insight into the awareness and perceptions of paraffin safety among such stakeholders. Discussions also aimed to investigate the current and potential future role they might play in paraffin safety either directly or indirectly through collaborations. This section presents the current scope of activities, their own views on their mandates in this regard, their willingness to engage and play a collaborative role in the future and some views of petrochemical sector stakeholders on government.

7.1 Petrochemical sector representatives

Shell and SAPIA

The general view of these stakeholders was that government was giving strong (if indirect) indications that there will be little future interest or support for paraffin. Efforts are instead focussing on promoting LPG. Government's priorities in turn influence how the oil companies plan their own strategic future, and with no indications or discussion about the future of this product, the focus and attention on safety has also declined. Stakeholders felt that the potential role of oil companies in the safety aspects of this fuel was minimal. Oil companies are no longer involved in distribution activities related to paraffin and once the product leaves the oil depot, the oil companies have no responsibility for it. The product goes from the refinery either by pipeline, road or rail to bulk depots (operated by the refineries) from where large distributors (either retailers or 'middlemen') buy the product. The distribution or packaging parts of the supply chain therefore lies beyond their domain of direct control. The only potential manner in which refineries can affect safety aspects of this fuel is in relation to reducing the smoke point of the fuel, which impacts indoor air pollution. Shell noted that there is potential to refine it further so that the product smokes less, but this would add to the costs of production.

7.2 Government stakeholders

Department of Energy

The DoE is perhaps the key stakeholder in the issues around paraffin safety. Whilst the electrification section deals most closely with energy access, paraffin-related issues fall under the hydrocarbons section. Numerous attempts were made to engage with representatives from both the electrification and hydrocarbons sections of the department.. With the DoE structured along a supply-side basis it is difficult to address issues about household energy in an integrated manner, which incorporate various fuels and therefore various sub-sections of the DoE. DoE officials showed limited engagement with ERC on issues around paraffin safety and access to other fuels, possibly indicating lack of political will. The DoE emphasised that they are not planning an active phase-out of paraffin. Instead mention was made of programmes to transition households away from paraffin to LPG, although no details were given. Their current activities relating to paraffin regulation lie only in the regulation of pricing. They indicated awareness of issues of non-compliance with the regulated retail price and said they were attempting to address them, but no details were given. In discussions around safety efforts, they indicated that they rolled out pilot projects of safe stoves and child-safe containers in four areas in 2009. DoE's view appears to be that responsibility for regulating the safety of paraffin lay with PASASA.. This stance presents a major challenge for planning a safe future for this fuel in South Africa, particularly in light of the closure of PASASA.

The South African National Energy Development Institute

SANEDI is an agency reporting to the DoE, and its role in the energy sector relates primarily to research and energy efficiency. SANEDI noted that until now the domestic sector has largely been overlooked in efficiency initiatives to date, with only limited initiatives around solar water heaters

and CFL roll-outs. Efficiency gains in this sector were described as requiring 80% of the effort with only 20% of the impact in terms of efficiency gains. However, with energy demand in the household sector set to grow significantly there is a growing awareness that it requires a dedicated efficiency focus. SANEDI's own view is that energy interventions should be coordinated and consolidated, and that safety could and should be integrated with efficiency initiatives that they undertake, for example safe-stove swaps. Safety was seen to be a cross-cutting issue requiring the engagement of multiple stakeholders. The current lack of an integrated approach to energy programmes and interventions was described as one of the biggest challenges in the industry, with multiple programmes and organisations in existence all working in silos, for example LPGASA, PASASA, SWH roll-out initiatives, the City of Cape Town's insulated ceilings roll-out, etc. There was an acknowledgement that electricity dominates the energy agenda and has not necessarily turned out to be the pro-poor policy it was intended to be. It was noted that in the context of the electricity supply constraints there is interest from Eskom in de-marketing electricity for certain services for which alternatives exist, which thus opens up the opportunity to develop a greater focus on other fuels.

National Regulator for Compulsory Specifications (NRCS)

The NRCS is a key stakeholder in household energy safety and paraffin through its role in developing, monitoring and enforcing compulsory specifications for paraffin appliances. Compulsory specifications/regulations are based on national standards which are the responsibility of the South African Bureau of Standards (SABS). The NRCS serves as the enforcer of regulations developed by South African National Standards (SANS). These standards are usually adopted from ISO or other international standards and may be adapted if necessary for the South African context. There are currently standards in place for non-pressure appliances (SANS 1906) and pressurised appliances (SANS 1243). The non-pressure appliance standard has been a compulsory specification since January 2007 (VC9089-2006) with a compulsory specification for pressurised appliances forthcoming.

The predominant focus in the NRCS's programme of monitoring activities related to paraffin is now on border points of entry, manufacturers and huge distributors. The NRCS has also in 2012 commenced a 'Winter campaign' programme with funding from the DTI. This campaign is aimed primarily at raising awareness among households by doing a community 'walk-about', switching non-compliant appliances they find with the safe compliant versions. Three 'high risk' low-income informal settlements were selected around the country to run the campaign. The walk-about in the un-electrified Mfuleni settlement in Cape Town revealed that use of non-compliant products was widespread and greatly outnumbered the use of compliant products. Where households were using compliant products these were often too old or had been modified (to fix them when they broke) so that they could no longer be considered a 'safe' appliance. Some households were using compliant paraffin heaters to cook with. The walk-about revealed generally little awareness of the existence of compliant versus non-compliant products, nor what to look for in terms of SABS or NRCS approval numbers.

Insufficient funding and resourcing for the NRCS is a serious constraint on their expansion of their enforcement activities. They currently have three inspectors for the entire country responsible for monitoring all products in the Chemicals, Mechanical & Materials division. Their activities are currently funded only out of levies on manufacturers products. It is possible in theory to increase such levies on paraffin appliances and thereby enable them to fund more enforcement work. However such costs would ultimately be passed onto the consumer. This would in turn further increase the cost of compliant products in relation to non-compliant ones. The NRCS noted that there has been very little engagement and support from other government departments in relation to their paraffin activities to date, particularly from the DoE. He described that attempts to organise stakeholder meetings in the Eastern Cape had had minimal attendance from any invited stakeholders. A collaborative effort is regarded as essential to enable more effective solutions and programmes.

Department of Health

Since the bulk of the burden of the costs associated with paraffin injuries falls on the Department of Health (DoH), many stakeholders saw this department as a prominent stakeholder. At the time

of interviewing, the DoH was establishing a new strategic framework and implementation strategy for a new unit, set up in 2012, that now has responsibility for all types of injuries including burns and poison ingestions. The scope of activities for the unit was envisaged to extend from prevention and mitigation right through to rehabilitation. Mitigation activities are receiving increasing prominence in DoHs strategy. It was acknowledged that disabilities, from burns for example, incur significant costs to the state and that low-income households are the most vulnerable and have the highest incident rates. Interest and support was therefore expressed for collaboration around mitigation activities relating to paraffin and energy safety, such as awareness campaigns, education and advocacy. There are opportunities to incorporate such activities into existing programmes and departmental resources as opposed to developing major new funding streams. As an example, there could potential to incorporate such activities into the scope of work of currently under-utilised resources such as 'basic ambulance assistants'. Any such activities would, however, require collaboration from an organisation like PASASA which has the appropriate knowledge and expertise to develop training for such employees.

Department of Human Settlements – Western Cape

The representative from the Western Cape DSH said that, from the perspective of the DSH, electrification is the only overlap between energy and housing delivery. The DSH sees basic services as sanitation, refuse removal, electricity provision and water, and other fuels are not seen to be within their remit. Whilst there have been some overlaps with other forms of energy, for example solar-water heater roll-outs, these have been driven by the Eskom subsidy and donor grant funding and are not necessarily a priority for the department. Another area of overlap with energy is in the inclusion of insulated ceilings in RDP housing but, whilst these have been included in the building codes in the Western Cap,e they are not yet being rolled out as the DSH is still busy surveying to see what the impact would be on the housing subsidy. No real interaction with paraffin was identified, except in the arena of disaster-related events where the DSH is involved in fixing shacks after fires. However, in general the DSH does not get involved in activities exploring and addressing the causes of such disasters. There might be some awareness-raising in consumer education programmes for beneficiaries of new houses, but this would generally be ad-hoc and there is no over-arching or coordinated programme. Despite acknowledgement of the reality of multiple fuel use in low-income households, the departmental focus is on electrification and there was generally seen to be limited scope for further involvement of the DSH in paraffin safety.

Disaster Risk Management Centre – Cape Town (DRMC)

The mitigation and reduction of risks is the main focus area for the DRMC. They undertake a municipal risk assessment process identifying hazards and potential risk reduction measures, with fires in informal settlements listed as one of the top five hazards. The key contributing factors to fires in informal settlements are described as deriving from high density living conditions, social conditions such as domestic violence, alcohol, drugs and child negligence (for example leaving children on their own whilst cooking); as well as behavioural practices such as leaving stoves or candles unattended and falling asleep. In Cape Town, wind is also a key risk factor in the spread of fires. Paraffin was noted as one of the leading causes of fires due to stoves and general negligence.

The DRMC undertakes an interactive approach in awareness raising with communities around risk mitigation. High risk communities are identified, of which one of the defining risk characteristics is if the community is unelectrified, and activities are undertaken during the high fire-risk season (in Cape Town from November to January). Such activities include talks in schools, theatre productions and plays about fire risks, as well as content in community newspapers and other local media channels. They focus on directing their message particularly at children as a means of reaching adults as well. It was noted that effecting lasting behaviour change is challenging and there are limits to what the DRMC can achieve in this regard. It was noted that there are 234 informal settlements in the city and the DRMC obviously cannot target all of them. With regards to paraffin appliances, the DRMC had in the past tried to undertake interventions such as monitoring local retailers and spaza shops. However, the DRMC faces limitations in such activities in that they do not have the power or authority to confiscate illegal stoves that they

might find. It was noted there was on-going debate around whether to give the DRMC such powers.

8. Modelling the future of paraffin in SA

This section outlines the results of a modelling process that was undertaken to quantify the possible demand for paraffin in the residential sector over the medium-to-long term (to 2030). Four scenarios were modelled, a business as usual scenario, an LPG scenario, a least cost scenario, and a safe stove scenario. The model, assumptions and characteristics of the different scenarios are described below. A more detailed description of the model can be found in Appendix C.

8.1 Modelling of scenarios

The Residential Sector Module of the South African TIMES model (SATIM 2012) developed at the ERC was used to make a range of scenario projections for the use of paraffin in the residential sector. Four scenarios were developed to explore a range of possible evolution of the demand for paraffin in the residential sector:

- a BAU scenario – based on a continuation of existing trends;
- an LPG programme scenario – based on an assumed government initiated LPG programme which encourages greater use of LPG by low-income households;
- a least cost scenario – based on an assumed education and awareness programme educating households about the relative costs of different fuels and encourages fuel use based on least-cost.
- a safe stove scenario – based on increased penetration of safer non-pressure stove technology based on existing available technology and more expensive 'aspirational' appliances.

A brief description of the Residential Sector Module of SATIM is given below, as well as a more detailed description of each scenario. The detailed documentation of the SATIM is currently being developed and is available on the ERC website (http://www.erc.uct.ac.za/Research/esystems-group-satim.htm).

SATIM Overview

The SATIM model uses a least-cost optimization, bottom-up approach for modelling the South African energy system. Projections of future demand are done in terms of the demand for energy services or 'useful energy' (cooking, lighting, etc) rather than in terms of 'final energy' (paraffin, LPG, etc) to allow for a better study of the substitution between alternative fuels, as well as an appraisal of the effect that evolution of the technological improvements has on projections of fuel requirements.

In SATIM, the residential sector is split into three income groups (low, middle and high) and the two lower income groups are again split into 'electrified' and 'non-electrified', resulting in five income/electrification groups. The five groups were identified by a cluster analysis on appliance ownership and fuel use of the community survey data (Statistics South Africa, 2007). The high income group has a per-household annual income of above R76,800 (in 2005). The lower income group has a per-household annual income of less than R19,200 (2005), and the two are separated by the middle income group. In 2006, the populations of the low, middle and high income groups were 23.4, 14.1 and 9.4 million, respectively.

The residential sector model has seven end-uses, namely:

- lighting,
- cooking,
- space heating,
- water heating,
- refrigeration,
- other electricity,
- non-energy use of fuels.

The base year for the model is 2006, for which the latest most reliable energy balance data is available. The model is set up and run in three steps:

1. base year calibration,

2. useful energy demand projection,
3. least-cost optimization and fuel calculation.

Base year calibration

Useful energy in the base year is estimated from final energy in the base year, the base-year share of the provision of useful energy by fuel/appliance and the efficiency of the appliance using each fuel in the base year. The final energy in the base year is based on the DoE's energy balances (EB2006), with some adjustments made to electricity, coal, LPG and biomass. The paraffin sales are based on the SAPIA sales categories. The DoE allocates the sales to the energy balance sectors: industry, residential, commercial and agriculture. It is very likely that there are errors in the split of sales of paraffin and that some of the sales attributed to the residential sector should be attributed to the commercial sector. However, there was no good basis for making any adjustment there. Further disaggregation of the paraffin consumption by the models different income groups and end-uses was done using the community survey data (CS, 2007) adjusted to 2006, and a bottom-up calculation on what the per-household annual consumption would be for each income/electrification group and end-use. This bottom calculation itself relies on experience and past studies (e.g. Cowan, 2008: Hughes, 2010). The full results of the base-year calibration and assumptions are given in the appendix.

Future demand projections

The future demand for energy services is computed in two steps. In the first step, the evolution of the population in each income/electrification group is projected with the help of an economic CGE model (described briefly in the appendix), and the exogenous projection of the electrification rate (an exogenous assumption roughly based on historical trends and future government/Eskom targets). In the second step the total useful energy demand in each year for each income/electrification group is computed by multiplying the per capita useful energy demand of each income/electrification (based on the base-year) by the population in each of the income/electrification group. The per capita demand is assumed to be constant for the 4 lower income groups (as average income of those groups remain constant) and is assumed to grow with income in the high-income group.

Least cost optimisation model and final energy (fuel consumption) calculation

The TIMES model finds the least cost way of meeting the useful demand for each end-use, based on the fuel and appliance costs, appliance efficiency, and subject to constraints imposed on penetration rates (shares of useful energy for each end-use)

$$Minimise\ C(t) = \sum_{t=2006}^{2030} \frac{Fuel\ cost(t) + Appliance\ cost(t)}{(1+r)^{(t-2006)}},$$

Where:

- *Fuel cost(t)* is the total fuel used multiplied by the cost of each fuel in each year,
- *Appliance cost(t)* is household expenditure on energy appliances each year,
- r is the discount rate – set at 8% real (as used in the IRP).

The total annual fuel use is calculated as follows:

$$F_f(t) = \sum_{i=1}^{5} \sum_{e=1}^{7} \left(s_{f,i,e}(t) \times U_{i,e}(t) \times \eta_{e,f} \right),$$

where:

- $Ff(t)$ is the final energy consumption of fuel f in year t,
- $si,f(t)$ is the share of useful energy met by fuel f for income/electrification group i, and end-use e in year t and is a result of the optimization,
- $Ui,e(t)$ is the useful energy demand for end-use e in income/electrification group i in year t (e.g. cooking end-use in low income electrified group in 2010),
- $\eta_{e,f}$ is the efficiency of conversion from final to useful energy for fuel f and end-use e.
- The inside summation is across the end-uses e and there are 7 end-uses for each income group. The outside summation is across income/electrification groups i and there are 5 groups. The TIMES model is solving for $s_{i,f}(t)$, subject to constraints imposed on $s_{i,f}(t)$. For example in the BAU scenario $s_{i,f}(t)$ is given very little freedom to move away from what it was in 2006 (with an adjustment for 2010 in the case of paraffin).

Common assumptions across all scenarios
The following assumptions are common to all three scenarios:

- A moderate GDP annual growth rate of 3.9% with a gradual decline in the 'low-income' as shown in Figure 2. The 3.9% growth scenario is described in the appendix. At this stage it is not possible to model other growth rates in the CGE model because at the time of this research there was no capacity within ERC to do so, but further sensitivity analysis with regards to this variable could/should be undertaken in the future.
- 96% electrification of households by 2030 (90% low income and 95% middle income), as shown in Table 1.
- Figures 2 and 3 below illustrate the projected population changes over time for the various defined income/electrification groups. These projections were derived from the CGE model and are consistent with the 3.9% GDP growth and a total labour employment grows at 2.6 per cent per year, implying an employment growth elasticity of 0.67 and a gradual decline in the national unemployment rate (given annual population growth of 1.5%). GDP growth is fairly even across sectors as a result of uniform productivity growth and mobile labour. Overall, the baseline scenario provides a reasonable economic trajectory for South Africa.
- The income bands associated with the definitions of high, middle and low income are as follows: low income (R0–R19,200), middle income (R19,201–R76,800) and high income (R76,801 and above). Its important to note that the middle income grouping of households still contains households that may be regarded as poor – for example, the lower end of the bracket includes households earning R1600 per month. These bandings have, however, been devised for the purposes here to capture observed changes in energy consumption patterns and appliance ownership.
- Fuel price projections are given in Table 4. The electricity price is based on the MYPD 2 application with adjustment for MYPD 3. The projections of the prices of oil products are based on the International Energy Agency's World Energy Outlook for 2011 projections. The price of woodfuel is assumed to stay constant in real terms (increase with inflation).

Table 3: Exogenous assumptions on electrification rates

	2006	*2010*	*2020*	*2030*
Low income	71%	71%	80%	85%
Middle income	83%	83%	90%	95%
Overall electrification	80%	81%	90%	95%

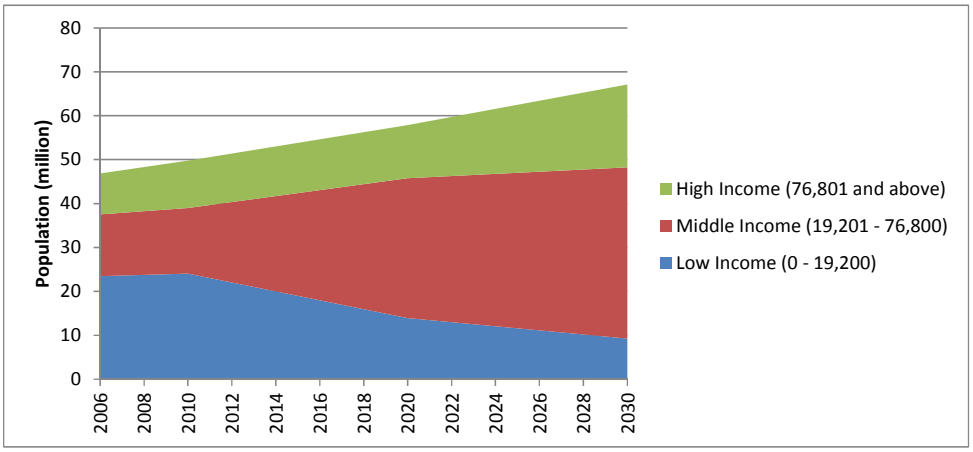


Figure 2: Population by income group derived from CGE model

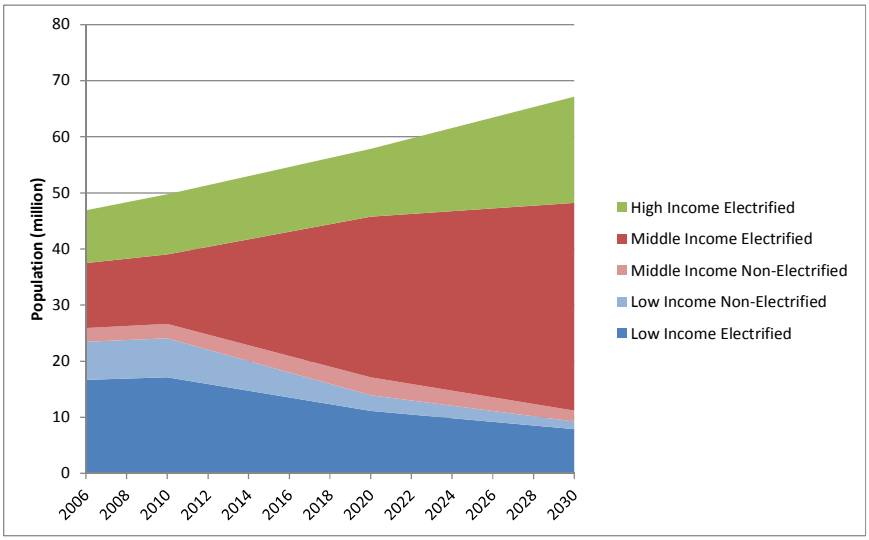


Figure 3: Population broken down by income group and electrification status

Table 4: Fuel price assumptions in 2012 rands

	WEO oil price	*Paraffin*	*Electricity*	*LPGas*	*Wood*
	$/bbl	*R/l*	*R/kWh*	*R/kg*	*R/kg*
2012	100	10.9	0.85	22.8	0.25
2015	106.3	11.6	1.17	24.2	0.25
2020	118.1	12.8	1.50	26.9	0.25
2030	134.5	14.6	2.22	30.6	0.25

8.1.1 Scenario 1: Business as usual

In the BAU scenario each household group continues to behave in a similar way to observed trends (2006-2009) with regards to their energy consumption patterns for cooking, space heating and water heating. An adjustment of the shares is made to paraffin such that the 2010 figures matches the 2009 fuel sales figure. The tables below show the shares of useful energy if these shares, except for paraffin are kept constant and are averaged across the five income groups

(weighted by population). The useful energy shares by income group and end-use are imposed as constraints on the TIMES model effectively giving it 'no room' for optimization. Efficiency developments in the BAU scenario have been taken into account by allowing for some penetration of new technology options for lighting (LEDs, CFLs) and for heating (e.g. heat pumps).

Table 5: BAU aggregate shares of the different fuels for meeting cooking services

	2006	*2010*	*2015*	*2020*	*2025*	*2030*
Coal	2%	3%	3%	2%	2%	1%
Biomass wood	32%	34%	33%	32%	29%	27%
LPG	2%	2%	2%	2%	2%	2%
Paraffin	11%	8%	7%	6%	5%	4%
Electricity	53%	53%	56%	59%	63%	66%
Total	100%	100%	100%	100%	100%	100%

Table 6: BAU aggregate shares of the different fuels for meeting space heating services

	2006	*2010*	*2015*	*2020*	*2025*	*2030*
Coal	23%	24%	22%	21%	19%	17%
Biomass wood	20%	20%	16%	12%	10%	8%
Paraffin	10%	7%	7%	7%	6%	6%
Electricity	47%	49%	55%	60%	65%	69%

8.1.2 Scenario 2: Government-initiated LPG programme

This scenario describes a future where a government-initiated LPG programme is launched to encourage greater use of LPG in the low-income household sector. It assumes that the useful energy share of paraffin and coal drops by half in 2030 relative to 2010, and the reduction in paraffin share is replaced by increasing the LPG share by the same amount. For example, in the Low Income Electrified group, the paraffin share is 5.4% and the LPG share is 1.2% in 2010. In 2030 the paraffin share is thus reduced to 2.7% and the LPG share is increased by 2.7% to 3.9%.

Table 7: LPG scenario – aggregate shares of useful energy by fuel

	2006	*2010*	*2015*	*2020*	*2025*	*2030*
Coal	2%	2%	2%	1%	1%	0%
Biomass wood	32%	34%	33%	32%	29%	27%
LPG	2%	2%	3%	4%	4%	4%
Paraffin	11%	9%	6%	4%	3%	2%
Electricity	53%	53%	56%	59%	63%	67%
Total	100%	100%	100%	100%	100%	100%

8.1.3 Scenario 3: Least cost scenario

This scenario assumes that widespread education and awareness campaigns are initiated to educate households about the relative costs and efficiencies of different energy types. It therefore assumes that households behave in a more rational way when choosing which fuel and appliance to use, always selecting the most cost-effective option. Constraints on penetration are gradually relaxed over time to ensure a smooth fuel transition in the results.

The estimated annual expenditure of a low-income household on cooking is shown in Figure 4. This is based on the fuel price assumptions given above and on the estimates of annual energy consumption for cooking for a low-income electrified household. This is assumed to be 4.3 GJ/year for paraffin (10 litres/month), 2.34 GJ/year for electricity (54kWh/month), 3.62 GJ/year for LPG (7kg/month), and 46 GJ/year for wood (225kg/month). These energy consumption

estimates were based on various studies, including (Cowan, 2008) that estimated the comparative costs of cooking with different fuels. Implicit in these cost estimates are the efficiencies of different appliances that were used in cost experiments. The data reveals that, to achieve an equivalent level of cooking services using different energy sources, wood would be the cheapest option, followed by electricity then paraffin and LPG. This scenario therefore clearly shows that if households were to behave rationally, they would, after 2012, pick wood as their first option then electricity, then paraffin then LPG. A similar picture would be seen for other households and end-uses. In the model however we constrained the share of wood to stay the same as 2006, and allowed households to gradually shift towards the next cheapest fuel, namely electricity, across all household groups and end-uses. The aggregate shares that result from this constrained optimization are shown in Table 8.

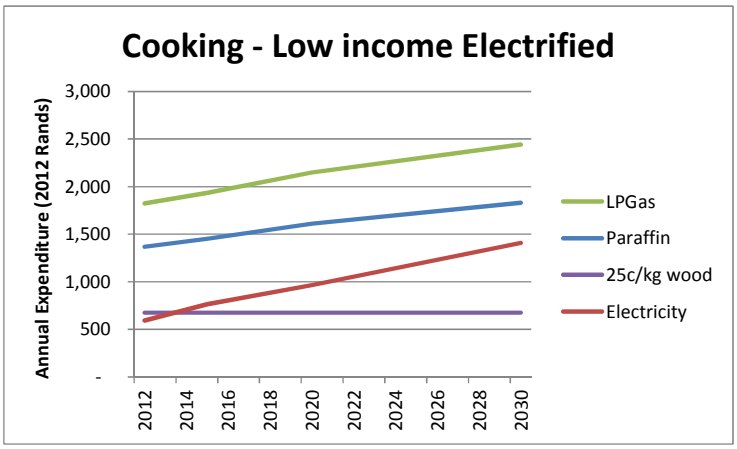


Figure 4: Annual expenditure of low-income households for cooking

Table 8: Least cost scenario – aggregate shares of useful energy by fuel

	2006	*2010*	*2015*	*2020*	*2025*	*2030*
Coal	2%	2%	2%	1%	1%	0%
Biomass wood	32%	34%	33%	32%	29%	27%
LPG	2%	2%	3%	4%	4%	4%
Paraffin	11%	9%	6%	4%	3%	2%
Electricity	53%	53%	56%	59%	63%	67%
Total	100%	100%	100%	100%	100%	100%

8.1.4 Scenario 4: Safe stove scenario

This scenario assumes penetration of safe non-pressure stoves into the low-income residential market. Within this scenario, two different technology types were investigated. The first version of the scenario looked at using existing technology and so used a typical compliant stove already in the market, the so-called 'new Panda' or second-generation Panda[3] stove. However, since there are reported issues with the usability and durability of these stoves, another better quality appliance was also investigated as an 'aspirational' option. Given that no better quality stoves are available in the South African market, a Japanese appliance, the Toyitomi, was modelled, based on PASASA's recommendation. Since the Toyitomi is significantly more expensive than any of the other stoves (it is estimated that it would retail for approximately R1000) it was necessary to assume in the model that its take-up would be facilitated by a partial government subsidy that would be gradually phased out over time.

[3] Panda is an appliance brand.

This scenario was therefore run using two stove technology variants which were assumed to displace use of existing non-compliant non-pressure stoves for cooking and water heating. The model assumed appliance efficiencies shown below (Lloyd, 2013). It is evident that these proposed safer designs do not necessarily imply greater efficiency. Their usage therefore implies an increase in fuel consumption to achieve the same end-user energy service.

- Existing non-compliant non-pressure stove: 44%;
- 'New Panda' stove: 42%;
- Toyotomi stove: 39%.

Table 9: Aggregate shares of different fuels for meeting cooking services

	2006	*2010*	*2015*	*2020*	*2025*	*2030*
Safe stoves 1: New Panda stoves						
Coal	2%	4%	3%	2%	2%	1%
Biomass wood	32%	34%	33%	32%	29%	27%
LPG	2%	2%	2%	2%	2%	2%
Paraffin	11%	7%	6%	6%	5%	4%
Electricity	52%	53%	56%	58%	62%	66%
Total	100%	100%	100%	100%	100%	100%
Safe stoves 2: Toyitomi stoves						
Coal	2%	4%	3%	2%	2%	1%
Biomass wood	32%	34%	33%	32%	29%	27%
LPG	2%	2%	2%	2%	2%	2%
Paraffin	11%	7%	6%	5%	3%	2%
Electricity	52%	53%	56%	59%	64%	68%
Total	100%	100%	100%	100%	100%	100%

Table 10: Aggregate shares of different fuels for meeting space heating services

	2006	*2010*	*2015*	*2020*	*2025*	*2030*
Safe stoves 1: New Panda stoves						
Coal	23%	24%	22%	21%	19%	17%
Biomass wood	20%	21%	17%	13%	10%	8%
LPG	0%	0%	0%	0%	0%	0%
Paraffin	10%	7%	7%	6%	6%	5%
Electricity	47%	48%	55%	60%	65%	69%
Total	100%	100%	100%	100%	100%	100%
Safe stoves 2: Toyitomi stoves						
Coal	20%	21%	17%	13%	10%	8%
Biomass wood	20%	20%	16%	12%	10%	8%
LPG	0%	0%	0%	0%	0%	0%
Paraffin	10%	7%	7%	7%	6%	6%
Electricity	47%	49%	55%	60%	65%	69%
Total	100%	100%	100%	100%	100%	100%

8.2 Model results

8.2.1 BAU results

Figure 5 shows the consumption of final energy by fuel in the residential sector in the BAU scenario. It shows that paraffin forms a relatively small part of the residential energy use (6.6% in 2006 and 5.1% in 2010), and this share is projected to drop further over the study horizon to around 3% in 2030. Figure 5 shows the paraffin consumption by income group. In BAU, annual paraffin consumption is expected to drop from around 500 million litres in 2010 to around 400 million litres in 2030. Since the useful energy shares are kept constant from 2010 onwards, the decrease in paraffin use is entirely explained by the shift of population to higher income groups and greater electrification. This also explains the increase in paraffin use in the middle-income group, as the per-household consumption is kept constant.

Figure 7 shows the consumption of paraffin by end-use. The notable change here is in the decreased use of paraffin for lighting, which drops from 4% in 2010 to 1% in 2030. This is again explained by electrification, as it is assumed that only non-electrified households use paraffin for lighting.

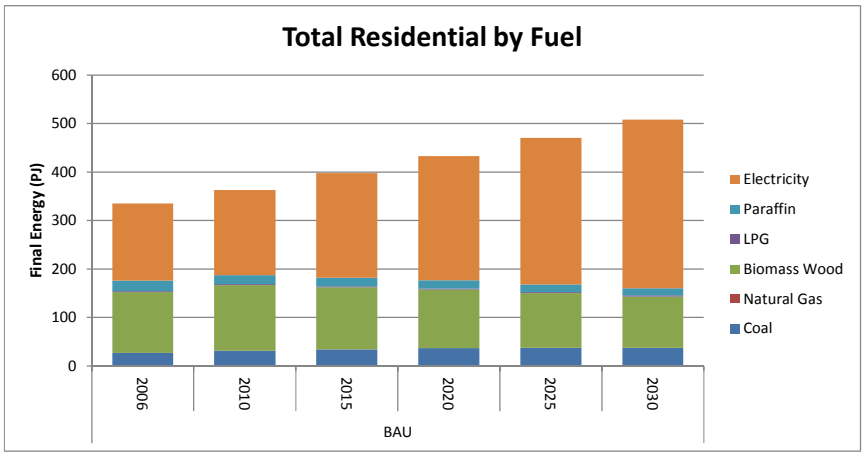


Figure 5: Final energy consumption in residential sector by fuel in the BAU scenario

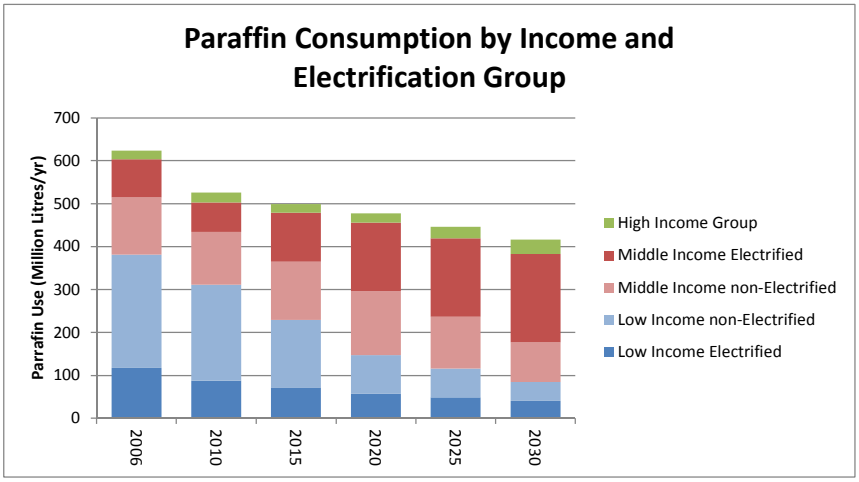


Figure 6: Paraffin use by income and electrification group

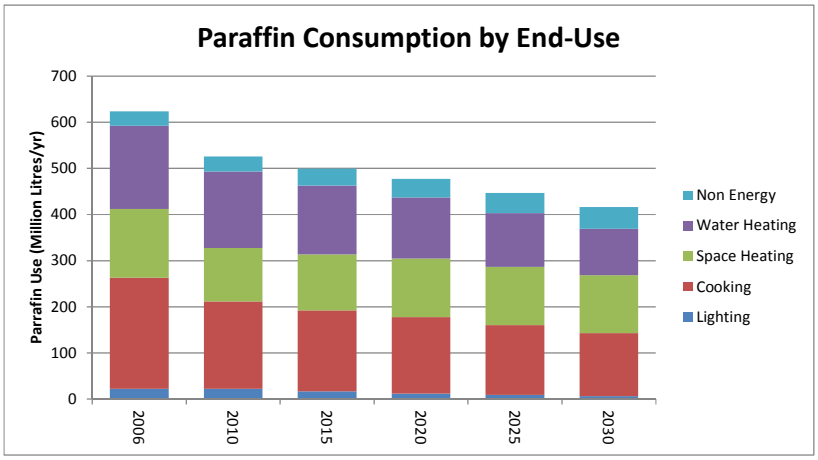


Figure 7: Paraffin consumption by end use

8.2.2 Scenario comparisons

Figures 8 and 9 show a comparison of the scenarios indicating paraffin consumption by income group and by end-use for the various modelled scenarios. All scenarios indicate a declining longer-term trend in the overall consumption of paraffin. The greatest reduction would be in an LPG scenario in which there would be a shift from paraffin and coal to LPG. The results for the least-cost scenario reflects consumer choice based on rational least-cost energy choices and shows a shift away from paraffin, and to a certain extent from LPG, to electricity and to some extent biomass.

The first version of the safe stove scenario using the 'new Panda' stove would see a slower decline in consumption compared to BAU due to the lower appliance efficiencies and hence greater fuel requirements. Conversely the safe stove 2 option using an aspirational Toyitomi appliance would see an initial rise in consumption facilitated by a partial subsidy to incentivise roll-out and lower efficiencies which would increase fuel inputs. However the model results show a steeper reduction in paraffin consumption over time as the appliance subsidy is phased out over time it is likely that households would transition to cheaper options over the longer term (cheaper both in terms of appliance costs and cost of delivering the energy service).

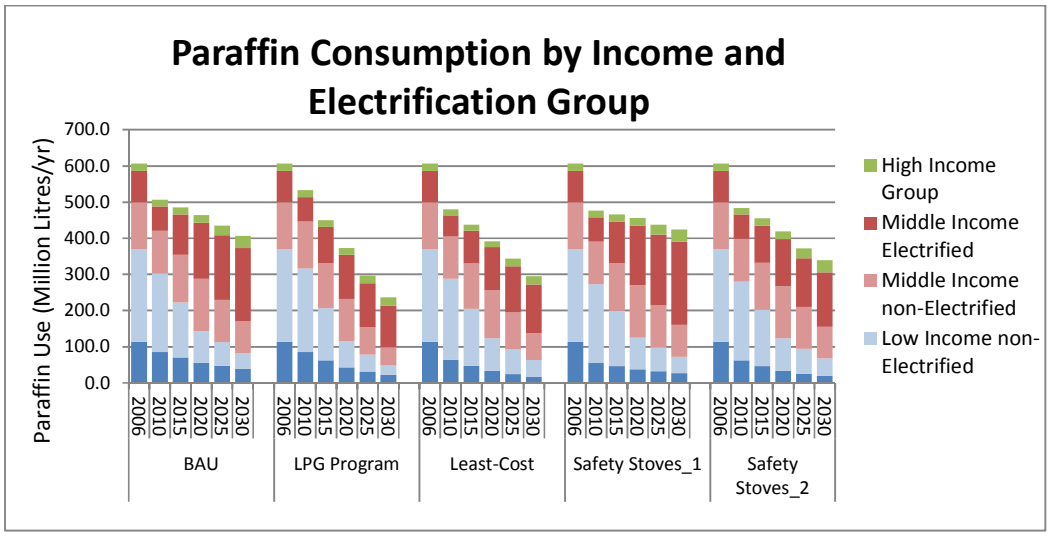


Figure 8: Scenario comparison of paraffin consumption by income/electrification group

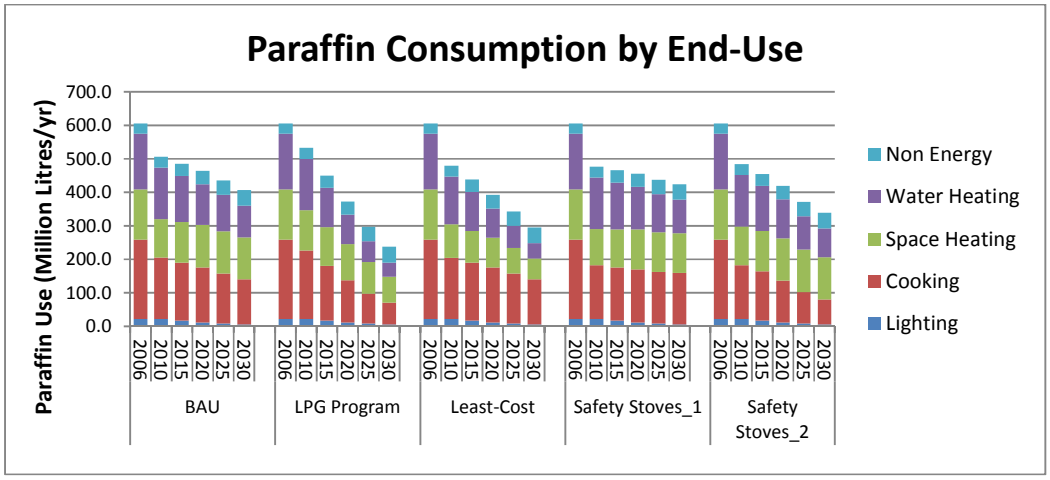


Figure 9: Scenario comparison of paraffin consumption by end-use

9. Planning for the future of paraffin in South Africa

So what is the future of paraffin in South Africa? This study was investigating both how things are but also how they should be. Most stakeholders were of the opinion that the optimal future in terms of household energy was one were paraffin were phased out and alternative fuels were encouraged. There was widespread scepticism about the ability to transform the system of paraffin into a safe one in South Africa given the local context and associating challenges. However, there was also acknowledgement that a future without paraffin is not necessarily possible at this stage. There is little indication that either the DoE or the petrochemical sector would actively phase it out. Secondly there is doubt as to whether alternatives such as LPG and electricity could currently fulfil the gap in the household fuel mix.

Stakeholder interviews, focus groups and the modelling process suggest that paraffin may continue to gradually decline but nevertheless retain its presence in the low-income market for some time to come. Its presence will continue to be driven by factors such as household preferences, perceptions of its cheapness and being a 'poverty fuel', fears of LPG, the electrification backlog as well as the unreliability of electricity supply and appliances. The most likely policy shift that might foreseeably have an impact on this sector is if the DoE develops LPG programmes for the domestic sector, for example subsidies, which may hasten the rate of decline in consumption. But overall it will continue to be used by the poorest and most vulnerable parts of the population with its associated health and safety concerns. In terms of safety, it appear that the DoE would not of their own accord play a more active role in enhancing the safety of this product. Although it is noted that active lobbying by household energy stakeholders could influence this. Without any clear or decisive policy directives with respect to this fuel, it is not possible to envisage either option of completely transitioning away from this fuel or transforming it into a safe fuel.

9.1 The potential for policy interventions around safety

It is likely that the only way to address issues around ingestions and fuel contamination lie in education, in conjunction with safe packaging and labelling. Such packaging interventions themselves are, however, only feasible with regulation. Any packaging requirements will be onerous to design and administer and will increase prices for consumers and make the product relatively more difficult to sell. It is unlikely that the private sector would voluntarily engage in this. The oil companies do not view themselves as having a role in this regard and such requirements would need to be directed at the level of distributors and retailers. The lack of interest from the DoE in this regard is a major impediment to addressing these safety issues. One way forward may be to explore the teeth of legislation such as the Consumer Protection Act to initiate required regulatory changes. Most stakeholders felt that PASASA would be the most logical organisation to take forward a test case, but with the closure of this organisation it is unclear who else would have the resources and interest to do so. PASASA has expressed intentions, in the wake of PASASA, to establish a similar organisation but with an expanded focus on safety issues relating to all energy sources. If attempts to establish a Household Energy Safety Association (HESASA) are successful, this could be the most appropriate actor to take ownership of these issues and coordinate lobbying efforts.

The NRCS is currently playing the leading role in appliance issues but it is evident that they need more support and funding for their activities, particularly for monitoring and enforcement. Illegal appliances are still widespread in many areas in Cape Town and is evidence that their activities are insufficient to address the scale of the issue. There are strategic issues relating to their funding model that limit their ability to fund an expansion of their programme of activities. Addressing this issue is probably beyond the scope of advocacy from external pressure groups and needs to be taken up by government players with the power to influence such processes. It appears critical that the DoE plays a greater supportive role around safe appliances. There also needs to be more engagement from stakeholders such as PASASA/HESASA or universities in drawing attention to the inadequacies of some of the compliant products on the market. Without well-designed user-friendly alternatives, consumers will continue to choose and use the unsafe but more effective illegal appliances. There does also appear to be potential to develop cooperative programmes with

SANEDI around appliance issues. SANEDI have expressed both a willingness to engage and to see the value in integrating efficiency and safety objectives.

The most substantial opportunity to intervene in safety lies in influencing the behavioural aspects of energy use through education and awareness campaigns for consumers. One of the key messages to emerge from the focus groups is the lack of awareness and education around safety practises and energy use. There are many 'energy myths' and misinformation regarding affordability and safety of energy usage which constrain people from making optimal energy decisions. Given the challenges around achieving a supportive regulatory regime to support safety of this fuel, education programmes should have a two-pronged focus: continue to build awareness and behaviour change to enhance the safety of this fuel, but also encourage and educate households to consider the use of alternative fuels to transition away from paraffin. Misperceptions about the expense of electricity and safety of LPG serve as a major barrier to transitioning to these safer fuels.

Paraffin safety is a cross-cutting issue and there are opportunities to work with several different government stakeholders, other than the DoE, to build safety issues into their own awareness programmes and activities. There are indeed already government resources being directed at safety and these could be further strengthened. These activities are currently uncoordinated and often only sporadically implemented. Developing a more coordinated and synergistic approach could greatly enhance the overall impact of efforts in this sector. This would require a dedicated stakeholder to lobby for awareness of more safety programmes, and is probably dependent on the establishment of a HESASA going forward.

9.2 A national household energy strategy

There was broad support from many stakeholders for the idea of a household energy strategy that integrates the approach to household energy in South Africa. Stakeholders felt that the current political discourse on household energy is not reflective of the underlying objectives of improving the welfare of poor households through health and safety, poverty alleviation and improved economic wellbeing.

An overarching policy framework does exist that makes provision for a wider approach to household energy (as described in section 3). This energy policy framework makes clear indication of the need to address energy access, defined as a range of fuel sources and is supportive of health and safety objectives. There is, however, a gap between the policy framework and programmes and strategies around implementation. A seeming lack of awareness by policymakers on the actual impacts and shortcomings of the electrification programme is part of the issue. There appears to be a pressing need for the current policy discourse to reflect on-the-ground realities.

A household energy strategy would ideally build on and bring together all programmes and objectives related to household energy, and consider demand and supply options in an integrated manner for all household fuels. Such a strategy should develop a long-term vision to bring clarity to the sector. This vision needs to clearly articulate what the objectives around household energy transitions are and what they should look like in the short, medium and longer terms. This is critical to give clarity to key role-players, both private and public. A meeting of household energy stakeholders was organised by PASASA and SANEDI in May 2012 to discuss the challenges around the low-income sector. One of the outcomes of the meeting was an outline of the key aspects a household energy strategy should cover (PASASA et al, 2012a). These included:

- access,
- affordability,
- efficiency,
- safety practices and implications,
- health impacts,
- supply and availability, and
- environmental impacts.

The discussion also recommended that, due to the cross-cutting nature of this sector, a diverse range of government stakeholders should be involved. Such a strategy should also consider improved methods of data collection around energy use, which is currently a major limitation in better understanding the complexity of this sector. The political will for improved data collection will only stem from better articulation of energy access objectives. Currently the DoE only has an interest in demonstrating access to electricity to meet their programme objectives around household energy.

The strategy should also consider appropriate institutional arrangements to coordinate and drive efforts. One suggestion was to investigate setting up an 'associated institution' with its own management, similar to SANEDI, but still under the auspices of the DoE. It could be useful to explore how other countries have approached the use of such outside agencies or other models to address specific household energy sector objectives, for example, energy efficiency.

It is clear that to achieve this objective would require dedicated lobbying activities by external and internal government stakeholders. Some of the stakeholders interviewed here commented on the necessity of finding a political champion inside government to take ownership of this issue and drive it forward. Others suggested that an important lobbying tool would be to develop a comprehensive evidence base to support key lobbying points around the issue in household energy currently not being addressed. It was suggested that government could only respond to evidence-based concerns and recommendations. It was also felt necessary to organise as many stakeholders in the sector around this issue. The success of advocacy and pressure groups is greatly enhanced if they are seen to represent an entire sector. It was therefore considered important to develop a common understanding of the needs of the sector to be able to present viewpoints and recommendations that are widely canvassed and supported.

Another option in lobbying efforts is to use parliament. There is a clearly observable gap between stated objectives around energy safety articulated in various pieces of energy legislation and the implementation thereof. The DoE has a clear mandate to address household energy safety and consumer protection as laid out in the Energy Act of 2008. However, this has been largely neglected to date. Parliament has a legislative mandate to play an oversight role and to monitor the impact of legislation. A parliamentary document expounding on this oversight role states that 'the concept of oversight contains many aspects which include political, administrative, financial, ethical, legal and strategic elements.' This therefore includes 'To ensure that policies announced by government and authorised by Parliament are actually delivered. This function includes monitoring the achievement of goals set by legislation and the government's own programmes' (Parliament, no date: 7). Since the issues and objectives that are pertinent to household energy which are not being implemented have already been articulated in authorised policies, this is an issue that parliament should follow up on.

10. Conclusion and recommendations

This study has explored the topic of current and future paraffin use by low-income households in South Africa and particularly issues around its desirability and necessity as part of the household fuel mix. As part of this, the viability of alternatives were investigated. Stakeholder perceptions were also explored around key challenges around health and safety of this fuel and potential options to address these going forward. The study also investigated the role of energy legislation and the DoE's approach to the household sector. Key shortcomings were identified in the design and implementation of national household energy policy interventions that focus predominantly on electrification.

This research did not elicit any information that either the DoE or petrochemical companies are likely to phase out paraffin. From a demand perspective, the focus groups indicated that there is likely to be continuing demand for this product. Consumers see paraffin as an important part of their household energy mix, and indicate that it is their preferred fuel for cooking certain meal types and is seen as an essential backup fuel. Paraffin is likely to continue to be used by low-income households, although overall consumption is estimated to continue to gradually decline. This decline may be accelerated if government initiates an LPG switching programme for the low-income household sector or if there are significant awareness and education campaigns around

costs and affordability of different fuel types. There appears to be little support for actively encouraging the growth and use of paraffin in South Africa. The DoE do not view it as a modern fuel aligned with the aspirations of a post-apartheid society, and their preferences clearly lie in electrification or LPG. Other stakeholders interviewed felt it problematic to promote a fuel with such significant health and safety challenges, particularly for the most vulnerable parts of the population.

Going forward, it is difficult to adequately address the challenges of health and safety without the active participation and cooperation of the DoE. They do not, however, appear to be interested in taking a proactive stance in this regard. Although active lobbying by stakeholders could alter this, it may take a considerable amount of time before this could be achieved, if at all. The stakeholders interviewed discussed various barriers to addressing health and safety of paraffin but viewed the lack of political will as the most significant. The most promising area of intervention in health and safety in the meantime, therefore, is to focus on education and awareness-raising efforts. In this regard there is potential to capacitate and grow the efforts of various other institutional stakeholders to develop their programmes. Successfully lobbying for and developing a household energy strategy may take a significant amount of time and resources. It is therefore important that, whilst pushing for a comprehensive framework response from national government, there is also concurrent action to strengthen linkages with other government programmes. A HESASA could play a key role in training and capacitating government departments to grow their own safety programmes.

A high-level summary of key recommendations is presented below. These recommendations are directed at different strategic levels and pertain to different stakeholders. Critically, many of these recommendations are without relevance in the absence of any formalised and institutionalised approach and/or actor to take ownership to drive initiatives forward. This therefore needs to be a primary focus in any efforts to enhance paraffin safety in South Africa. Further active lobbying by stakeholders could be instrumental in this regard. Whilst PASASA may have been a well-placed organisation to do this, there would be strategic benefit in having greater governmental ownership of the issue. Furthermore the closure of PASASA leaves a gap in this sector. The organisation did also announce intentions to set up a new organisation, HESASA, with a wider mandate looking at safety issues relating to all fuels. However whether such an organisation will go ahead and be established is not yet confirmed.

Key recommendations from this research include the following:

- A task team or institution should be formed that could take a lead in addressing paraffin safety issues. This would need to include and coordinate diverse government stakeholders including but not limited to the DoE, NRCS, SABS, DTI, SANEDI, DoH, DRMC, DSH and COGTA. From the initial interviews undertaken here, SANEDI appears to be the institution most proactively interested and engaged which could play a lead in taking these issues forward.
- There should be lobbying activities by non-governmental sector stakeholders. There is a wide range of issues and concerns that could be better publicised to key governmental stakeholders either through more targeted research outputs or other active lobbying activities. Ideally, efforts should be coordinated amongst different stakeholders (such as NGOs, universities etc) to be able to present widely canvassed sectoral concerns and issues.
- Any issues to do with paraffin should ideally be considered within a coordinated approach to household energy, and there is a clearly recognised need to develop a national household energy strategy or framework to provide overall strategic planning for this sector in terms of delineating clear objectives and goals, roles for different stakeholders and programmes for implementation.
- Regulations for packaging should be introduced.
- The role of the Consumer Protection Act should be investigated, using a test case of accidental paraffin ingestion as a means to lobby for regulations around safe packaging.
- There should be education and awareness campaigns around safety and other relevant issues pertaining to household energy use. These should ideally be organised in a coordinated

manner with various government stakeholders at national and provincial level to maximise efficacy of resources and budgets and to achieve maximum spread and impact.

- Safe stoves initiatives – there is a need to both improve existing non-pressure safe stove technology, as well as to investigate how regulation and monitoring activities of non-compliant products by NRCS can be better supported and expanded.
- Better data collection systems should be established to support evidence-based interventions in the residential sector.

References

Bekker, B., Eberhard, A., Gaunt,T. and Marquard, A. 2008. South Africa's rapid elecrification programme: Policy, institutional, planning, financing and technical innovations. *Energy Policy*, 36: 3115– 3127

Cowan, B., 2008. *Alleviation of Poverty through the Provision of Local Energy Services (APPLES*). Project no. EIE-04-168. Cape Town, South Africa.

Dugard, J. 2008. *Power to the people? A rights-based analysis of South Africa's electricity services*. In Electric Capitalism: Recolonising Africa on the power grid. HSRC press.

DoE. 2011. *Integrated National Electrifcation Programme*. Presentation by Department of Energy to Parliamentary Portfolio Committee on Energy. 8 March 2011. Cape Town.

DoE, 2012b, Options for LPG Expansion, Presentation to Parliamentary Portofolion Committee on Energy, 17th August, 2012. Available at http://www.pmg.org.za/report/20120817-transformation-liquefied-petrolium-gas-sector-briefing-department-ene

DME. 2003. Electricity Basic Service Support Tariff Policy (Free Basic Electricity). Department of Minerals and Energy, Pretoria.

DME. 2007. *Free Basic Alternative Energy Policy*. Department of Minerals and Energy, Pretoria.

DME. 2005. *Energy Efficiency Strategy*. Department of Minerals and Energy, Pretoria.

Jaglin, S. 2008. Differentiating networked services in Cape Town: Echoes of splintering urbanism? *Geoforum*, 39: 1897 – 1906.

Le Roux, L., Zunckel, M. and McCormick, S. 2009. Reduction in air pollution using the 'basa njengo magogo' method and the applicability to low-smoke fuels. *Journal of Energy in Southern Africa*, 20 (3): 3-10.

Lloyd, P. 2010. *Changes in cooking energy could have a major impact on South Africa's carbon emissions*. Domestic Use of Energy Conference 2010 Proceedings. Cape Peninsula University of Technology. Cape Town.

Lloyd, 2013. 2013. *Appliance efficiencies*. Personal email correspondence.

Kipruto, W. 2011. A review of the cook stove test methods and their applicability in small scale CDM cook stove projects. Available at https://energypedia.info/images/a/a7/Review_of_cook_stove_test_methods_29_Mar_11.pdf

Matinga, M. 2010. "We grow up with it." An ethnographic study of the experiences, perceptions and responses to the health impacts of energy acquisitions and use in rural South Africa. Phd thesis. University of Twente, Netherlands.

Mensah, S. and Benedict, E., 2009. Entrepreneurship training and poverty alleviation, empowering the poor in the Eastern Free State of South Africa. *African Journal of Economic and Management Studies*, 1(2): 138-163.

Mohlakoana, N., and Annecke, W. 2009. The use of liquefied petroleum gas by South African low-income urban households: A case study. *Journal of Energy in South Africa* 20 (4): 2 – 10.

Muller, E. Diab, R. Binedell, M. and Hounsome, R. 2003. Health risk assessment of kerosene usage in an informal settlement in Durban, South Africa. *Atmospheric Environment*, 37: 2015 – 2022.

National Planning Commission. 2012. *National Development Plan 2030*. The Presidency of the Republic of South Africa. Pretoria.

PASASA et al, 2012a. *Household Energy Policy, Final Report of the "Panel of Experts" on Household Energy Policy and Strategy in South Africa*. 3 May 2012. Johannesburg.

PASASA et al. 2012b. *The Need for a Household Energy Strategy and Policy*, Submission to the National Planning Commission in response to the National Development Plan. Cape Town.

Parliament, no date. *Oversight and accountability model, Asserting Parliament's role in in enhancing democracy*. Available at www.parliament.gov.za

Prasad, G. 2006. *Social issues*. In: H. Winkler, ed. Energy policies for sustainable development in South Africa: Options for the future. Cape Town, Energy Research Centre University. pp 61 – 76.

PDC. No date. Review of the effectiveness of energy subsidies and related taxation policies in South Africa. Available at

http://www.pdc1.co.za/energy.html#_Toc144022368

SAPIA. 2011. *Annual Report*. South African Petroluem Industry Association.

Statistics South Africa. 2012. *Census 2011, highlights of key results*. Pretoria, South Africa.

Tait, L. and Winkler, H.. Estimating greenhouse gas emissions associated with achieving universal access to electricity for all households in South Africa. *Journal of Energy Southern Africa*, (forthcoming 2012).

Webb, C. and Kevern, J. 2000. Focus groups as a research method: a critique of some aspects of their use in nursing research. *Journal of Advanced Nursing*, 33(6): 798-805. 2001 Blackwell Science Ltd

Appendix A – Interview schedule

Institution	*Date and type of interview*
Local government	
City of Cape Town - Disaster Risk Management Centre	Personal, 6 June 2012
Western Cape Provincial Government Department of Human Settlements	Personal, 23 May 2012
National Regulator for Consumer Standards (NRCS) Western Cape	Personal, 13 June 2012
COGTA	No response
National departments	
Department of Health	Personal, 20 June 2012
National Regulator for Consumer Standards (NRCS)	Personal, 19 June 2012
South African National Energy Development Institute (SANEDI)	Personal, 22 June 2012
Department of Energy	Email, 11 July 2012
Petrochemical sector	
South African Petroleum Industry Association (SAPIA)	Phone, 28 May 2012
Shell	Phone, 8 June 2012
Kayagas	Personal, 9 July 2012
Engen Petroleum Limited	No response
BP Southern Africa Limited	No response
Sasol	No response
Academics and development organisations	
Energy Research Centre, University of Cape Town	Personal, 5 May 2012
Cape Peninsula University of Technology (CPUT)	Personal, 1 June 2012
Sustainable Energy Technology and Research (SeTAR) Centre University of Johannesburg	Personal, 18 June 2012
Sustainable Energy Technology and Research (SeTAR) Centre University of Johannesburg	Phone, 3 July 2012
University of Twente, Netherlands	Phone, 30 May 2012
Sustainable Energy Africa	Personal, 23 July 2012
None – retired.	Phone, 25 July 2012

Appendix B – Focus groups write-ups

Introduction

Three peri-urban low-income settlement locations in Cape Town were chosen for the focus groups. Areas were chosen where either PASASA or the ERC had local community contacts that could assist and facilitate the process of finding and selecting participants. Community contacts were asked simply to find paraffin users and ensure a selection of people who live in housing with their own formal electricity connections and those who lived in shacks with informal or no connections. It was deemed relevant to get users from a range of dwelling types and electricity access as energy usage and behaviour is often influenced by these factors.

The first location was Imizamo Yethu, a settlement in the suburb of Hout Bay in Cape Town. Focus group participants were all shack dwellers including some people living in formally declared areas with their own electricity connections and those living in the informal or illegal part of the settlement without connections and who 'bought' electricity from neighbours by running cables between houses. The issue of energy safety was very prevalent in people's minds in Imizamo Yethu as there had been a township fire only a few weeks previously where 40 shacks had burned. The fire was allegedly caused by a man who was drunk and had gone to sleep with a candle burning.

The other two focus groups were held in different parts of Khayelitsha – Site C and Kuyasa. Khayelitsha is one of the largest townships in South Africa and is divided into a number of sub-sections which range between the older formally declared areas to much newer informal areas due springing up with the high rate of inward migration to this area. Site C participants were shack dwellers and included some from an approved area called Chris Hani, with their own electricity connections and others in Taiwan, an unapproved area some of which had informal connections from neighbours. Two participants had no electricity connection. Participants from Kuyasa were all residents in RDP houses, relocated several years from another illegal area they were living in.

Household perceptions around their energy choices

Participants in the focus groups used a combination of the following fuels – electricity, paraffin, LPG, candles and wood. No one reported using coal. Fuel usage is generally intricately interwoven into people's lifestyles, behaviour patterns and modes of socialising. The literature on determinants of household fuel usage in SA often tends to focus on factors such as affordability and accessibility but the focus group discussions here presented a much richer picture of household energy choices in the context of social, economic and cultural and personal factors. Key issues relating to different fuels are discussed below.

Electricity

All participants from all focus groups, except for two in Site C in Khayelitsha, had some form of access to electricity through either a legal or illegal connection. Electricity is highly desired and most people seem willing to tolerate the higher prices of buying from neighbours rather than not have it. As a household fuel it does offer unique utility for certain energy services which no other fuel can provide – such as TVs, charging cellphones, washing machines etc. It is also seen as a convenient cooking fuel for meals with short preparation times, but is widely regarded as too expensive or not appropriate for cooking meals with longer preparation times. Most participants feel that paraffin is better suited to these meal types. Electricity was also noted as useful when there is a need to have multiple pots cooking at the same time as paraffin stoves generally only allow for one pot at a time.

Despite the prestige of this fuel and its usefulness there were many concerns and issues that were raised in the discussions relating to affordability, safety, appliances and irregular supply. Electricity is generally regarded as the most expensive fuel and most participants felt they could not afford to use it all the time. In Imizamo Yethu some felt that the electricity there received in Cape Town was a 'rich man's' version compared to the cheaper and more basic service they got in the Eastern Cape. They believe electricity in Cape Town to be more expensive than in the Eastern Cape and something they cannot adequately afford.

One of the most prominent issues raised of foremost concern amongst all the focus groups was the intermittency and unreliability of electricity supply. An intermittent supply appears to be a constant feature in the lives of residents of low-income settlements. To illustrate from anecdotal experience of the participants, in Imizamo Yethu participants noted that they hadn't had access to electricity for the last three weeks since the shack fire, which had burnt cables as well. Site C participants reported that the electricity had been out the whole of the previous evening before the focus group. Kuyasa participants also echoed that blackouts were a regular feature and that recently electricity had been out for two weeks. This has a major impact on people's lives. There is of course the inconvenience factor of the sudden and unannounced disruptions that last for an indeterminate time period and cannot be planned for. Kuyasa participants also reported that when the electricity came back on again after a blackout, there were often power surges which destroyed their appliances. Although they were warned by Eskom to turn off appliances or unplug the mains when the electricity goes off, this is not always possible if they are not at home or asleep when it happens. This imposes an additional cost factor on households when they have to replace appliances. Perhaps most significantly from the perspective of achieving access to safe and modern energy services, this intermittency in supply necessitates the on-going use of other 'backup' fuels and means that, regardless of other factors such as affordability, a full transition away from less safe fuels, (for example candles for lighting or paraffin for cooking), is not possible even for residents of electrified settlements.

Participants in Site C and Imizamo Yethu who were buying electricity from neighbours noted that household sellers abused electricity prices by charging a (often quite significant) premium on the electricity. They also noted that the system, originally designed to meet the load of a single household but now stretched across multiple households drawing power, often gets overloaded and trips. Typically a single low voltage connection cannot support more than one household cooking at a time (because of the energy intensity of cooking) and therefore some participants noted they either had to coordinate cooking around the main household or were simply not allowed to use their electricity for cooking at all and had to use other fuels instead. Interestingly two participants in Site C who were shack dwellers without their own connection said that they felt getting an informal electricity connection was too much hassle in terms of all the issues, costs and intermittency and they chose not to have any electricity access at all.

Another major issue related to electricity usage is the poor quality of low cost electrical stoves that frequently malfunction. The primary problem relates to the temperature dial which often breaks. The result is that the stove only works at full power, with no intermediate temperature ranges. Having a stove that only cooks at full power is not only extremely energy inefficient for households, increasing their energy costs of using electricity but also means that electricity cannot be used for all cooking purposes for example those meals that need to be cooked over a low heat for a long period of time such as samp and beans or steamed bread. This situation therefore necessitates the continued usage of other fuels such as paraffin to cook these meal types. It therefore appears that without addressing the problems with low-cost electrical stoves, households cannot make a full transition to using electricity for all their cooking requirements.

Paraffin

Paraffin is used for cooking, space heating, water heating, ironing and to a lesser extent, lighting. Paraffin was felt to be an important part of the household fuel mix and particularly served an important role as a backup fuel when there were electricity shortages.

Participants view this fuel as their cheapest and most affordable option (not taking wood into consideration). A key reason given by participants for using this fuel was often that they could not afford alternative fuels. Using this fuel for cooking for example was seen as a key way to save electricity for other uses, such as watching TV or charging cellphones etc. However participants did also regard paraffin itself as quite expensive but still cheaper than other fuels such as electricity and LPG.

In all focus groups there was also general discussion around the fact that different fuels were better suited to cooking different meals types. For example electricity is seen to be best for quick to prepare meals and paraffin is the best fuel for cooking longer and slow-cooking meals such as samp and beans, steamed bread or vetkoek. Exploring what lies behind this perception reveals a

multitude of different drivers. Firstly as discussed above there are issues with electrical appliances which probably feeds into and supports this reality. They noted that if you cook steamed bread on electricity it would come out doughy and under-cooked. Secondly however with the dominant belief that paraffin is the cheapest fuel to cook with, it makes sense to people that it is cheaper to cook meals with longer preparation times with a cheaper fuel. Participants regarded that they could save on electricity expenses by cooking such meals on paraffin. However participants noted that even if they had enough money for electricity they would still choose to cook slower cooking meals with paraffin because of electricity's inability to cook these meals. This perception that paraffin and electricity are better suited to different meal types now appears to be entrenched as 'cultural myth'.

Another advantage of using paraffin for cooking that was commonly mentioned by participants was the space heating co-benefit. Using a paraffin stove or heater for cooking meant that the whole house gets heated which neither electricity nor LPG appliances do. This saves on heating costs for the household energy budget and is seen by participants as an important benefit, especially in winter. Preparing meals such as steamed bread are often timed for early evening rather than during the day as that is when they want the house to be warmed. Many participants viewed paraffin as the only viable space heating option from a cost perspective, emphatically stating that electricity and LPG were both too expensive. The only other option they tended to see was an imbaula, although these were generally disliked for the purposes of indoor heating.

Participants in all the focus groups noted that there were sometimes issues with intermittency in the supply of paraffin. Site C participants said often there might be periods of 2 to 3 days when they couldn't get paraffin. They noted that it would generally still be available from a supermarket or petrol station but note that (depending on the area) these shops are often far to go and would incur travel costs. Participants in the Kuyasa focus group noted that there had been a 2 week period during which they hadn't been able to get any paraffin and that they had 'really struggled' during this time. Participants in all of the focus groups also recorded that paraffin is generally not available in South African spaza shops, but only in Somalian owned spaza shops. Interestingly one participant in the Imizamo Yethu focus group used to sell paraffin but has since stopped because of the difficulty of getting paraffin. He complained that distributors are Muslim and would sell only to other Muslims shop owners rather than to South Africans such as himself. Whether this is an individual experience is indicative of the general situation cannot be determined without further research into the situation but is interesting to note in relation to the general statement that most people made about it generally only being available in Somalian owned stores.

When questioned about the disadvantages of using paraffin participants had many complaints. Principally people complained about physical symptoms such as respiratory issues, sore throat, sore or itchy eyes, headaches and the fact that using it exacerbated asthma etc. One woman in the Imizamo Yethu focus group noted that if a child had respiratory issues and was taken to a clinic, one of the first questions they would be asked by the doctor was whether they were using paraffin to cook with. Participants also said they did not like the smell of paraffin, that it lingered in their houses and on their clothes and noted for example that if they got on a taxi everyone else would be able to smell it on them. Participants in the Kuyasa focus group noted that the paraffin they buy from spaza shops tends to be 'dirty', generally a pink or yellow colour. They noted that they can only get clean and clear paraffin from shops such as Shoprite which comes in its own container but they said this was more expensive.

During each of the focus groups, the issue of appliances and the risks and safety issues were discussed. In each focus group no one had ever seen or heard of the safe legal pressure stoves nor were they aware that the ubiquitous flame stoves were in fact illegal. The only stoves participants had ever seen available shops were the illegal flame stoves. They were all however well aware of the safety risks associated with these stoves and expressed great interest in trying out these safer legal stoves now that they knew about them. All the participants spoke about the tendency of the flame stoves to explode and had either experienced it themselves or from a friend or neighbour. A participant in Kuyasa noted that her previous shack had burnt down from a fire started by one of these stoves exploding in a neighbour's shack. Participants had many complaints about these stoves, principally about them exploding but also that they are difficult to put out, they frequently break and do not last long and were poor value for money. When these stoves break most

participants in Imizamo Yethu reported that they tend to fix them themselves rather than buying a new one. They said they replace their stoves about once a year. Only those Site C participants without any access to electricity reported used paraffin for lighting. They said they generally don't have much trouble with the paraffin lamps and they note that they only smoke when the glass breaks.

Interestingly the illegal flame stoves were only used by participants from the Imizamo Yethu focus group. In the two Khayelitsha focus group, participants had switched to using paraffin heaters instead to cook with. People reportedly remove the top enamel plate of the heater when they want to cook and replace it again when using it as a heater. These focus group participants were vocal and vehement in their dislike of the illegal non-pressure stoves, referring to 'that useless thing' when the stoves were presented in the focus group sessions and all said they'd stopped using these stoves a long time ago. Their principal motivations for changing related to all the risk and value for money criticisms. There was significant appreciation expressed for the benefits of the heaters including their safety in use, ease of use as well as their reliability and durability. Imizamo Yethu participants did mention that they also used heaters sometimes but said they were more expensive to cook with. Although they didn't like the flame stoves they felt they were their only real option and there was a certain acceptance of the associated issues these stoves brought to their lives. The paraffin heaters apparently need 2 or 3 litres at a time in order to work and cannot run with just 1 litre which may relate to the affordability constraint of Imizamo Yethu participants.

Participants generally bought and stored paraffin in their own containers, often cooldrink bottles. Participants from Kuyasa however said they do not store paraffin in cooldrink bottles because they are worried about their children drinking it by mistake. Instead they use 5 litre bottles but noted these too had no warning labels or child safety features. They generally try and hide the paraffin bottles away from their children. They said they'd never had any incidents with burns or children drinking paraffin. A woman in the Imizamo Yethu focus group related a story of her one-year-old son accidentally drinking paraffin one day out of a coca-cola container. She noted that his breathing changed immediately. She reported that she gave him milk to drink.

In the Imizamo Yethu focus group all the participants had experienced accidents related to energy usage, if not to them directly then to friends or neighbours. Most recently there had been a shack fire in which 40 shacks had burned. They related an experience of a friend who had caught fire from an exploding stove and had died. Participants were concerned about the fact that none of them had fire safety knowledge and that no one in the community had been able to save the woman who died from the exploding paraffin stove. They were also concerned about the fact that there was so little information available to them about which stoves to use. In all the focus groups participants raised the concern that there was a great need for programmes of awareness of safe stoves as well as safe energy practises in their communities. Some of the Imizamo Yethu participants remembered some energy safety programmes in their community, however neither of the Khayelitsha focus group participants reported having any exposure to energy safety programmes. One of the men in the Imizamo Yethu focus group noted that the burden of energy issues mainly falls on women who generally have more exposure to cooking and that safety programmes are generally targeted at them. He noted they are often during the week when those who work are not at home. He raised the point that many men live alone and thus cook for themselves and are the primary ones responsible for energy usage in their household. He felt that men also do not know how to use energy safely and often engage in risky behaviour. He cited the recent example of the township fire being caused by a drunk man coming home and leaving a candle burning. He felt it important that energy safety programmes needed to target both men and women.

Candles

Candles are commonly used as a backup fuel for lighting particularly during electricity blackouts. They were noted as being the simplest and cheapest form of lighting when there was no electricity. They were also easy to borrow at short notice from a neighbour. The participants generally disliked candles because of their fire risk. Differing attitudes to safety and risk amongst different people were demonstrated by the different discussions around candle usage. In Imizamo Yethu, participants noted that they were generally careless in their candle usage, often putting

them straight onto plastic or wooden table-tops. In the other two focus groups however, participants displayed a much more cautious attitude and greater appreciation for the fire risks that candles posed although they did not have specific knowledge of the appropriate and safe candle usage behaviour that was demonstrated by PASASA representatives during the focus groups. These participants either put candles into the top of beer bottles or on saucers.

LPG

LPG is definitely a less commonly used household fuel than either paraffin or electricity, although there was at least one person in each focus group who used this fuel. Most used it for cooking, although one person used it for heating as well. In general LPG appears to be used as a substitute for paraffin so that household fuel mix of these participants had shifted to using a combination of LPG and electricity rather than paraffin and electricity.

The focus group discussions revealed many fears of LPG particularly of the risk of cylinders exploding. For example one woman in Imizamo Yethu related that if she goes to visit her daughter who uses gas while she is busy cooking, she would prefer not to even go inside the house because she is so afraid. Even those who use it still appear mistrustful. Of the 3 participants in the Imizamo Yethu focus group who used LPG they noted that they prefer not to use it when children are around because of perceived safety risks. The fact that gas is invisible and cannot be easily measured or controlled probably contributes to the somewhat mysterious and riskiness of this fuel. Fears also appear to be correlated with a lack of exposure to, or familiarity with, this fuel. LPG is beyond the direct experience or frame of reference for most people and therefore their perceptions are predicated on commonly held misperceptions that are passed on between people relating to its safety. It appears that those who did use the fuel often had had some previous exposure to it, for example one woman in Site C who used LPG said she had had to use it at a previous work place and therefore was used to it.

In all areas, gas is generally the preferred cooking fuel choice for large social gatherings or events such as weddings or funerals. Generally gas stoves, cylinders and big pots are hired for the occasion. They noted that wood would have played this role in the Eastern Cape but in urban settings it is commonly gas. Paraffin is not seen as a viable option as the stoves are too small to accommodate the big pots they use.

When asked why they used gas many people were vague about their motivations, saying they could afford to or were used to it. Interestingly though one woman in Site C reported that she uses gas specifically because of the risks that paraffin poses. She had received a LPG stove some time ago in a switching programme[4], but had only transitioned to using gas after she had come home from work one day and found her child playing with the paraffin and which had spilled all over the child's clothes. She said her shack is too small for her to adequately hide the paraffin away from her child and after this incident had decided keeping paraffin in the house was too risky and decided to stop using it. She noted that she cannot use electricity for cooking as she is a backyard dweller and the primary household on the stand will not allow others to cook with electricity. She had therefore switched to LPG. She noted that she liked it because it was easy to detect if something was wrong (by the smell of the gas) and that the stove was self-igniting and she did not have to use matches, which she felt was a key safety feature and made her more comfortable in using it.

Noting her transition from paraffin to LPG is interesting. Some key factors that played a role appear in this transition away from paraffin include, firstly when the safety risks of paraffin became real and personal and no longer a 'potential'. Secondly she had had some exposure to gas (possibly from the switching programme or perhaps elsewhere as well) such that she did not have some of the commonly held fears of explosions, which keep many people from using this fuel. Thirdly she already had a 2 plate stove and did not have to invest in a new appliance, thus the barriers related to hassle or expense of switching were minimised.

[4] This is possibly the Eskom LPG switching programme.

Wood

Wood was used in all three areas that the focus groups were held in, although the context and usage thereof varied significantly. It is often collected from surrounding forested and fynbos areas. In Imizamo Yethu and Kuyasa participants noted that wood is used for cooking and heating, mostly using imbaulas. Imbaulas are devices used for the combustion of biomass, they are typically paint containers or half drum barrels that are punched full of holes and sometimes have a grate inside as well. They are typically used to burn wood or coal, although there was no coal usage reported amongst these participants. In Imizamo Yethu and Kuyasa there were strong associations of wood with poverty, only to be used as a last resort when people ran out of money. Kuyasa participants in particular were fairly disdainful of the idea of using wood, regarding it as something that is used in Eastern Cape and not in Cape Town, implying it was more in line with traditional lifestyles rather than their modernised lifestyles.

In contrast, participants in Site C regard the role of wood in their energy usage very differently and it does not appear to carry the same connotations of poverty. Imbaulas in Site C are frequently used for warmth in winter outside on the roadside in communal gatherings. Participants described the social etiquette involved whereby if someone is burning an imbaula in the evening, anyone is free to join as long as you contribute something to the gathering, for example a piece of wood for the fire. Participants' generally expressed great appreciation for imbaulas for their role in community and socialising as well as for the warmth they provide. This role of wood and imbaulas in daily socialising was not a feature of the energy habits of participants in other focus groups. In all focus groups however wood was noted for still retaining a particular role for social occasions for braaing, and for being suited to particular meals. For example wood is regarded as the best way to cook sheeps heads (or smileys as they are colloquially known). The head is put right into the fire to burn all the hair off, then scrubbed clean, cut into pieces and cooked slowly for a long time.

Kuyasa and Imizamo Yethu participants had a generally disdainful attitude of imbaulas and described them as being 'full of problems'. All participants in all focus groups noted that it was not good to bring imbaulas inside the house. Imizamo Yethu participants did report that occasionally they might bring imbaulas inside but only after they had burned outside for some time and had died right down. Although imbaulas were regarded as being good at heating the house quickly but generally was not a good idea. Participants reported that bringing imbaulas inside the house caused drowsiness, dizziness and headaches, and leaving it inside whilst you slept could kill you. Imizamo Yethu residents reported that some types of wood from the forest has chemicals that when inhaled can kill a person. They are also aware that one shouldn't use painted or tarred wood. Imbauals are also dislike because they blackens walls and ceilings and make houses 'dirty'. Interestingly in all three focus groups everyone reported noted that burning an imbaula inside the house attracted 'incukuthu' or bed bugs. Whether this is true or a cultural myth is not known. Bed bugs are apparently attracted to warmth and carbon dioxide, which is how they locate humans to feed on and perhaps wood smoke produces both of these elements and serves to attract these pests.

Perceptions about costs and affordability

This section briefly explores focus group participants experiences around costs of fuels and appliances and perceptions of affordability. It then discusses this in relation to research that has been done looking at the relative costs of cooking with different fuels. Focus groups are not an appropriate way to gather quantitative information regarding consumption and spend of different fuel types, which itself is highly variable between households. Particularly in the context of multiple fuel use when different households may use varying amounts of 2 or 3 different fuels for one energy service such as cooking. Consumption and spend is very prone to memory bias. Direct observation, household questionnaires or energy diaries are a better way of recording this information. Focus groups are also not a representative sample of the population. When asked about consumption and spend of paraffin, participants themselves noted that it was variable and dependent on what it was being used for. Some used it for cooking some meals only whilst others used it for multiple energy services such as heating water for bathing, ironing, lamps or cooking. In Imizamo Yethu participants estimated that if they used paraffin for everything they'd use about 1 litre per day, but if they were using electricity as well for certain things 1 litre would last 2 or 3

days. In Site C those shack dwellers who used only paraffin (no electricity) said they would go through 5 litres of paraffin in 3 – 4 days. Others in site C who used electricity and paraffin said they used about 3 litres a week for cooking and heating.

In terms of the direct cost of fuel, it appears that participants often pay more for their energy than the regulated price. For paraffin most participants in Imizamo Yethu and Site C reported paying between R11 and R12 but noted that at some shops you could pay up to R13. In Kuyasa they noted they paid 'about R10', but said that when there had been a recent shortage in the availability of paraffin for nearly two weeks, after which retailers were selling it for nearly R16. The maximum retail price set by the Department of Energy in September is R10,88 per litre (and was R10,76 in May). From the experiences of these participants it would appear that they do not benefit from the regulated maximum paraffin price which is designed to protect poor consumers from markups in the supply chain. Prices are also subject to significant fluctuations in response to supply shortages.

In terms of electricity, there are several factors that combine to mean that the poor appear to pay significantly more for this service. Participants generally noted that spaza shops add a mark-up to the electricity they sell. Whilst they can get electricity from a shop or garage instead, they noted that often this might entail additional travel costs that would negate any price saving on electricity. For those shack dwellers buying electricity from neighbours, participants noted that the primary household inflates electricity prices, often quite significantly. Furthermore the collective consumption of several households on one prepaid meter would very likely push those households into a higher tariff bracket, meaning they pay more per kWh of electricity. The inclining-block-tariff structure is designed as a poverty measure to provide lower tariffs for households with lower consumption. Furthermore those households buying electricity from their neighbours do not benefit from FBE subsidies.

Appliance costs are often regarded as a constraint to transitioning to different energy sources in both the literature and amongst several stakeholders interviewed. Focus group participants were asked about the relative costs of different appliances and these were verified with costs in Shoprite and Kayagas (an LPG distributor in low-income settlements in Cape Town) to give an indication of typical appliance prices. These prices are approximate and presented for indicative purposes only, they have not been widely verified. In many instances difference in prices between appliances for different fuels are not that significant, and many people own paraffin heaters which is one of the more expensive options. Most participants also generally owned a range of appliances, in Imizamo Yethu for example most participants owned a paraffin stove, paraffin heater and a 2-plate electric stove. The comparability of prices of different appliances will obviously always play a role in purchasing decisions, however this factor did not emerge out of the focus group discussions as one of the principal factors, or the barriers to making fuel choices. In fact participants in both Site C and Kuyasa would choose to pay significantly more for a paraffin heater based on its safety and durability qualities. So for example the price difference between a legal and illegal version of the non-pressure stove does not seem play as much of a role as the availability and awareness of these appliances.

Typical appliance prices

Appliance	*Typical price*
Paraffin stove – illegal	R85 - R100
Paraffin stove – legal	R100
Paraffin heater	R400
Electric 2 plate stove	R100 – R150
Electric 2 plate stove with oven	R400 – R600
LPG 1 plate burner	R100
LPG 2 plate stove	R270

Source: Focus groups, Shoprite, Kayagas

Appendix C: Model background

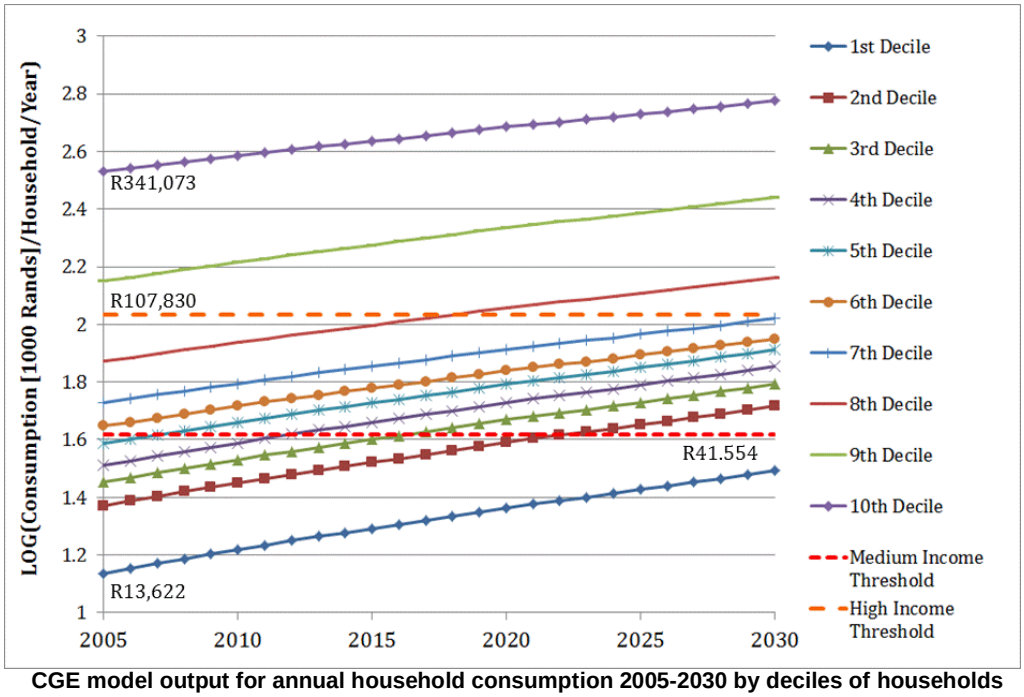
Computable general equilibrium (CGE) models have been used for policy analysis in many countries including South Africa. The premise of these models is to simulate the functioning of a market economy by modelling the interactions of producers across all sectors, households, government and the rest of the world through prices and capital flows. Their general application is to assess the impacts of a policy or project that affects the output or cost of one good or service on the economy as a whole, across all these sectors.

A CGE model for South Africa has been developed to study the economic implications of introducing carbon taxes in South Africa for the purpose of greenhouse gas emissions mitigation (Alton, et al., 2012). Our analysis used this CGE model to estimate the probable future evolution of household income in South Africa, for the 3 income groups used in the TIMES model given a moderate and stable GDP growth of 3.9% between 2010 and 2025.

The CGE base case required a number of assumptions regarding the future South African economy including, for instance the effects of technical changes, skilled labour supply growth, labour market rigidities and growth in public sector consumption which are described in detail in Alton, et al (2012). The authors however sum up the general outcomes of their base case as follows:

> Total labour employment grows at 2.6 per cent per year, implying an employment growth elasticity of 0.67 and a gradual decline in the national unemployment rate (given annual population growth of 1.5 per cent). GDP growth is fairly even across sectors as a result of uniform productivity growth and mobile labour. Overall, the baseline scenario provides a reasonable economic trajectory for South Africa.

As the CGE model presents results in 14 deciles it was necessary to map the results to the three groups required for the TIMES model. The figure below presents the income group growth projected by the CGE model from 2005 to 2030. Household consumption has been plotted on a log scale because the Rand value of the upper decile is so much higher than the bottom eight deciles. The two income thresholds used to split the population of households into the three groups we need are shown as dashed lines.



CGE model output for annual household consumption 2005-2030 by deciles of households
Author's calculations using data from Alton et al. (2012)

It is evident from Figure C.1 that by 2025 all but the lowest income decile of households will exceed our threshold for the Medium Income Group and that this decile will be on course to exceed it within the following decade. Likewise by 2030 the 7th and 8th household deciles will have transitioned to the high-income group. Little narrowing in relative wealth seems likely but wealth in absolute terms increases with vast numbers of people acquiring more buying power which has important implications for the energy use pattern of households.

Assumptions for costing calculation for low-income cooking

		Paraffin	***Electricity***	***LPGas***	***Wood***
Year	*WEO oil price*	*Paraffin wick*	*Spiral hot plate*	*Single burner*	*open fire*
Fuel Price (2012 Rands)	$/bbl	R/l	R/kWh	R/kg	R/kg
2012	100	10.9	0.85	22.8	0.25
2015	106.3	11.6	1.17	24.2	0.25
2020	118.1	12.8	1.50	26.9	0.25
2030	134.5	14.6	2.22	30.6	0.25
Conversion unit		GJ/l	GJ/kWh	GJ/kg	GJ/kg
Conversion		0.0353	0.0036	0.046	0.017
Fuel Price		R/GJ	R/GJ	R/GJ	R/GJ
2012		308	236	495	15
2015		328	326	526	15
2020		364	416	584	15
2030		415	615	665	15
		10	54	7	225
GJ/yr		4.34	2.34	3.62	45.84
Annualized Fuel Costs		R/yr	R/yr	R/yr	R/yr
2012		1,337	552	1,792	674
2015		1,421	762	1,905	674
2020		1,579	972	2,116	674
2030		1,798	1,439	2,410	674
Discount rate	30%				
Appliance cost		100	130	100	0
Appliance lifetime		5	5	5	1
Annualized cost of appliance		31.6	41.1	31.6	0.0
Total annualized cost		Paraffin	Electricity	LPGas	25c/kg wood
	2012	1,368	593	1,824	674
	2015	1,453	803	1,936	674
	2020	1,610	1,013	2,148	674
	2030	1,830	1,480	2,442	674

Base year calibration

Residential Subsectors	PJ	RESELC	RESOKE	RESCOA	RESBIW	RESOLP
Low Income Electrified	LE	27.76	4.18	5.96	28.87	0.34
Middle Income Electrified	ME	55.80	3.15	7.46	17.81	0.42
High Income Electrified	HE	75.36	0.71	0.80	0.89	0.48
Low Income Non-Electrified	LN	-	9.76	7.73	55.52	0.37
Middle Income Non-Electrified	MN	-	4.76	4.88	22.66	0.25
Total		**158.92**	**22.56**	**26.82**	**125.76**	**1.85**
End use demands	**Demand**					
Lighting	L	27.30	1.14	-	-	-
Cooking	K	26.86	8.58	5.50	84.88	1.06
Space Heating	H	18.28	5.33	21.32	16.27	0.16
Water Heating	W	54.17	6.43	-	24.61	0.63
Refrigeration	R	17.10	-	-	-	-
Other	O	15.21		-	-	-
Non Energy	N		1.08			

End-use Fractional Shares by Sub-sector	**Demand ID**	Electricity	Oil Paraffin	Coal	Biomass Wo	Oil LPG
Low Income Electrified						
Residential - Lighting - Low Income Electrified	RLEL	17%	-	-	-	-
Residential - Cooking - Low Income Electrified	RLEK	25%	36%	-	68%	47%
Residential - Space Heating - Low Income Electrified	RLEH	15%	27%	100%	13%	4%
Residential - Water Heating - Low Income Electrified	RLEW	29%	29%	-	19%	48%
Residential - Refrigeration - Low Income Electrified	RLER	10%	-	-	-	-
Residential - Other - Low Income Electrified	RLEO	4%	-	-	-	-
Residential - Non Energy - Low Income Electrified	RLEN	0%	9%	0%	0%	0%
Total		**100%**	**91%**	**100%**	**100%**	**100%**
Middle Income Electrified						
Residential - Lighting - Middle Income Electrified	RMEL	21%	-	-	-	-
Residential - Cooking - Middle Income Electrified	RMEK	19%	33%	-	68%	62%
Residential - Space Heating - Middle Income Electrified	RMEH	11%	37%	100%	13%	6%
Residential - Water Heating - Middle Income Electrified	RMEW	29%	20%	-	19%	31%
Residential - Refrigeration - Middle Income Electrified	RMER	11%	-	-	-	-
Residential - Other - Middle Income Electrified	RMEO	9%	-	-	-	-
Residential - Non Energy - Middle Income Electrified	RMEN	0%	10%	0%	0%	0%
Total		**100%**	**90%**	**100%**	**100%**	**100%**
High Income Electrified						
Residential - Lighting - High Income Electrified	RHEL	14%	-	-	-	-
Residential - Cooking - High Income Electrified	RHEK	12%	12%	-	19%	58%
Residential - Space Heating - High Income Electrified	RHEH	10%	52%	100%	36%	16%
Residential - Water Heating - High Income Electrified	RHEW	40%	6%	-	45%	25%
Residential - Refrigeration - High Income Electrified	RHER	11%	-	-	-	-
Residential - Other - High Income Electrified	RHEO	13%	-	-	-	-
Residential - Non Energy - High Income Electrified	RHEN	0%	29%	0%	0%	0%
Total		**100%**	**71%**	**100%**	**100%**	**100%**
Low Income Non-Electrified						
Residential - Lighting - Low Income Non-Electrified	RLNL	-	11%	-	-	-
Residential - Cooking - Low Income Non-Electrified	RLNK	-	39%	41%	68%	57%
Residential - Space Heating - Low Income Non-Electrified	RLNH	-	17%	59%	13%	5%
Residential - Water Heating - Low Income Non-Electrified	RLNW	-	32%	-	19%	38%
Residential - Refrigeration - Low Income Non-Electrified	RLNR	-	-	-	-	-
Residential - Other - Low Income Non-Electrified	RLNO	-	-	-	-	-
Residential - Non Energy - Low Income Non-Electrified	RLNN	0%	1%	0%	0%	0%
Total		**0%**	**99%**	**100%**	**100%**	**100%**
Middle Income Non-Electrified						
Residential - Lighting - Middle Income Non-Electrified	RMNL	-	2%	-	-	-
Residential - Cooking - Middle Income Non-Electrified	RMNK	-	46%	48%	68%	60%
Residential - Space Heating - Middle Income Non-Electrified	RMNH	-	21%	52%	13%	9%
Residential - Water Heating - Middle Income Non-Electrified	RMNW	-	30%	-	19%	32%
Residential - Refrigeration - Middle Income Non-Electrified	RMNR	-	-	-	-	-
Residential - Other - Middle Income Non-Electrified	RMNO	-	-	-	-	-
Residential - Non Energy - Middle Income Non-Electrified	RMNN	0%	1%	0%	0%	0%
Total		**0%**	**99%**	**100%**	**100%**	**100%**