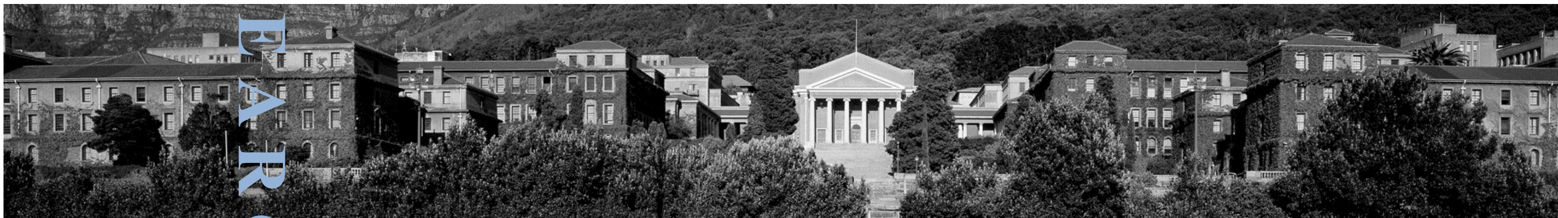
ERC

ENERGY RESEARCH CENTRE
University of Cape Town

RESEARCH REPORT SERIES



Evaluating the electrification programme in urban settlements in South Africa

Louise Tait

2015

Energy Research Centre
University of Cape Town
Private Bag X3
Rondebosch 7701
South Africa

Tel: +27 (0)21 650 2521
Fax: +27 (0)21 650 2830
Email: erc@erc.uct.ac.za
Website: www.erc.uct.ac.za

Contents

Executive summary

Since 1994 the South African democratic government has successfully implemented one of the largest electrification programmes in the world. Almost six million households, approximately 75% of the population, have been provided with access to the national grid (DoE, 2014). Yet despite the country's high level of technical electricity access, there are a growing number of concerns associated with both the sustainability of the programme and to what extent it meets the demand for energy services by poor households. This project undertook a process and a results-based evaluation to gain a comprehensive understanding of the implementation experience thus far.

Process evaluation

The process evaluation investigated four key aspects of the programme, based on UNDP's (2012) principles in an Energy Plus approach to energy access programme design. These included policy integration, institutional sustainability, financial sustainability and monitoring and evaluation. The integration of this programme into wider national and sub-national policy has been essential for its continuance, at scale, for the last 20 years. It was a cornerstone of the democratic transition in South Africa, and thus benefited from strong political support that has helped to mainstream it into national and sub-national policy agendas. The programme is predominantly state-subsidised and has benefited from long-term and sustained public financial commitments. This has been made possible by two key factors: firstly, strong political will; secondly, the necessary revenue base. But the financial sustainability is declining, hampered by rising programme costs, unsound municipal funding models, and large backlogs in maintenance spending. Approximately a third of municipal distributors face financial difficulties and many face high levels of indebtedness. The electricity distribution industry is in a crisis. With over 180 distributors, it is highly fragmented. Many municipal distributors face severe capacity and funding constraints and such a fragmented industry does enable economies of scale, efficiency or standardisation, and inhibits performance oversight of the industry as a whole. One of the greatest challenges facing the electricity distribution industry to date has been a lack of spending on maintenance and refurbishment. This negatively impacts system performance and compromises energy access by increasing the rate of outages that customers receive. There is inadequate monitoring and evaluation being undertaken. Without key monitoring and evaluation systems in place it is not possible to illustrate progress, understand whether outcomes are being achieved, or to evaluate the effectiveness of public spending.

Although the electrification programme has an extensive policy framework in place, many financial and institutional aspects of the programme are increasingly threatening its sustainability. Although it was a cornerstone of the democratic transition, over time this picture has changed, administration and governance of the programme have shifted, funding sources have changed, and the operating environment has increased in complexity. However the political paradigm favouring grid electrification as well as the current approach to planning and implementation is entrenched in institutional structures. The challenge for the programme is to embrace further reform to enable universal access goals.

Outcomes evaluation of household energy access

The second part of this project aimed to understand the results of the electrification programme to date. This study interrogated the outcomes, or whether the supply of electricity connections and subsidies (outputs) was indeed enabling access to modern energy services such as lighting or cooking. A multi-dimensional approach to measuring energy access was developed. The indicators developed were based on the conceptualisation of a modern energy service as one that is safe, affordable, reliable, adequate and environmentally benign (UNDP, 2000). These are as follows:

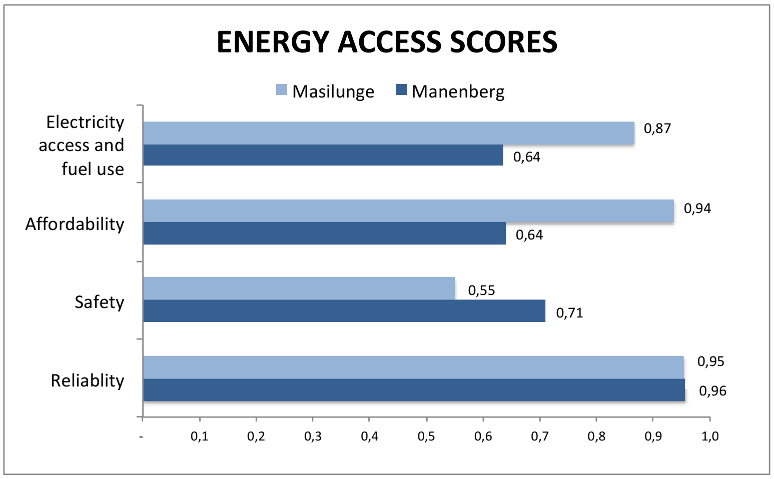
Electricity access and fuel use: Measures the type electricity access and other fuels used concurrently, classifying these based on their suitability in the South African context as either desired 'safe fuels' like LPG or solar, or 'unsafe fuels' such as paraffin or wood.

Affordability: Measures the ratio of monthly expenditure on energy to household income.

Safety: Measures the incidence of various physical, behavioural and environmental risk factors that could influence the likelihood of energy health or safety hazards.

Reliability: Measures the extent of service interruptions due to higher voltage incidencts, as measured by the municipal electricity distributor.

Household surveys were undertaken to collect a range of qualitative and quantitative information on the various aspects of energy access shown in the figure below. The figure below presents a range of indicators measuring each dimension of energy access in the two household samples. A higher score indicates a better state of 'access' in respect of that particular dimension.



Energy access indicators

The usefulness of developing indicators is to summarise a diverse range of information about complex issues in a concise and accessible manner. Developing a more holistic state of energy access enables a more nuanced discussion around the targeting and prioritisation of different energy-related interventions. The two household samples, whilst both low-income, illustrate significant diversity in the type and severity of issues they experience. The results suggest there might be different priorities in interventions in each area, for example around safety awareness in Masilunge or affordability and better targeting of subsidies in Manenberg. This study supports the view that policy interventions should focus on all energy carriers and multiple objectives related to energy. Electricity supply has dominated the household energy agenda. The current policy challenge is to integrate household *electricity* access into a broader household *energy* access policymaking agenda. It also suggests that the mechanisms used to target the poor for electricity subsidies could be reviewed, particularly in light of continuing price rises. The differences in electricity consumption amounts and affordability between the two areas surveyed reinforce that there are limitations to setting blanket consumption thresholds to target poor households. Energy health and safety has long been a neglected aspect of household energy. The results from this small study suggest a range of risk factors are present in poor households, and require targeted programmes and interventions to address these. The available data suggests that reliability in both areas is good. Measuring and assessing reliability of electricity supply is, however, challenging due to both data limitations and a lack of consensus on assessment and benchmarking methods.

1. Introduction

Since 1994 the South African democratic government has successfully implemented one of the largest electrification programmes in the world. Almost six million households, approximately 75% of the population, now have access to the national grid (DoE, 2014 Yet despite the country's high level of technical electricity access, there are a growing number of concerns associated with both the sustainability of the programme and to what extent it meets the demand for energy services from poor households. South Africa has adopted a typical big-infrastructure, supply-oriented and single technology approach to energy access. The electrification programme has, for various political reasons, crowded out other energy access considerations. These include the supply of other fuels, like paraffin and biomass, but also aspects like energy safety and the quality and reliability of energy services. Despite tremendous successes in initial phases of the electrification programme, delivery rates have been declining over recent years. Two thirds of the remaining backlog is concentrated in remote rural areas, which are more difficult and expensive to electrify. The rate of new household connections is not keeping pace with household growth, calling into question the feasibility of achieving universal access. Many of the financial, institutional and operating conditions under which the programme started have changed, raising questions about the future policy orientation toward household energy.

This project explores the current experience and challenges of the electrification programme. It falls under GNESD's Energy Plus research theme. An Energy Plus programme design advocates that energy access programmes go beyond a 'minimalist' service delivery approach, and adopt broader delivery mechanisms that aim to also improve wider socio-economic outcomes (UNDP, 2011). The project used a programme evaluation methodology and conducted both a process evaluation and a results-based evaluation of the electrification programme.

The process evaluation investigated the efficacy of the programme's design and its implementation activities in terms of policy integration, institutional sustainability, financial sustainability and monitoring and evaluation. The choice of these criteria was based on UNDP's (2011) report *Towards an Energy Plus approach for the poor*. The results-based evaluation investigated the outcomes of the programme in terms of modern energy access at the household level. Results based evaluations can be directed at either a programme's outputs, outcomes or impacts. Although the original motivation for this study was to better understand the impact on the human developmental impacts, we make the case that an interrogation of programme outputs and outcomes (access to modern energy services) is a more useful way to interrogate programme effectiveness. Household surveys of two communities in Cape Town were undertaken to interrogate the levels of modern energy access.

The remainder of this report is structured as follows: section two presents the process evaluation focussing on key Energy Plus components. Section three discusses the results evaluation and presents a framework to measure household energy access. Section four presents the results of the household surveys in terms of each dimension of access. Section five concludes and summarises the recommendations going forward.

2. Process evaluation using an Energy Plus framework

South Africa's electrification programme is at an interesting stage of its development to reflect on the progress made thus far. It is at an advanced market stage, having electrified 6 million households over 20 years. It has been highly successful by many accounts (Bekker et al, 2008), and yet it concurrently also faces many challenges. This section explores the implementation experience to date, including the resources and processes through which delivery is targeted. This is a desktop study and makes use of existing information sources to interrogate each of these components of South Africa's electrification programme. The study departs from the traditional 'logic model' approach to process evaluations and instead used the Energy Plus criteria on good programme design to structure the analysis of the implementation process. Four key aspects of the South Africa's programme are interrogated here:

- the integration of the energy policy with broader development planning;
- financial sustainability;
- institutional sustainability; and
- monitoring and evaluation activities.

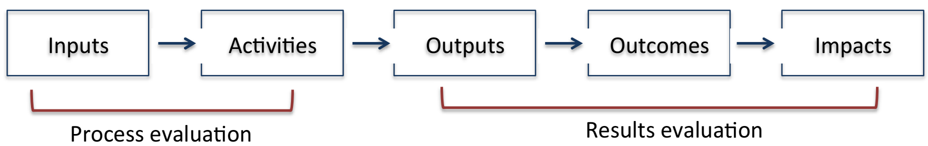


Figure 1: Programme evaluation model

2.1 Policy integration

In South Africa the grid electrification programme is a government-led and publicly financed programme. The integration of the programme into wider national and sub-national policy has been essential for its continuance, at scale, for the last 20 years. This in turn has been supported by strong political support for service delivery. The previous apartheid administration denied basic services to non-white citizens. Thus, when the constitution was reformed during the democratic transition, a proactive stance toward the delivery of socio-economic rights and basic services was adopted. The electrification programme is entrenched by constitutionally mandated requirements for the delivery of basic services (Dugard, 2008).

National objectives around universal access are supported in other national and sub-national planning processes and strategies. At the national level, for example, South Africa's National Development Plan makes explicit mention of universal access objectives. At a sub-national level, the electrification process is required to be situated within local municipal development planning processes, called Integrated Development Plans. These are comprehensive five-year development plans that municipalities undertake to assess the developmental needs of their citizens. Electricity reticulation and electrification are core functions of local government, and they must report on their performance in this regard. The programme is financed by the national fiscus. Financing is ensured by constitutional stipulations that a portion of nationally raised revenue be targeted at service delivery. As well as the core electrification programme, it is supported by various policy measures to support affordability by end users including the Free Basic Electricity (FBE) policy and inclining block tariffs.

As important as a facilitative policy framework is, it only provides the starting point, or the potentiality for effective implementation. Despite the strong policy framework, the planning and execution of electrification projects are not always undertaken in a sufficiently integrated manner. There is often a lack of joined-up planning with municipal development planning processes, and with housing departments around the planning and declaration of new settlements. In many municipalities there are supply areas governed by both the national utility, Eskom, and the municipal distributor. There are instances of inadequate co-ordination that often create confusion regarding rollout plans and responsibilities (Deyer and von Holdt, 2008). Some of these challenges have been addressed in a new electrification roadmap implementation plan that aims to work from a common implementation plan. Another challenge is the disconnect between national objectives around how a policy like a consumption subsidy is intended to be rolled out, versus the reality of the challenges that municipalities face in doing so. The national Department of Energy has been criticised by stakeholders for its top-down approach lack of consultation in policy making (Kruger and Tait, 2015). Municipalities, as the implementers of policy, should play a key part in policy formulation. In addition, performance failures at local government pose a serious challenge in South Africa (National Treasury, 2009). High vacancy rates, limited skills and competency amongst officials are pervasive issues across the local government sector (Peters and van Nieuwenhuyzen, 2012). Poor and rural municipalities especially find it challenging to attract and retain skills, which directly impacts service delivery.

Whilst electrification is well integrated and mainstreamed within the national development landscape, it is also perceived to have dominated the household energy agenda (SEA, 2014; Matinga et al, 2014; Tait et al, 2013). Grid electrification is emphasised as a supply solution whilst alternative energy carriers such as biomass, paraffin or off-grid solar have received very limited policy attention. Various political and historic factors contribute to this situation. Services such as energy, water and sanitation have become a key feature of the democratic government's policy to redress past imbalances. Equality of access has become central in service delivery. Technologies such as electricity therefore represent much more than the direct services they provide. They have become symbolic of inclusivity in government policy and of the development aspirations of post-apartheid South Africa (Matinga et al, 2014, Tait et al, 2013). Energy options other than an electric grid connection are therefore often perceived to be inferior. Thus electricity is not integrated within a coherent household energy strategy, but rather as a stand-alone supply oriented solution. This is problematic firstly because electricity does not necessarily meet 100% of many households' energy service demands, as evidenced by ongoing multiple fuel use. Secondly not all households are legally entitled to an electricity connection (for example those in informally settled areas) or are economically viable to connect (for example rural households). The programme faces serious delivery constraints in both these area types (Bekker et al, 2008; Tait and Winkler 2013). Many of these constraints are outside of the scope of energy policy directly. In the case of urban informal areas, constraints relate to urban planning frameworks and restrictions on land use and settlement policies. The electrification programme is based on the foundational assumption that grid electrification, as a supply option, will be suitable for all contexts. This is not, however, the case. The current policy challenge therefore is to integrate household *electricity* access into a broader household *energy* access policymaking agenda (SEA, 2014). Given the political priorities on grid electricity, however, the current situation appears unlikely to significantly change without substantive lobbying by external stakeholders (Tait et al, 2013).

2.2 Institutional sustainability

Institutional sustainability underpins all aspects of the programme and its delivery. The concept refer to the norms, values and regulations that guide and constrain the behaviour of individuals and organisations in a society. Institutions therefore incorporate a range of levels including individuals, organisations and the overall system and its governance. In South Africa, a wide range of institutional entities are involved in the process. National government is responsible for formulating policy and funding, the National Electricity Regulator oversees governance, whilst municipalities and the national utility are responsible for implementation and rollout. There are many organisations, policies and regulations involved. The municipal electrification programme, which accounts for about 25% of the remaining backlog, faces particular institutional challenges and this section will explore these in particular.

There are a huge number of electricity distributors in South Africa acting as implementers of new electrification projects. Approximately 180 of the 278 municipalities in the country distribute electricity (Eberhard, 2013). Whilst this has arguably been a strength of the programme by involving local institutions more integrated within each local context, it has also created a highly fragmented industry. Municipalities are granted a high degree of autonomy in the governing of their municipal functions, such as electricity reticulation. This has led to a significant degree of variation in approaches to planning, financing, tariff-setting and allocation of subsidies. Furthermore, municipalities themselves vary widely in size, financial sustainability and organisational capacity. Such a fragmented industry does not take advantage of economies of scale, results in a lack of standardisation, contributes to inefficiencies, and inhibits performance oversight of the industry as a whole.

Certain municipalities experience severe organisational capacity constraints and routinely underspend budgets and under-perform on their electrification targets (DoE, 2014). Some of the challenges they face include human resource constraints with limited technical, administrative and project management skills and high vacancy rates. This leads to poor planning and implementation. The procurement systems of municipalities are often slow due to organisational capacity constraints, with the result that they cannot expedite projects within the timeframes required by national stipulations in order to not lose that year's funding allocation (DoE, 2014). The organisational structure of municipalities is often a hindrance, with financial and operational aspects of electrification undertaken by two different departments. Inadequate interaction between the two reportedly affects efficacy of new projects (Deyer and von Holdt, 2008). Municipalities also face external threats such as electricity theft and copper cable theft. South Africa has a thriving black market for copper that causes substantial losses to the electricity industry: it not only affects service reliability, but it also diverts budget away from other aspects of maintenance (Deyer and von Holdt, 2008).

There is also inadequate national oversight and governance of the electricity distribution industry. Weak capacity in the national regulator means they do not adequately enforce all the licence conditions of distributors, exacerbating and prolonging the issues (EDI Holdings, n.d.). Monitoring of subsidy allocations and disbursements, reliability of supply performance and maintenance of assets is inadequate (Deyer and von Holdt, 2008; SEA, 2014). Governance of the distribution industry is complicated by the fact that it is undertaken by both the national regulator and municipal legislation.

One of the greatest challenges facing the electricity distribution industry to date has been a lack of spending on maintenance and refurbishment. This negatively impacts system performance and compromises energy access by increasing the rate of outages that customers experience. Whilst investment rates in maintenance should be in the region of 10% of asset value per year, in many municipalities it has averaged 2% a year (Deyer and von Holdt, 2008). This is attributed in part to a poor asset management culture and an overemphasis on shorter-term performance goals related to service delivery and number of connections (Deyer and von Holdt, 2008). Meeting these goals has therefore come at the detriment of longer-term infrastructure management goals, contributing to the massive backlogs in maintenance. Furthermore, the current approach used by government assumes that municipalities will generate sufficient revenue from their capital investments to cover maintenance requirements. However, in the current system of national government subsidising capital investments in new infrastructure, assets are sometimes created without corresponding increases in revenue streams for municipalities, because of the limited cost-recovery of electrification infrastructure for the poor (Financial and Fiscal Commission, 2013).

There have been attempts at institutional reform to enhance electrification access goals, rationalise the tariff system and improve the financial viability and performance of distributors. Moves such as restructuring the industry into six regional electricity distributors (REDs) to cover the whole country have not succeeded. Municipalities themselves have resisted, as such a reform would lose them a key revenue stream. Electricity sales are a major source of revenue for municipalities and often cross-subsidise other municipal functions such as water and sanitation. The proposed reform would therefore have required concomitant reforms in the entire public sector funding model. Electricity is so thoroughly integrated into the wider system of public administration, that any systemic change has become extremely challenging. Any change in roles and responsibilities regarding electricity distribution (and thereby electrification access projects) would require a constitutional amendment. There is, in effect, institutional lock-in to the current delivery model. So. despite the massive challenges and declining performance rates that the programme is facing, reforms have proved difficult.

2.3 Financial sustainability

2.3.1 Funding models

The existing electrification programme is predominantly state-subsidised and has benefited from long-term and sustained public financial commitments. This financial support has been made possible by two key factors: first, strong political will; secondly, the necessary revenue base. The programme was initially financed by the utility, but since 2001 funding has come from national budget allocations. These are dispersed to the utility and municipalities who then implement projects (Bekker et al, 2008). This funding contributes towards new connections, maintaining infrastructure and subsidising consumption to improve affordability. But distributors are also expected to augment this, either through cross-subsidisation of tariffs from industrial and higher income electricity users, or via other revenue streams such as property rates and taxes.

Financial constraints are becoming an increasing restriction on programme delivery rates. The average cost per connection has risen steeply over time, and is a major factor influencing financial sustainability. These costs have been driven by rising labour and copper costs, but also the higher costs of connecting rural households (where the bulk of the backlog remains). Rural areas incur higher transport costs and require greater investments into bulk infrastructure to strengthen and extend networks and transformers. Inefficient and slow procurement processes in municipalities, due to organisational capacity and skills constraints (Peters and van Nieuwenhuyzen, 2012), also raise costs unnecessarily.

Municipal financial models for their electrification programmes are a big area of concern. Approximately a third of municipal distributors face financial difficulties and high levels of indebtedness (EDI Holdings, n.d.). Financial insecurity is contributed to by cashflow problems caused by a declining revenue base, non-payment by households, illegal connections, aging infrastructure, incorrect billing due to meter-reading problems and high rates of interest charged by the utility. Tariffs are often not well designed and not cost-reflective (Deyer and von Holdt, 2008). The lack of investment into maintenance and refurbishment has led to a massive backlog, estimated at R35 billion in 2013 (Eberhard, 2013).

Cross-subsidisation and raising revenue from other sources to augment national contributions is feasible only when municipalities have sufficient numbers of high-income electricity consumers or a rates base to collect property taxes. Smaller and more rural municipalities are not always able to raise their own revenue through these means. Although this is taken into account in national funding disbursements (where less financially viable municipalities get more national funding) many have reported that disbursements for capital projects from national government are not reliable, nor sufficient (Deyer and von Holdt, 2008; SEA, 2014). Whilst political commitment to keep funding the programme is unlikely to wane, the question is whether it will be sufficient and whether municipalities facing significant financial constraints and challenges with their funding models can reform.

2.3.2 Targeting end-users for consumption subsidies

The South African government has acknowledged that poverty also acts as a barrier to access and proposes both direct and indirect consumption subsidies. As South Africa is facing steeply rising electricity prices for the next several years, the issue of subsidies and effective targeting thereof is even more important. Electricity tariffs in South Africa have been under-priced for many years, leading South Africa to have one of the lowest electricity prices worldwide (Newbery and Eberhard, 2008). As the sector moves towards cost-reflective pricing, electricity tariffs are rising substantially (Deloitte, 2012). Despite the policies, the rollout and implementation of these two mechanisms has been mixed, and the efficacy of these policies not established. The actual number of indigent households benefitting from FBE and inclining block tariffs is currently unknown. Government departments vary in their estimates of the percentage of qualifying poor households that actually receive FBE. These range from 30% to 70% (SEA, 2014). Implementation has been very uneven across municipalities. One contributing factor is that funding given to municipalities comes as part of an unconditional grant. This gives municipalities discretion over how it is spent, and depends on their own spending priorities. Furthermore, since the regulator does not enforce reporting on FBE, this serves as a weak enforcer of compliance.

The targeting methods to identify poor households are also a source of concern. A good targeting mechanism aims to reach all poor households whilst minimising leakage to non-poor households. Municipalities have discretion over the type of targeting mechanism used to allocate subsidies. Targeting measures could be based on consumption or property values, on means-testing of household income, based on geography or incorporated into property taxes. Many municipalities have adopted consumption-based mechanisms (DPLG, 2005) – allocating subsidies or lower tariffs to consumers that consume below a certain threshold of kWh per month. Electricity is an easily measurable service and therefore lends itself to this method. This method is also administratively easy to implement. In comparison, undertaking means-testing, or developing registers of all poor households in a municipal area, is very burdensome.

Consumption-based targeting has however drawn criticism for its mis-targeting and leakage. This approach is underpinned by an assumption that poor households are low consumers of electricity. In reality there are many instances where several households share a meter. This results in higher consumption levels and thus households falling into higher tariff brackets, and not being deemed eligible for FBE. High-income households are also often low consumers, especially where they are able to invest in energy efficiency technologies such as solar water heaters. This therefore further benefits those with the capital to invest in energy efficiency.

Of course, no targeting mechanism will be perfect and there will always be leakage. Whilst policymakers may be aware of the current shortcomings, the choice of targeting mechanism needs to weigh the efficacy of targeting beneficiaries with the administrative complexity and burden of the system. Systems like the indigent register have proved too onerous for many municipalities to administer (DPLG, 2005) and do not necessarily result in better allocation in the long run. Means-testing is seldom properly implemented despite widespread promotion (DPLG, 2005). The process is difficult to implement and the poorest and most vulnerable are often those least able to engage with the difficult administrative processes. But as electricity prices in South Africa will continue to rise substantially in the future (Eskom, 2012), a discussion around improving targeting mechanisms may be necessary.

2.4 Monitoring and evaluation

As described in previous sections, many licence conditions are not reported on to the national regulator. Aspects like FBE disbursements, reliability and IBT statistics are incomplete. At the local government level, there are often inadequate organisational systems to collect and process data (Peters and van Niewenhuyzen, 2012; Deyer and von Holdt, 2008). At the national level the energy regulator suffers from a lack of expertise and capacity as well as the political strength to enforce many of its functions (Newbery and Eberhard, 2008). The only aspect that gets reliably and consistently reported on is the rate of new household electrical connections. This single metric of electrification programme performance does not enable a more holistic interrogation of programme performance and outcomes. Whilst supply-side indices are both useful and necessary, there is broad acknowledgement of the need to augment them with an understanding of the energy services they provide and how these are used (Bhanot and Jha, 2012; Sovacool, 2011; Practical Action, 2013; Nussbaumer et al, 2011). Overall, South Africa places insufficient attention on many wider aspects of electricity access and household usage thereof. Without key monitoring and evaluation systems in place it is not possible to illustrate progress, understand whether outcomes are being achieved, or to evaluate the effectiveness of public spending.

The reliance on supply-side metrics feeds into a discourse in South Africa that is dominated by fuels and infrastructure, as opposed to *services*. The result is a somewhat mechanistic view of programme design that a set of outcomes will follow a given set of inputs (Matinga, 2011). In reality, a wide range of factors can constrain optimal energy usage at the user level despite having an electricity connection. The existence of an input, such as a subsidy, does not mean that an outcome such as affordability necessarily follows. Despite availability of cheap electricity in South Africa, households do not necessarily stop using other fuels. Such assumptions about linear causal mechanisms, however, dominate South African energy policy for poor households. There is a need to adopt a wider set of indicators to measure household energy access in a more holistic manner. The next sections of this report will develop and test a framework of indicators to measure household energy access in South Africa.

2.5 Conclusion

South Africa's approach to mainstreaming, financing and institutional set-up have served it well to make it one of the most extensive and successful access programmes around the world. But today there are challenges in each aspect of the electrification programme considered in the above discussion. Moving forward it is important for government strategy to acknowledge that electricity is not a panacea. It cannot be the only energy access solution that the country pursues. The programme needs to be situated within a coherent household energy strategy that considers multiple supply options and takes into consideration a more holistic paradigm of the demand for energy services. Within the existing programme, institutional and funding aspects need to be reconsidered. Monitoring and evaluation is essential to improve the performance of the programme. What gets reported on influences where policy attention is placed. Without appropriate data on programme performance as well as broader aspects of household energy it is difficult to reorientate political priorities. The second part of this report therefore focuses on developing a comprehensive set of indicators to better understand household energy usage and report on key aspects of energy usage that are relevant to policymakers going forward.

3. Results evaluation of energy access in an urban settlement

The three main elements in a programme theory model are:

- outputs – such as electrification meters and other physical infrastructure; subsidies;
- outcomes – the modern energy services households use such as lighting or cooking;
- impacts – the improved developmental impacts such as health or income generation.

A comprehensive results-based evaluation requires quantifying the rates of delivery, understanding the quality and level of services delivered at a user level, and then attributing their use to developmental outcomes. Whilst there is fairly good information on the outputs of the programme in terms of number of connections delivered and subsidies, there is much less information in South Africa on the outcomes and impacts. The merits and complexities of an outcomes and an impact evaluation are discussed below.

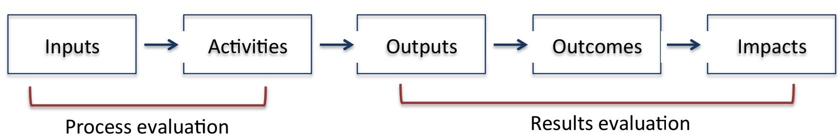


Figure 2: Programme theory mode

3.1 Complexities of measuring the development impacts of energy interventions

3.1.1 The relationship between energy and development

Energy is a means rather than an end in itself. What is of interest is less the service itself than the human development outcomes that are associated with its use. These can include improved maternal and child health, improved educational achievement, and enabling productive activities (GEA, 2012), etc. Each of these development impacts is, however, influenced by a far greater number of contextual factors than just the provision of energy. Poverty is a multi-dimensional concept and one which has many varying theoretical conceptualisations. Approaches to defining and measuring poverty include using basic needs, capabilities approaches or material deprivations (UNDP, 2006). There are also objective versus subjective measures and consideration of both individual and structural aspects (Du Toit, 2005). Poverty has proved both a contested and unstable concept, with its meaning and measurement changing over time. What we do know is that it is influenced by a wide array of deprivations and vulnerabilities, including income and employment, basic needs, material lack, political freedom, powerlessness and working conditions (UNDP, 2006). To try to understand poverty alleviation requires understanding how all these multiple aspects interact and come together to produce the experience of what we call poverty (Du Toit, 2005). Focussing on one aspect, like employment or energy access, to the exclusion of others, can oversimplify what is a much more complex process. Modern energy services are a necessary but insufficient condition for development.

Programme theory evaluations typically follow a linear logic between measuring inputs which through a causal mechanism lead to outputs and impacts. Development is, however, a non-linear process. This can limit its suitability to projects, such as human service interventions, that involve complexity (Rogers, 2008; Iverson, 2003). As illustrated in the figure below, the focus of enquiry for an impact evaluation would be on understanding the arrow between outcomes and impacts in terms of causality and degree of impact. This simple linear model of flows ignores aspects of complexity in the programme intervention. This complexity occurs both in that there are multiple causal strands (or arrows) to consider; and secondly that the degree of impact may differ across different sites of intervention given different contextual factors and actors involved. Impacts in complex systems are emergent, with feedback loops and disproportionate effects. (Rogers, 2008)

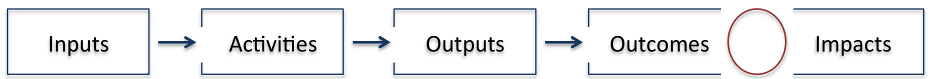


Figure 3: Causal mechanisms of interest in an impact evaluation

To measure attribution, an evaluator must control for other contextual factors that may also influence outcomes. But poverty alleviation involves a vast number of environmental and other factors that can influence impacts (Bazilian et al, 2010). To illustrate, an impact such as increased income-generating activities is influenced by a wide range of causal strands, or arrows, as illustrated in the diagram below. An impact evaluation has to measure and understand the impact of all of these in order to control for their influence on the variable of interest (income generating activities). Furthermore each causal strand may interact with others, leading to disproportionate effects; alternatively, the absence of one (e.g. structural interventions to enhance participation in the informal economy), may render many of the other interventions ineffectual.

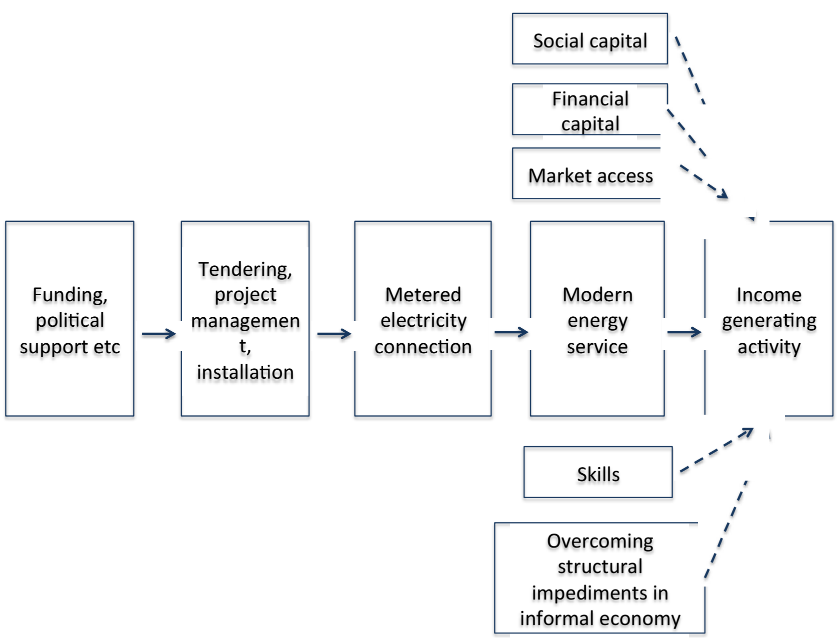


Figure 4: Illustration of multiple causal strands in development impacts

Attribution of impacts to outcomes is a complex, and often impossible, undertaking (Iverson, 2003). Not surprisingly, studies measuring impacts of energy interventions are limited (Pachauri and Spreng, 2011). Whilst the impacts of energy access are very important, they are highly data-intensive and costly to measure and monitor at scale. Further, to focus solely on one causal strand (energy) to understand the impact (income generation), can lead to misleading conclusions about the importance of this factor. As Rogers (2008:34) summarises: 'By leaving out the other factors that contribute to observed outcomes, including the implementation context, concurrent programmes and the characteristics of clients, simple logic models risk overstating the causal contribution of the intervention, and providing less useful information for replication.'

In this study we therefore chose to investigate programme outcomes as a more realistic and useful interrogation of the electrification programme, shown in Figure 5. There is often a tendency to conflate outputs and outcomes and it is assumed that supply of an electricity connection will result in modern energy access. Thus, many stakeholders assume that since 75% of households have access to an electricity connection, they can be considered as having modern energy access, when in reality this may not be the case. The existence of an input, such as a subsidy, does not mean that an outcome such as affordability necessarily follows. Nor does investment in infrastructure result in a reliable service. An unreliable service necessitates the on-going use of 'backup fuels' in households, such as candles, which are significant fire risks in poor settlements in South Africa. This has the risk of undermining the investment in services for the poor and compromising developmental impacts. Therefore, focusing on whether households are accessing modern energy services at the household level is very necessary to understand whether electrification is having the desired impacts and householders are using electricity for all their needs. The focus here is on understanding the attributes of energy services that are necessary to enable developmental impacts. By ensuring that energy services provided are affordable, reliable and of sufficient quality to users, one maximises the potential for developmental outcomes.

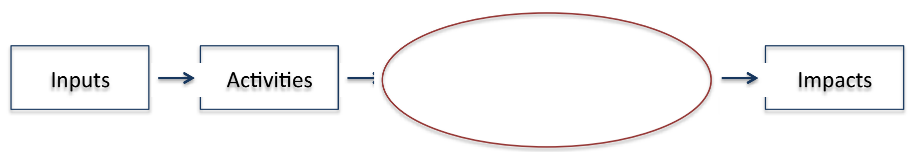


Figure 5: Programme theory model

3.2 Outcomes evaluation – developing a framework

3.2.1 Conceptualising and measuring energy access – a review of the literature

A review was undertaken of literature relating to defining and measuring access to modern energy services. This aimed to guide the development of a measurement framework for use in this study pertaining to South Africa. In order to develop appropriate measures or indicators, it is necessary to define a concept and its theoretical underpinning. Delineating what 'access to modern energy services' entails is a complex and contested matter. Various definitions, and their associated critiques, exist and yet a definitive and overarching definition remains outstanding (Serwaa Mensah et al, 2014; Bhanot and Jha, 2012; Bhattacharyya, 2012; Bazilian et al, 2010). In some ways the concept of energy access demonstrates many of the features of what Gallie (1956) first referred to as an 'essentially contested concept'. This term refers to situations where there may be widespread agreement about the existence of a concept but further definition or understanding of the concept is disputed. Some features Gallie (1956) used to describe these concepts are that they are internally complex in character, involve value-judgements, with different users of the concept often allocating different weightings and importance to the constituent elements of the concept, and they may be subject to modification in light of changing circumstances. The varying approaches to defining and measuring energy access reviewed below demonstrate many of these features.

The dominant approach to measuring energy access has typically been from the supply side. Most measure the penetration rates of 'modern' or commercial fuels or end-user technologies (Pachauri and Spreng, 2011). Some measure energy services by types of fuels used and appliance ownership. The multi-dimensional energy poverty index of Nussbaumer et al. (2011), for example, measures access to cooking, lighting and entertainment, etc. Supply indicators provide essential information in a simple way that enables comparability across regions or countries, and are easily communicable, but they are also limiting in what they convey. Supply indicators, whilst important, do not give information about the quality of services that users actually derive. They cannot, for example, illustrate where poor supply reliability may compromise the use of electricity services, nor where ongoing usage of biomass fuels may compromise the anticipated health benefits of electrification. In designing a holistic energy access policy, it is also useful to understand these various components that all play a significant role in how energy poverty is ameliorated (Pachauri and Spreng, 2011).

Understanding the extent of energy poverty includes understanding aspects such as consumption, affordability and service quality. Measuring these aspects and setting thresholds is, however, a lot more challenging. Defining consumption levels that meet basic needs is inherently complex and there is no definitive consensus on what energy consumption levels are required to meet them at a household level (Pachauri and Spreng, 2004; IEA; 2012). Any definition of basic needs necessarily involves a degree of subjectivity and value judgements (Pachauri, 2011; Bhanot and Jha, 2012).

The IEA (2012) has a definition of energy access that uses regional average electricity consumption as a benchmark to measure appropriate consumption levels. Another study by Barnes et al (2011) estimates an energy consumption poverty line based on surveys of existing demand profiles of households. Both approaches make assumptions that the regional average or existing demand represents an adequate amount of consumption. Practical Action (2010) adopted a somewhat related but different focus in defining minimum thresholds for energy services themselves. These specified desired indoor ambient temperatures, lumens of light required etc. Appropriate basic consumption levels, as well as desired service quality, will differ by region and context. They are also dynamic and likely to change over time as incomes and/or aspirations change (Bhattacharyya, 2012). These approaches are also more onerous in terms of the cost and practicality of measuring and collecting data. Data scarcity is one of the biggest constraints. Trade-offs exist in taking different approaches in terms of what information one would like to convey and practical considerations. This is often why supply-side data is relied upon, as it is generally easier to capture and monitor (Bazilian et al, 2010).

The UNDP (2000) put forward a definition that places the focus firmly on the energy service itself and the desired attributes it should encompass. These include safety, affordability, reliability, user adequateness and environmental considerations. This conceptualisation of modern energy services has found support among many authors and is reiterated in many studies (Bhanot and Jha, 2012; Pachauri, 2011, GEA, 2012; Sovacool, 2011, Bhattacharyya, 2012; ESMAP, 2014). There have not been many efforts to operationalise this definition into a set of measurable indicators. Recently, however, ESMAP (2014) developed a multi-tier approach to measuring energy access that utilised this definition. The study measured several dimensions of energy services including capacity, availability, reliability, quality, affordability, legality, convenience, and health and safety, for both electricity and cooking fuels. A household's state of access is reflected with a composite indicator calculated as the sum of individual scores of each dimension.

The definition has many advantages. It is multi-dimensional and brings into focus the various inter-related factors that influence 'access'. It is independent of fuel or technology, and so does not introduce specific technology biases, nor rule out specific energy carriers (e.g. biomass). Theoretically, almost any energy carrier could deliver a modern energy service (although perhaps to differing degrees along a continuum of 'modern'), provided that the *energy delivery* system is well regulated, and meets certain standards (Tait, 2013). The elements of an energy delivery system that require consideration may include how the energy carrier itself is distributed, appliances, financing etc. Thus various appliance and fuel combinations can deliver a modern energy service, but these combinations may differ in different country contexts. The ESMAP operationalisation of this definition has several benefits, including that it provides a multi-dimensional picture of access, scores for each dimension are measured on a continuum rather than binary, and it captures important aspects of the quality of service – an aspect of access that is absent in most metrics (Bazilian et al, 2010).

Much conceptual work has been done around measuring energy access. The varying approaches briefly reviewed here serve to reinforce the understanding of access as a multi-dimensional concept, which is not easily captured by viewing only dimension – be it physical supply or affordability. The review brought out some key aspects to consider in developing measurements indicators for this study. Firstly, that it communicates the multi-dimensional nature of energy access; secondly, that it represents a range of intermediate states of access rather than a binary picture of either having or not having access; thirdly, that there should be flexibility in considering various fuels and technologies, not introducing undue technology biases; fourthly, that the development of any measurement framework needs to consider the feasibility of data collection. As a result the definition of modern energy services as put forward by the UNDP (2000) and the approach to operationalisation by the ESMAP (2014) study is considered to be particularly useful for this research. This definition gives an insightful explanation of energy services, is comprehensive, and is amenable to operationalising through survey data. ESMAP's operationalisation included the following dimensions for measurement: capacity, duration and availability, reliability, quality, affordability, legality, convenience, health and safety. The next section describes the proposed measurement framework for this study and the approach to operationalising each dimension into measurable indicators.

3.3 Developing a framework to measure outcomes: household energy access

3.3.1 Proposed measurement framework for energy access

Based on the review undertaken in section 3.2, this study adopted the UNDP's (2000) definition of a modern energy service, and applied these concepts at a household level to better describe the state of energy services that people have access to. Four dimensions – electricity access and fuel use, affordability, safety and reliability – will be used to guide the interrogation of the state of access to modern energy services among two case study settlements. This framework is shown in Figure 6, along with the proposed metrics to operationalise them into indicators.

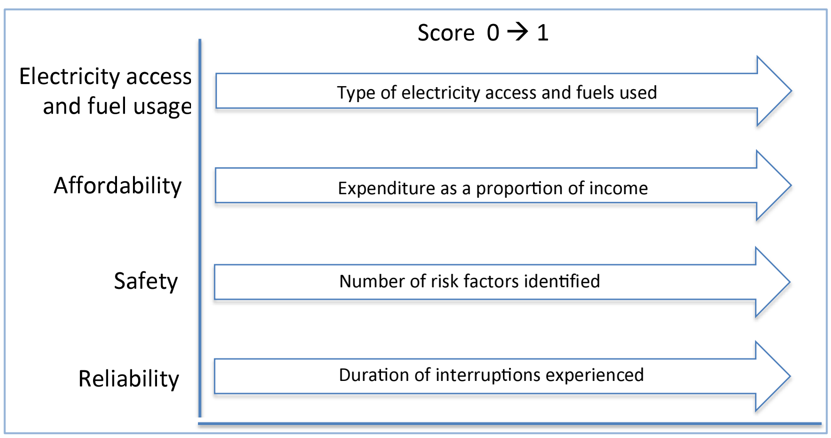


Figure 6: Multi-dimensional framework for measuring energy access

Indicators are used to bring meaning to and interpret statistics. Their aim is often to enable clarification and comparability, and to communicate particular issues or complex concepts simply and easily to a wide audience (Bazilian et al, 2010; Pachauri and Spreng, 2011). There are various types of indicators, including quantitative or qualitative; single metrics, 'dashboards' of indicators, or composite indicators. The choice depends on the context in which they are to be used and the information they must convey. In this instance the indicators are meant to enable stakeholders in South Africa to engage more broadly with issues of energy in poor households.

Each dimension of the framework was operationalised into an indicator and given a score between zero and one, with zero indicating poor access and one representing good access. Each indicator was calculated individually using different methods, and then normalised to enable easy visualisation on a single graph. The indicators were not aggregated into a single score for several reasons. Firstly, aggregating involves a loss of information and an abstraction into a number that would, on its own, communicate very little information. Since one of the key underlying objectives of this process is to highlight the multi-dimensional nature of 'energy access' this was not considered useful. Furthermore, the indicators aim to be simple and accessible to stakeholders viewing them, and avoid undue complexity where possible. The description of each dimension and the method of calculation is described further in section 5.

3.3.2 Household survey and data collection

The two study areas selected were located in Manenberg and Gugulethu within the City of Cape Town municipality. They were chosen based on various criteria requiring areas that:

- are located within the City of Cape Town's electricity supply area;[1]
- have been electrified for a fairly long period of time; and
- include both formal and informal housing.

The Manenberg settlement, established in the 1960s, is a mixture of formal semi-detached housing, flats and informal backyard shacks. Many of the formal houses are rental stock owned by the municipality. The South African census, undertaken in 2011, recorded 1 163 informal dwellings in Manenberg, representing about 11% of all households in the area (Statistics South Africa, 2011). The backyard shacks are not electrified and typically share electricity meters with the main property they are on. Masilunge is a small settlement in Gugulethu with approximately 100 informal households living on land surrounded by formal houses. The settlement was electrified in 2009. Both areas are poor, with low levels of income and high reliance on governmental social grants and services. Unemployment rates in 2011 were 41–47% in Manenberg and 40–51% in Gugulethu, depending on whether the narrow or broader definitions[2] of unemployment are adopted (Statistics South Africa, 2011).

A total of 227 households were interviewed, 150 in Manenberg and 77 in Masilunge. Fieldworkers from the respective local communities were trained and paid to conduct the surveys. Separate questionnaires for metered and non-metered households were administered. The sample in Masilunge covered 77 of the 100-odd households. Those households not interviewed either declined to participate or fieldworkers were unable to contact them. The sample in Manenberg was originally intended to be a randomised sample of a discrete section of the settlement in and around several of the 'courts' or apartments of social housing. However, gang violence, a pervasive social problem in the area, continued throughout the surveying process and severely limited the ability of fieldworkers to move freely through the community, thus significantly compromising the survey. The Manenberg data therefore lacks the statistical underpinning to make broader representative statements for the whole of Manenberg, and can be regarded as illustrative of this sample only. However, since the objective of the collection of data is to support the development of the proposed indicators, the data collected is still considered useful for the purposes of this study.

4. Interrogating modern energy access at the household level – results from surveys

This section presents the findings from the surveys of the two settlements in Cape Town, describing each dimensions of energy access from a range of qualitative and quantitative findings.

4.1 Electricity access and fuel use

The City of Cape Town has a relatively high rate of household access to electricity. All formal households are reported to have a metered connection, with the backlog concentrated in informal areas.[3] The municipality is, however, constrained by legal and environmental factors which prohibit servicing of informal households. Backyard shacks, which comprise part of the household sample in Manenberg, are a grouping of informal households that are not eligible for services. Common to many developing countries, in the absence of formal market provision of electricity, various informal or illegal means of supply emerge (GEA, 2012; King et al, 2012).

---

1 The municipal area is divided into two supply areas – one operated by the national utility, Eskom, the other by the City of Cape Town municipality.

2 The narrow rate of unemployment excludes those members of the labour force that are not actively looking for work.

3 Informal areas that are not eligible for service delivery include those located on land not proclaimed for housing, backyard dwellers, under high voltage lines, in a road or rail reserve, flood-prone areas or flood plain, storm water retention, where there may be health or safety hazards such as on old landfills or on unstable land, or any households on private land.

Households connect illegally directly to the grid, or buy from neighbours, using extension cords. Thus most informal settlement dwellers have some level of access to electricity, although formal statistics in this regard are lacking. Informal and illegal electricity access can still be recognised as a valuable form of energy access. Although these connections present many concerns, from both a utility and a user perspective, they do address gaps and shortfalls in the formal market provision of electricity. From a household welfare point of view, an informal connection, even if used only for lighting, still provides a superior quality lighting service to either candles or paraffin – and also reduces exposure to their associated safety risks.

Nonetheless, this should not lead to ignoring concerns about informal and illegal connections. These connections introduce additional safety risks through overloading plug sockets and exposed wiring leads to increased risk of electric shock. The reliability of services available to both sellers and buyers is reduced through the associated overloading of circuits. Buying from neighbours also leaves informal households reliant on other households to control the availability and price of their service. There is anecdotal evidence of informal households being significantly overcharged for their electricity (Franks and Prasad, 2014). However since these transactions are informal and not recorded, a more general understanding of the extent to which households are burdened by overcharging is not known.

Figure 7 indicates the proportion of households in each sample with different types of electricity access, and where unsafe fuel use co-exists with grid access. Masilunge, a shack settlement, is fully electrified, except for a handful of households who either arrived after the area was electrified, or whose meter had broken and were awaiting a replacement. Manenberg, on the other hand, includes a mixture of formal households with backyard shacks, none of whom had a metered connection. Most of these share meters with nearby metered households. As mentioned, the proportion of metered and unmetered households in Figure 7 is not statistically representative of the wider area. Although shack dwellers comprised 50% of the survey sample, they comprise only 11% of the Manenberg population (Statistics South Africa, 2011).

The issue of multiple fuel usage is important. South African energy policy, with the primacy it accords grid electrification, has neglected the provision of safe energy delivery systems (for example, appliances) for other energy carriers (Tait, 2013; Matinga et al, 2014). In the South African context safe and modern energy delivery systems only exist for grid-connected electricity, LPG and potentially for solar electricity. Solar technology, however, is not widely used in urban areas and no respondents in the survey reported using it. Candles, wood, paraffin and coal all have negative implications associated with their use and do not provide a safe or modern energy service in the South African context (Matinga, 2011; Tait, 2013; Kimemia and Annegarn; 2011; Kimemia et al, 2014; Muller et al; 2003; Roux et al, 2009; Cowan, 2008). These have been classified as unsafe in the graph in Figure 7.

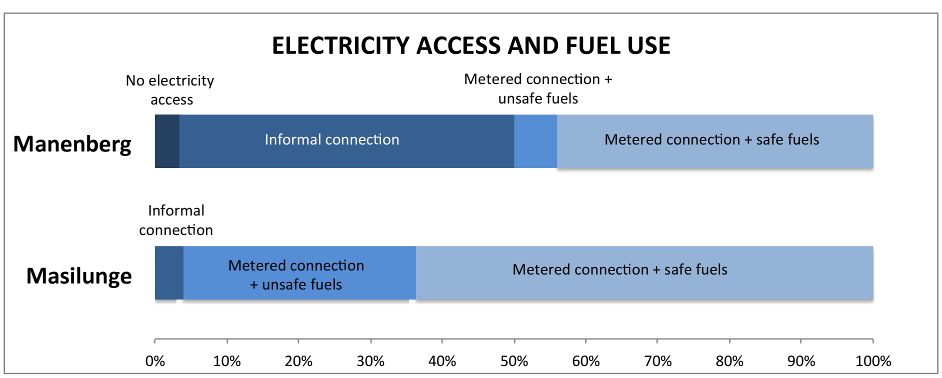


Figure 7: Electricity access and fuel use in surveyed households

As expected, given the high rate of electrification in Cape Town, electricity is the dominant energy carrier. Two thirds of the respondents in each area reported they were single fuel users of electricity only. Electricity is the primary fuel choice for most services in households even where there is multiple fuel use. Households with informal connections from neighbours also derived the majority of their energy services from electricity. Twenty seven percent of the households surveyed in Masilunge reported using paraffin as their primary heating option. The choice of supplementary fuels differed starkly in each area, with most multiple fuel users in the Manenberg sample choosing to use LPG, whilst most in Masilunge use paraffin.

The reasons households gave for using paraffin was that they were able to also heat water or sometimes cook whilst using their heaters. No household in either area recorded cooking with a paraffin stove. The most frequently cited reasons for using LPG were that it was fast and efficient, a useful backup when there was no electricity, and that it was preferred for cooking certain meal types. The prevailing barrier for households not using electricity all of the time, was that it is perceived to be relatively more expensive than other fuels. Alternative fuels were therefore used as a money-saving technique. However, various studies into the comparative prices of end-user services have found that electricity is cheaper than either paraffin or LPG – even with the electricity price rises to date (Tait, 2013; Cowan, 2008; Lloyd, 2010). This picture may, of course, change as electricity prices continue to increase, although all fuels are subject to price fluctuations so this picture is also influenced by oil price movements, for example. In the case of backyarders it is not possible to isolate what they are being charged for what level of services they derive. Therefore the cheapest fuel could be different if they are being overcharged for electricity.

As mentioned above, informal buying from neighbours probably has an overall positive impact on the welfare of these households. However, apart from the potential of being overcharged, it introduces some negative social dynamics. Backyarders lose their sense of autonomy over their own household services, and complex social arrangements often develop that are not always harmonious. When asked to describe their relationship with the main household, 10% of backyarders described it as very bad. A further 17% said it was generally good, but sometimes there were disagreements. The actual degree of discontent among backyarders may be higher, but the main householder was frequently present during the interviews, which probably compromised the reliability of these answers. Some of the issues that backyarders said they experienced were being threatened with eviction, frequent disagreements, and main householders pulling out their plugs and disconnecting their supply. Even those who said their relationship was good, also felt vulnerable; as one respondent commented: 'Fortunately they allow me to cook and heat water so my relationship is good. I don't know for how long'. From a government policy perspective, backyard shacks are regarded as informal and therefore not eligible for services such as water, sanitation and electricity. In national energy policy, the DoE acknowledges the negative impacts for backyard shacks and the main households who sell (DoE, 2012), but leave servicing decisions to local distribution utilities (Eskom and municipalities).

4.2 Affordability

Affordability is a much-cited component of energy access, but does not easily lend itself to objective measurement and verification. Whilst the concept is certainly related to variables such as income and the prices of the goods or services in question, it also includes an aspect of subjectivity. It is affected, for example, by personal priorities related to consumption patterns. Different preferences mean people have different thresholds of what they deem acceptable to spend on items. Matinga (2011) refers to affordability as a 'socially constructed' rather than an economic concept. Others contest whether the concept has any validity in economic theory at all (Niens et al, 2012).

Niens et al (2012:1) propose that affordability involves securing a good, service or a standard of living, at a price that 'does not impose, in the eyes of a third party … an unreasonable burden on household incomes'. Defining an 'unreasonable burden' requires making some judgement on an appropriate expenditure line. Two commonly used methods are the catastrophic payment method and the impoverishment method (Niens et al, 2012). The former calculates the ratio of the payment for the good to a household's total resources, the payment regarded as unaffordable when it exceeds a certain proportion. The latter determines what the residual income would be after paying for a good, and whether such payment would move a household below a poverty line. In the energy access literature, a commonly used expenditure burden is the former catastrophic payment method, and 10% of household income is often set as a reasonable energy expenditure (DoE, 2012; Bazilian et al, 2010). A survey of households in South Africa commissioned by the Department of Energy in 2012 estimated that 47% of households spend more than 10% of their expenditure on energy, and are thus deemed energy poor. Despite its common usage, there is often no accompanying justification for the calculation of this expenditure burden (Bazilian et al, 2010).

Illustrating affordability in purely financial terms provides a limited picture of the overall concept. However, such metrics do help to delineate a concept that, because of its subjectivity, makes comparison difficult. Expenditure burdens may also be misleading as to the actual welfare of households, as they say little about whether a household consuming an amount of energy deemed affordable (e.g. spending less than 10% of their income) is actually consuming enough to meet their needs. It does not elucidate whether the monetary (ZAR) value actually buys enough energy to adequately meet basic needs. Without undertaking more detailed econometric work analysing expenditure at different income levels, and impacts on residual income, which is outside the scope of this study, there is little to guide the setting of an appropriate affordability threshold in the South African context.

There has been various research into other aspects of economic welfare where objective measurements are compared with subjective assessments of the same concept. An example might be comparing income poverty lines with a self-assessment of whether people consider themselves poor or not (Posel and Rogan, 2013). Both objective and subjective measures can contribute to understanding complex concepts that involve a degree of subjectivity. Drawing on this approach, this study investigated both the expenditure/income ratio as well as a subjective self-assessment of energy affordability by householders themselves. Households were asked whether they felt they could afford their energy requirements all of the time, some of the time, or if they often felt they could not afford enough energy to meet their needs. This was then compared to income to expenditure ratios to get some insight into affordability thresholds.

Both objective and subjective assessments of affordability are presented in Figure 8. Those households that answered that they could afford their energy needs spent on average 10% of their income on energy. Those who answered 'sometimes' spent on average 18%, and those who answered 'no, they often couldn't afford enough energy' spent on average 20% of their income. If 10% is taken as the affordability threshold, then the internal consistency in the sample between the two measures was 60%. In other words, 60% of the sample either spent less than 10% and said they can afford their energy requirements, or spent more than 10% and said that they sometimes or often cannot afford electricity. If a 15% affordability threshold is tested, the internal consistency of answers drops from 60% to 53%. This gives some support to the setting of 10% as an expenditure burden for this sample.

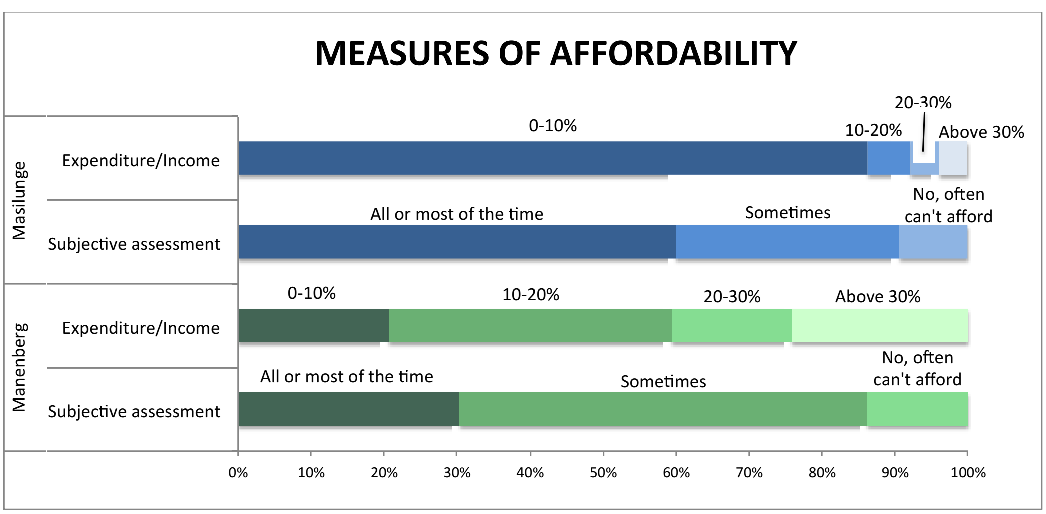


Figure 8: Measures of affordability

Both measures illustrate big differences in affordability between the two samples. A number of factors could affect this. Although average income levels in the two samples are fairly similar, there is a big difference in reported consumption and expenditure. Energy expenditure was three times higher in the Manenberg sample than in Masilunge, as seen in Table 1. Several factors may account for this. The average household size in Manenberg was five people, compared to 2.6 people in Masilunge. Overcrowding is a prominent social issue in Manenberg (CORC, 2010). Due to poverty constraints, children are unable to move out of home, and instead erect backyard shacks, or there may be extended families living under one roof (Leggett, 2004). Manenberg is a much older settlement than Masilunge, where families have lived for much longer. This may in part explain why overcrowding, from families expanding over generations, is more prominent in Manenberg than in Masilunge. The two areas also have differing housing stock. Masilunge, which is entirely shacks, often only one room, may have smaller physical house sizes, which may make them cheaper to heat. Another factor could be the presence of electric geysers in the municipality-owned rental stock in the Manenberg sample. These are very energy-intensive and could drive up consumption – but many Manenberg respondents did complain that they were too expensive and so hardly used them.

Table 1: Average monthly income and expenditure of the household samples

	Manenberg	*Masilunge*
Household income	R1 660	R1 800
Energy expenditure	R335	R110

As in all household surveys, there will be a degree of error in reported income and expenditure estimates due to recall bias (Yu, 2013). To examine the error in this sample, the electricity portion of reported energy expenditure was compared to prepaid meter purchasing data obtained from the municipality. What it revealed (see Table 2) is a tendency for the Manenberg sample to overestimate their electricity expenditure, whilst the Masilunge sample tended to underestimate their electricity expenditure.

Table 2: Comparison of average monthly electricity expenditures
Source: Household surveys and City of Cape Town

	Manenberg (electrified)	*Masilunge*
Households' own expenditure estimates	R350	R90
Municipal prepaid meter data	R300	R130

Figure 9 shows average monthly consumption in kWh per year for each sample. The meter data confirms the disparity in consumption levels between the two samples that was recorded in households' own estimates. In 2013, Masilunge households consumed approximately 150 kWh per month compared to 290 kWh in Manenberg households.

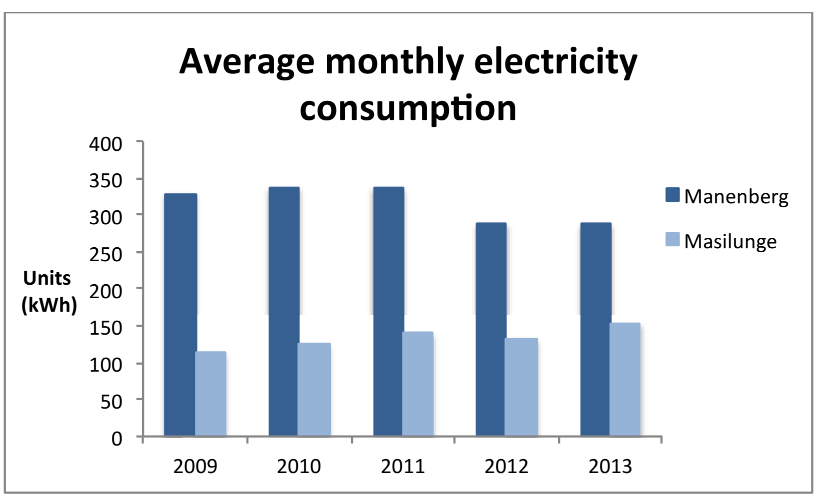


Figure 9: Average monthly electricity consumption
Source: City of Cape Town

Other variables that may influence energy bills, and are therefore of interest in understanding affordability, include the level of access to FBE subsidies, the use of energy-efficient appliances, and whether the cheapest fuels are being used. Access to FBE was higher in Masilunge households than in Manenberg, probably because of many Manenberg households not qualifying due to higher consumption levels. Prepaid purchasing data from the municipality shows 66% of households in Masilunge received FBE every month in 2013, and another 29% got it some of the time but not every month. In Manenberg 58% got it every month, and 20% received the subsidy some of the time. More than 90% of households reported in the survey that they use energy-saving light bulbs on some or all of their lights. Virtually all indicated that electricity was their primary fuel used for cooking – which is comparatively cheaper for cooking and heating than either LPG or paraffin. Whilst this is not an exhaustive exploration of cost minimisation practices, these results do indicate that most households are managing to minimise energy bills via some of the common measures available to them.

Electricity prices are a major variable in considerations of energy affordability. These have been steadily rising in South Africa since 2008. However, the inclining block tariff structure means that households in different consumption brackets have experienced different rates of increase over the last several years. Households in the Manenberg sample may have experienced higher price rises under the inclining block tariff structure due to their higher consumption. Since they consume more on average per month, they pay a higher per kWh rate. The demand response to rising electricity price rises in each sample has been quite different. Figure 10 shows Manenberg's total annual consumption in kWh has declined by 17% from 2010 to 2013, whilst Masilunge's has increased by 8%, although there was a slight decline in Masilunge between 2011 and 2012.

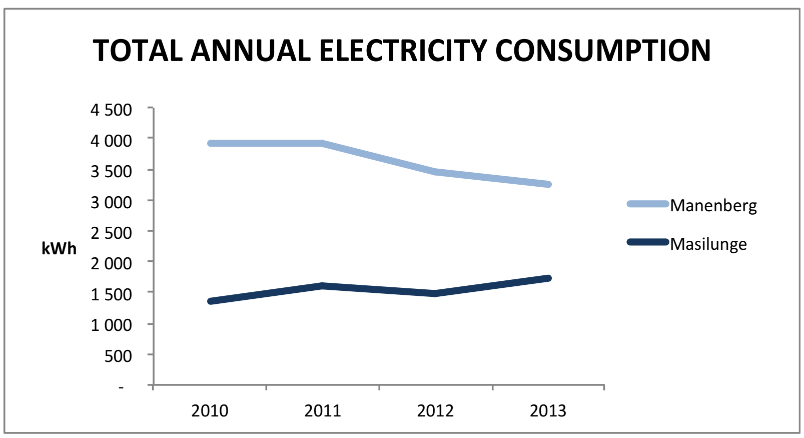


Figure 10: Annual electricity consumption of surveyed households
Source: City of Cape Town

To illustrate the degree of differences in price rises, Figure 11 compares the price paid per kWh for different monthly consumption levels over time. Comparing electricity price changes on a household's monthly bill is complicated by the fact that FBE allocation thresholds and the thresholds for the inclining block tariff change every year. Therefore the approach taken was to estimate the effective price paid per unit of electricity for a given monthly consumption amount (e.g. 100kWh), and calculate how this had changed over time. The monthly bill for a consumption amount was calculated and then divided by the number of units consumed. This takes FBE allocations into account by reducing the effective price paid per kWh shown in the graph if a household is eligible for FBE. All the prices are reflected in constant 2012 prices.

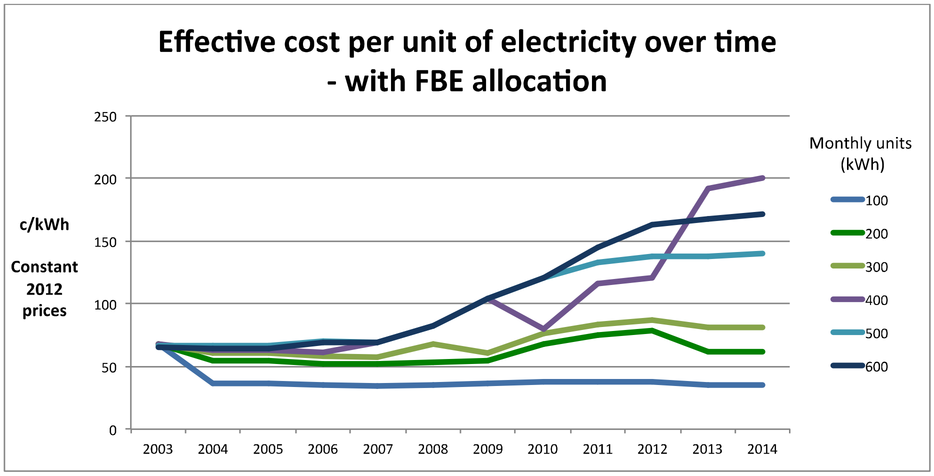


Figure 11: Comparative electricity prices for different consumption categories over time
Source: City of Cape Town and own calculations

Table 3: Total price increase per consumption bracket, 2003 – 2014
Source: City of Cape Town and own calculations

Monthly consumption bracket	*Total increase 2003 - 2014*
100 kWh	-6%
200 kWh	65%
300 kWh	116%
400 kWh	437%
500 kWh	281%
600 kWh	377%

As Figure 11 and Table 3 illustrate, the price of electricity for households consuming 100kWh per month has decreased in real terms over the last ten years. In comparison, households consuming 200kWh or 300kWh have experienced year-on-year increases from 2009 to 2012, after which prices declined in real terms again. Households consuming 400 kWh per month have experienced the sharpest increases. Average monthly consumption in the Manenberg sample (see Figure 9) has ranged between 280kWh and 330kWh between 2009 and 2013, whilst Masilunge households consumed a monthly average between 115 and 150 kWh over the same period. This suggests that Manenberg households have experienced higher price increases, and may explain their electricity demand reduction seen in Figure 10. This evidence does suggest that inclining block tariffs have been effective in protecting lower consumption brackets from price increases. But it also highlights the limitations of a consumption based targeting mechanism in reaching all poor households. Bigger household sizes and multiple households sharing meters excludes many poor households from subsidies and pricing protection mechanisms.

4.3 Safety

All types of energy can potentially present safety risks to users. Depending on the type of energy carrier, such risks could include respiratory and other health impacts from pollution, burns, fires, electric shocks and poisonings. An increased incidence of energy-related risks is often associated with poverty (Maritz et al, 2012; Rosenberg, 2013). The rate of deaths among children from burns, for example, is twice as high in developing countries as developed ones (Gevaart-Durkin et al, 2014). This section first describes the types of energy risks prevalent in South Africa among poor households, and then presents the findings from the household surveys on the prevalence of different risk factors.

Burns and fires are among the most significant energy-related hazards in South Africa, particularly in urban informal settings. Common risk factors contributing to these incidents in South African households include paraffin stoves, candles, alcoholism, and high abuse and assault rates. Their high incidence is also influenced by environmental factors such as housing materials and high-density living conditions which allow fires to spread more quickly and also makes it harder for fire trucks to gain access, as well as small homes with inadequate space for cooking away from children (Gevaart-Durkin et al, 2014; Maritz et al, 2012). Children between the ages of one and two years and young adult males are at particularly high risk of morbidity and mortality related to burns (Maritz et al, 2012; Gevaart-Durkin et al, 2014). This young adult male cohort may be at a higher risk due to alcohol abuse. Alcohol plays a big role in South Africa's burden of disease (Maritz et al, 2012). The temporal incidence of both fires and burn victims show peaks in the early hours of Saturday and Sunday mornings (Gevaart-Durkin et al, 2014), suggestive of a correlation with alcohol abuse. The other temporal peak for burns victims is in the mornings and evenings at typical meal preparation times.

Another major energy risk is the inhalation of toxins from the combustion of certain energy carriers. This includes not only biomass fuels, but also paraffin. Research on exposure patterns to pollutants from paraffin used for cooking in settlements in Durban, found that paraffin users experienced significant health risks from exposure to benzene and nitrogen dioxide (Muller et al, 2003). Accidental ingestions of paraffin by children are another major energy hazard (Balme et al, 2012; Gevaart-Durkin et al, 2014). Despite the declining usage of paraffin in South Africa's residential energy mix it remains the single most common substance in childhood poisonings in the country (Balme et al, 2012). Although not toxic in all cases, incorrect response by a parent or caregiver (for example giving milk to induce vomiting) significantly increases the risk of chemical pneumonitis and other complications by forcing paraffin into the lungs (Gevaart-Durkin et al, 2014).

Many risks can be mitigated with appropriate technologies, regulation or user education (Tait, 2013). The vulnerability of populations to energy risks is influenced by environmental, social, political and economic factors (Rosenberg, 2013). Assessing risk is both a function of the likelihood of an event occurring and the consequence thereof. In turn, consequences are influenced by both the impact of the event and the vulnerability of the population. A risk assessment quantifying these different aspects was not undertaken, due to the complex nature of such an assessment. Instead this study identified, through a household survey, various physical, behavioural and environmental factors that could influence the likelihood of energy health or safety hazards. Highlighting these risk factors can point to what types of interventions might best be targeted where. Five different categories of risk factors were identified that included factors that would either affect the probability of health or safety impacts, or a household's capacity to cope with an event such as a fire or burn.

- unsafe fuels – measured as users of wood, candles or paraffin;
- indoor air pollution – measured as paraffin use only, no respondents reported using wood indoors;
- lack of fire safety knowledge – measured as correct response to a paraffin fire, knowledge of correct response if clothes catch fire, and how to treat burns correctly;
- electrical safety risks – measured as overloading plug sockets and exposed electrical wires around the house;
- behavioural risks – measured as leaving children unattended, leaving cooking and heating appliances unattended, near flammable items.

There are, of course, limitations to using survey questionnaires to identify risk factors. Certain social and environmental risks, such as alcohol abuse, are difficult to capture this way. Figure 12 shows the proportion of households in each sampled area that scored in each risk category. The most prevalent type of risk was electricity-related. This is unsurprising given that electricity is the most commonly used energy carrier. The electrical risk category was the only one in which the Manenberg sample scored higher than Masilunge. The number of backyarders in the Manenberg sample sharing meters and using extension cords could influence this by introducing additional concerns around bare cables and overloading. There was no reported usage of paraffin stoves, which are a major fire risk. The only paraffin appliances in use in the samples were heaters and lamps. Sixty percent of the paraffin users interviewed indicated that using paraffin caused them discomfort, including asthma, headaches, nausea, and affects to their eyes. The evidence base of exposure to toxins from use of different paraffin appliances is currently limited, but the responses of households here suggests that there may be similar indoor air quality concerns with using heating appliances as have been measured with cooking appliances

(Muller et al, 2003). Figure 13 simply illustrates the proportion of households that scored in one or more of risk categories. Together, the graphs show that not only are most energy risk factors more prevalent in Masilunge households, but that Masilunge households typically displayed a greater number of risk categories than the Manenberg sample. Why the safety behaviour and awareness differs so starkly in the two areas is not clear from the survey responses.

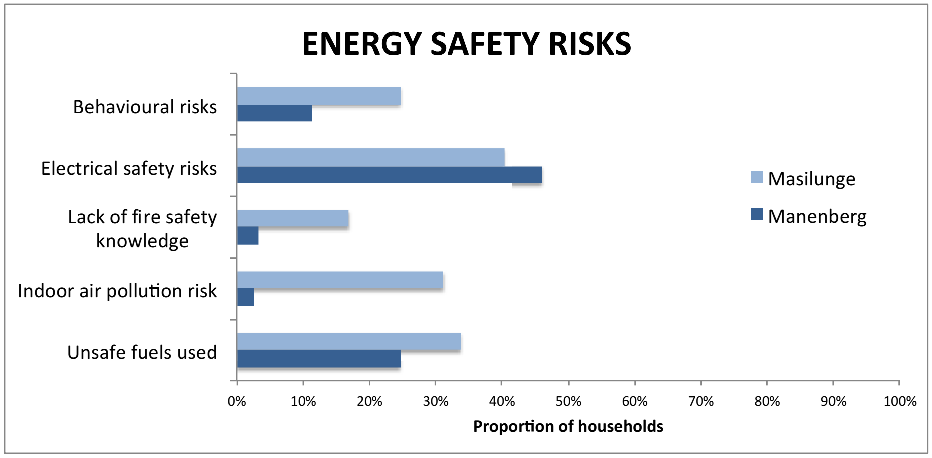


Figure 12: Proportion of households with various energy safety risks

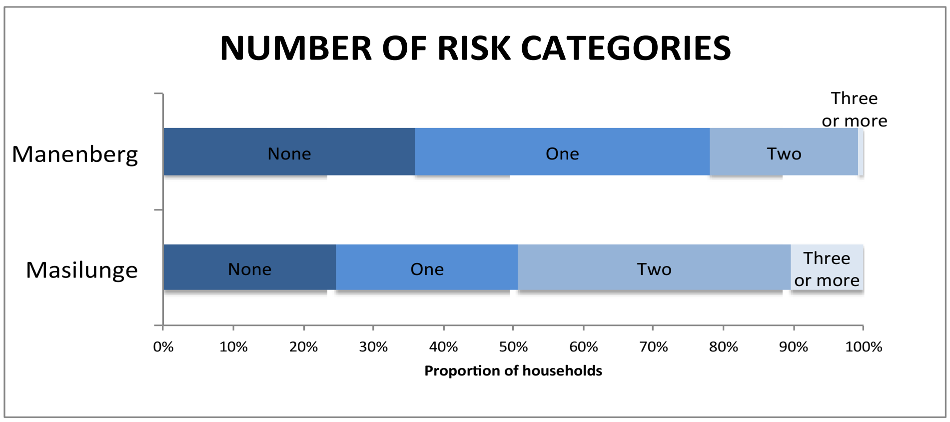


Figure 13: Number of risk categories in which households scored

4.4 Reliability of electricity

Poor reliability of electricity supply is a challenge common to many developing countries, and is prevalent in South Africa – although performance rates are highly variable across different distributors (Eberhard et al, 2008; Foster and Steinbucks, 2009). Various technical parameters are used to define electricity service quality, including frequency, voltage magnitude, voltage dips, flicker, voltage quality and interruptions. This study focuses on supply interruptions only. Generation, transmission and distribution can all influence reliability. From a supply perspective, the quality of services delivered to customers is a compromise between cost and reliability (CEER, 2008). There are various classifications of interruptions – momentary interruptions (typically lasting a few seconds), sporadic interruptions and chronic interruptions (Kufeoglu and Lehtonen, 2015). Interruptions in South Africa are caused by generation capacity constraints, network design (for example feeder length), under-investment in maintenance of the distribution network, the theft of cables and vandalism, weather-related events, and encroachment of trees and vegetation on lines (Cameron and Carter-Brown, 2012; Deyer and von Holdt, 2008).

The industry uses a range of measures for utility performance that typically describe the frequency and duration of interruptions, number of customers affected, or amount of power not supplied. An index measuring the frequency or number of hours a customer does not have a service is useful, but it does not illustrate the actual impact on consumers. There are various approaches and methodologies to investigate the cost of interruption to the customer in different sectors. Estimating these impacts for low-income households is a complex undertaking. Previous studies have typically used price discrimination metrics such as willingness to pay or willingness to accept certain service levels, or the direct worth of an outage to illustrate impact (Kufeoglu and Lehtonen, 2015; Herman and Gaunt, 2008). There is, however, no consensus on a methodology for this sector (Kufeoglu and Lehtonen, 2015).

In the low-income residential sector, reliability has both direct impacts for a household and indirect and wider socio-economic impacts. Particularly frequent interruptions have the potential to undermine the positive socio-economic gains coming from electrification. Some impacts may only occur over the long term, or be experienced above a certain threshold of lost hours of service (Kufeoglu and Lehtonen, 2015). Apart from the frequency and duration of incidents, factors such as the time of day of outages, the types of activities that are interrupted and whether these can be postponed are also relevant (Nahman et al, 2010).

Metrics focusing on monetisable losses are unlikely to provide a useful indication of impact in poor households. Electrification in this sector is an investment in the social welfare of citizens – and translating this into financial terms may miss or understate many impacts that are more social or non-monetisable in nature. For low-income residential consumers, some of the *potential* impacts of unreliability may be direct financial loss if productive activities are undertaken, spoilage of food, inconvenience, social and economic costs of using alternatives like candles and paraffin, as well as the increased vulnerability to crime if interruptions occur at night. Very bad reliability may impact a full transition away from undesirable energy carriers. There is no previous work in the South African low-income residential sector on impacts for use for this study. Nor is it appropriate to use values from other countries. Effects in the residential sector in different contexts are highly variable, making comparison difficult. Acceptable service quality may differ for different regions and different types of customers. Impacts can be influenced by factors such as methods of heating, climate and availability of alternative energy carriers (Nahman et al, 2010). Service quality may also change over time as investment patterns or equipment changes (CEER, 2008).

In the absence of a more detailed understanding of impacts, which were not collected in the household survey, this study reports on the extent of service interruptions measured by the municipal distributor and customer perceptions of interruptions. In South Africa data limitations are also a major challenge. Data is not collected on all types of interruptions, nor do all municipalities collect and report on the same information, making comparisons or benchmarking more difficult. Municipalities often lack the human and technical capacity to collect and manage supply-monitoring systems (NERSA, 2009; Deyer and von Holdt, 2008). In Cape Town good data does exist for incidents of long duration that occur on high (HV) and medium voltage (MV) lines. The available data thus excludes momentary interruptions as well as incidents occurring on low voltage (LV) lines. Typical events that can affect LV lines include weather related events, trees or vegetation interfering with lines, theft/vandalism as well as technical faults.

Figure 14 shows the average frequency and duration of higher voltage incidents over a five-year period, from 2010 to 2014. It must be noted that the survey was undertaken prior to the commencement of loadshedding in South Africa caused by national generation shortages. Masilunge has experienced a higher frequency of outages, but these have tended to be of shorter duration on average than for Manenberg. Overall the picture shows a good level of supply in both areas, with only a few hours of service lost per year, and is not suggestive of major negative impacts. The data omissions for incidents on LV lines, however, do imply that this could be an under-estimate. The extent to which these figures are an underestimate cannot be established. Whilst the data omissions are less pressing in a large metropolitan municipality that has good supply quality, many smaller municipalities in South Africa have a very different picture. Huge backlogs in the maintenance of distribution infrastructure means many areas experience much higher rates of interruptions related to distribution (Deyer and von Holdt, 2008).

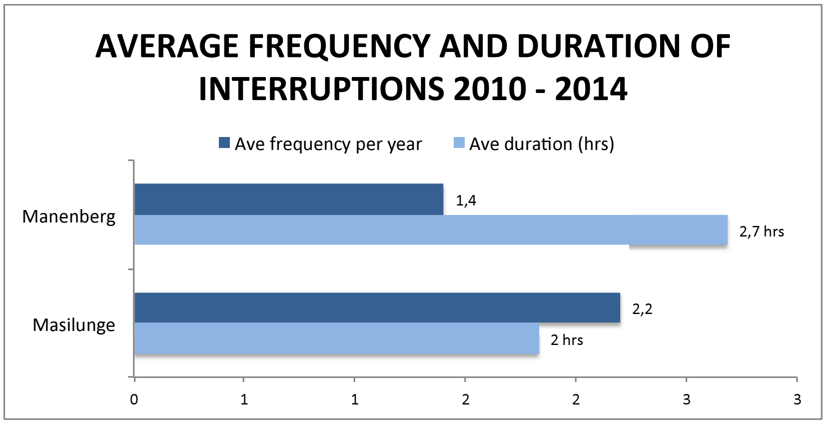


Figure 14: Frequency and duration of interruptions
Source: City of Cape Town

To support the municipal distributor's data on frequency and duration, a subjective assessment of householders' perceptions of the reliability of their supply was undertaken. The survey asked households to estimate the frequency of interruptions they experienced in a typical winter month, and to rate their satisfaction with the reliability of their service. Most respondents responded that outages were more frequent in winter than in summer. Estimates of winter monthly outages ranged from 2.6 times in a typical winter month in Manenberg to 1.8 times in Masilunge. These typical winter monthly estimates stand in contrast to the utility data that indicates between one and three incidents over a whole year. The survey also asked households to rate their satisfaction with their electricity supply, and this is shown in Figure 15. Masilunge residents were extremely dissatisfied with their reliability, again seemingly at odds with the reported number of hours lost per year. The accuracy of self-reported data in surveys on recollections about past events is affected by recall bias. This is especially true for emotive topics, of which service delivery in South Africa is definitely one. There is often a tendency for respondents to exaggerate negative events or losses (Kufeoglu and Lehtonen, 2015). This information error could lead to respondents overestimating the number of outages they experience. On the other hand, the disparity may suggest the municipal data under-estimates the actual number of outages experienced by households, by excluding momentary interruptions and incidents on LV lines.

Backyard dwellers sharing meters with neighbours face additional reliability issues. Respondents who shared a meter in the survey sample reported that their systems frequently tripped because of too many appliances being used at the same time. The main household also sometimes restricted backyarders from using electricity. Thirty percent of the backyarders interviewed in Manenberg reported some form of restriction imposed by the main household on when or how much electricity they could use. Some examples included only being able to use certain appliances at certain times of the day, only having their extension cords to the main house plugged in during certain hours of the day, or only being able to use electricity on certain days of the week.

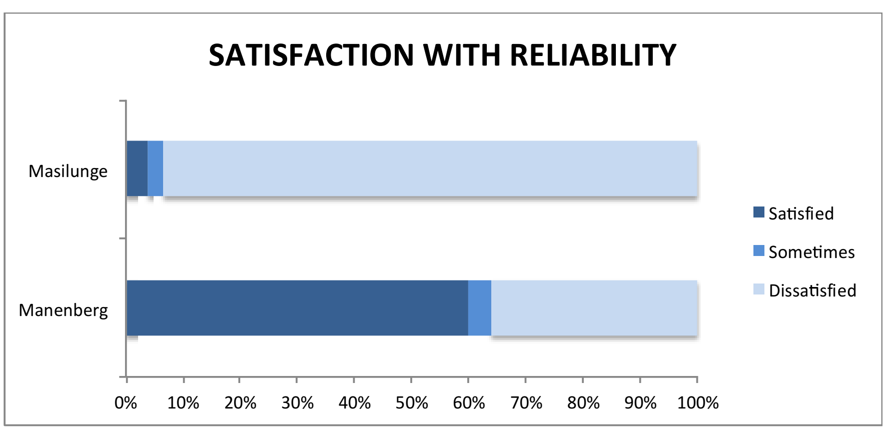


Figure 15: Subjective assessment of satisfaction with electricity reliability

4.5 Constructing a multi-dimensional index of energy access

This section describes the approach and methods undertaken to calculate an indicator for each dimension of energy access that has been discussed in the previous section. Each indicator was calculated individually, and then normalised to a score of 1. Each indicator aims to represent the particular dimension along a continuum, to reflect the on-going nature of energy access, as well as the fact that minimum thresholds are always disputable. There is value in acknowledging for example that informal electricity access still has social benefits. The overall state of energy access for each surveyed area is presented and discussed in section 4.6.

4.5.1 Methods for calculating the indicators

Electricity access and fuel use indicator

Each household received a score between 0 and 3 to measure a scaled hierarchy of access to different types of energy carriers:

0 – No access to electricity
1 – Informal or illegal electricity connection
2 – Metered electricity connection and usage of unsafe fuels
3 – Metered electricity connection and only usage of safe fuels

The overall score for each settlement area is calculated on the sum of the proportion of households in each tier multiplied by the score for that category. The score is calculated as follows:

$$Score = \Sigma\ (Proportion\ of\ households * Category\ scale)/3$$

Affordability indicator

The comparison of affordability scores based on expenditure income ratios and subjective self-assessments is shown in Table 4. There is consistency between the different approaches to measuring affordability. The expenditure method was selected as it allows for a more objective delineation for comparison purposes. In constructing a score, no single threshold of affordability was defined; instead the score represents a continuum of different levels of expenditure/income ratios. The table compares the approaches and results of using the expenditure method and the subjective method to calculate a score.

Table 4: Calculation method of scores for each measure

Expenditure method		*Subjective method*	
1	Less than 10%	1	Yes
2	10-20%	2	Sometimes
3	20-30%	3	No
4	Above 30%		
Score = Σ (P x S)/4		*Score = Σ (P x S)/3*	
Comparison of scores using each method			
Expenditure method		*Subjective method*	
Manenberg	0.64	Manenberg	0.72
Masilunge	0.94	Masilunge	0.84
P – proportion of households in each category S – scaled score for each category			

Safety indicator
In calculating a score for this indicator, no weighting process was adopted. Whilst weighting is certainly an important consideration, in the absence of a detailed risk assessment and quantification of variables such as probability of occurrence and impacts, a theoretically sound weighting process cannot be constructed. Therefore this indicator was calculated based on the number of risk categories that a household scored in the questionnaire. The score is calculated as:

$$Score = \Sigma \text{ (proportion of households x no. of risk factors)}$$

Reliability indicator
As discussed in section 4.4 the construction of a sound reliability indicator is constrained by incomplete data and the lack of industry benchmarks or assessments on reliability thresholds in general. This indicator therefore represents the number of hours lost to interruptions as a proportion of total hours over a five-year time period. A score of 1 would indicate no interruptions. The score is calculated as:

$$Score = 1 - (\Sigma \text{ (hours lost/total hours)}/5)$$

4.6 Implications of results evaluation for programme design

Figure 16 presents the indicators measuring each dimension of energy access for the two household samples. A higher score indicates a better state of 'access' in respect of that particular dimension. The benefit of developing indicators is to summarise a diverse range of information about complex issues in a concise and accessible manner. It enables both communication and comparison. Using a dashboard of several indicators highlights the multi-dimensional nature of energy access. Being able to compare different areas and different issues, also challenges the adoption of widescale and blanket approaches to interventions. The two household samples, whilst both poor, illustrate significant diversity in the type and severity of issues they experience. The results suggest there might be different priorities in interventions in each area, for example around safety in Masilunge or affordability in Manenberg. Developing a more holistic state of energy access enables a more nuanced discussion around the targeting and prioritisation of different energy-related interventions.

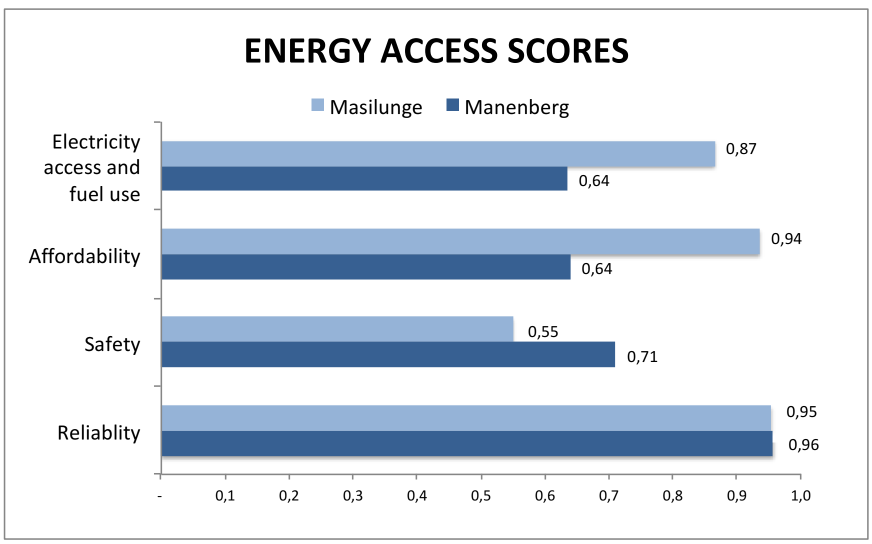


Figure 16: Energy access scores

Electrification is not a panacea for all household energy issues. High electrification rates and subsidies have not eliminated all of the concerns related to energy usage. There needs to be a targeted policy response looking at all dimensions. In Masilunge, despite virtually all sampled households having a metered connection, outcomes are compromised to a degree by continuing paraffin usage – which has many negative externalities. Energy health and safety has been a neglected area of household energy (Tait, 2013). Whilst the electrification programme has undoubtedly improved the risk profiles of many households that previously used more biomass, paraffin and candles, electricity carries with it its own set of risk factors that should not be ignored. Many of the risk factors identified in the survey could be mitigated through more public awareness and information campaigns, specifically around electrical safety, fire safety knowledge and the hazards associated with paraffin.

Affordability is a topical issue in South Africa, given the significant price increases of electricity since 2008. Manenberg scored much lower than Masilunge on this indicator. As discussed in section 4.2 not only do they spend a greater proportion of household income on energy, but they also do not receive as much tariff protection against price rises because of their higher consumption levels. This higher consumption is very likely driven by bigger household sizes and multiple households sharing meters, but does not mean they are less poor. The average income levels of both samples were very similar. This evidence supports concerns about the limitations of consumption-based targeting mechanisms to allocate subsidies (Palmer and Jooste, 2013). However this is currently the simplest and therefore most effective mechanism used in the South African context, and more research would be required to explore what alternative mechanisms could look like.

The available utility data suggests that reliability in both areas is good, but householders' perceptions and satisfaction ratings did not always support this picture, particularly for Masilunge. Given that there are data gaps, there is potentially a need for more research to investigate this issue further. The reliability indicators are a first step, but would benefit from both better data and more work on developing methodological approaches to understanding the impact of interruptions on households. This may require further detailed survey work in the low-income residential sector to better understand how households are impacted by service interruptions. Although the existing data picture for this indicator is incomplete, reporting on it here still has value in bringing visibility to an aspect of energy access that receives very little policy attention. It also brings attention to limitations in current utility monitoring systems in accurately reflecting the level of interruptions experienced by customers. This would require both more extensive monitoring systems but also increases in the organisational and IT capacity of local governments to manage them. Capacity constraints within local government are systemic and a major challenge to implementation in many sectors (Peters and van Niewenhuyzen, 2012).

5. Conclusion

Although the electrification programme has an extensive policy framework in place, many financial and institutional aspects of the programme are increasingly threatening its sustainability. It was a cornerstone of the democratic transition in South Africa, and benefitted from strong political support, necessary skills to implement it as well as revenue to sustain it. Over time this picture has changed, however, administration and governance of the programme have shifted, funding sources have changed, and the operating environment has increased in complexity. Nonetheless, the political paradigm favouring grid electrification as well as the current approach to planning and implementation is entrenched in institutional structures. The challenge for the programme is to embrace further reform to enable universal access goals. This is a key lesson for all countries in their energy access programmes. Implementation is a long-term and continuing process. Essential to its on-going success is for policymakers to be responsive and adaptive to changing contextual conditions, embracing the need for review and reform of policy and practise over time. It is, of course, relevant to point out that many of the challenges plaguing the programme are structural and others are even outside the ambit of energy policy. Local government capacity constraints are a pervasive issue, for example. The causes are multiple and complex and impact many sectors. The South African experience also shows the importance of having effective monitoring and evaluation systems in place to drive continued performance outcomes. A lack of regulatory oversight serves as a weak enforcer and signals low prioritisation of those issues.

The outcomes evaluation, which investigated total energy access in households, revealed that despite high levels of electricity access and consumption subsidies among the sampled households there are still issues related to the use of modern energy services. The term 'access to modern energy services' should be understood along a continuum or an ongoing process over time. It also encapsulates many dimensions including physical access as well as affordability, safety and reliability. Where electricity access does not displace other energy carriers, energy access as a whole is compromised for a household. This is an important point, and South African policy needs to develop a more integrated energy access response rather than just electricity access. Policy needs to better reflect the actual household energy context and should cater for all energy carriers that are used by households.

The multi-dimensional measure of energy access developed in this study to measure programme outcomes has shown the diversity of issues and deprivations that different areas face, which can be useful in developing and prioritising interventions for different localities. The energy indicators enable a simple and easy overview of energy access issues and priorities. In Masilunge households for example, scored relatively highly (above 0.85) for fuel types used, affordability and reliability of supply. They scored very poorly, however, on energy safety, and much lower than Manenberg. This would suggest prioritisation of safety interventions in Masilunge. By contrast, Manenberg fared better in terms of safety but far worse in terms of affordability and the types of fuels used, evidenced by the lower scores they measured. This study supports the view that policy interventions should focus on all energy carriers and multiple objectives related to energy. It also suggests that the mechanisms used to target the poor for electricity subsidies could be reviewed, particularly in light of continuing price rises. The differences in electricity consumption amounts and affordability between the two areas surveyed reinforce that there are limitations to setting blanket consumption thresholds to target poor households. These do not differentiate for household size, the presence of informal households sharing meters and other varying socio-economic determinants of consumption.

Energy health and safety has long been a neglected aspect of household energy. The results from this small study suggest a range of risk factors are present in poor households, and require targeted programmes and interventions to address these. The available data suggests that reliability in both areas is good. Measuring and assessing reliability of electricity supply is, however, challenging due to both data limitations and a lack of consensus on assessment and benchmarking methods. Further research into appropriate information systems and practices for distributors is required to better understand how data collection at local municipal level can be improved. Householders' perceptions of interruptions and satisfaction levels measured in the survey point to high levels of dissatisfaction with reliability in Masilunge, and both samples estimated much higher frequency of outages. This may be due to either incomplete data or recall bias among survey respondents, but it does suggest that more investigation into service levels would be useful. In addition, further research is required into methodological approaches to understand the impacts on low-income residential customers of supply interruptions. This study has revealed a gap in our knowledge and understanding of how to collect information at scale about service interruption impacts at the low-income residential level.

References

Balme K., Roberts J.C., Glasstone M., Curling L., Mann M.D. 2012. The changing trends of childhood poisoning at a tertiary children's hospital in South Africa. *South African Medical Journal*,102:142-146.

Barnes, D.F., Khandker, S.R. & Samad, H. a., 2011. Energy poverty in rural Bangladesh. *Energy Policy*, 39(2): 894–904.

Bazilian, M. et al., 2010. *Measuring energy access: Supporting a global target*. The Earth Institute, Columbia University.

Bhanot, J. & Jha, V., 2012. Moving towards tangible decision-making tools for policy makers: Measuring and monitoring energy access provision. *Energy Policy* 47: 64–70.

Bhattacharyya, S.C., 2012. Energy access programmes and sustainable development: A critical review and analysis. *Energy for Sustainable Development*, 16(3): 260–271.

CORC [Community Organisation Resource Centre], 2010. *Manenberg backyarders enumeration report*. Community Organisation Resource Centre, Cape Town.

Council of European Energy Regulators, 2008. *4th Benchmarking report on quality of electricity supply*. Brussels, Belgium.

Cowan, B., 2008. *Alleviation of poverty through the provision of local energy services*, Energy Research Centre, University of Cape Town.

Deloitte, 2012. *The Economic Impact of Electricity Price Increases on Various Sectors of the South African Economy*, Available at: http://www.eskom.co.za/CustomerCare/MYPD3/Documents/ Economic_Impact_of_Electrcity_Price_Increases_Document1.pdf.

Department of Energy, 2012. *A survey of energy-related behaviour and perceptions in South Africa.* Pretoria, South Africa.

Department of Energy, 2014. *Integrated National Electrification Programme*. Briefing to the parliamentary portfolio committee on energy. Available at www.pmg.co.za

Department of Minerals and Energy, 1998. *White Paper on Energy*. Pretoria, South Africa.

DPLG [Department of Provincial and Local Government], 2005. *Study to determine progress with and challenges faced by municipalities in the provision of free basic services and supporting those municipalities struggling with implementation*. Department of Provincial and Local Government. Pretoria, South Africa.

Dugard, J., 2008. Power to the people? A rights-based analysis of South Africa's electricity services. In D. MacDonald, ed. *Electric Capitalism: Recolonizing Africa on the Power Grid*. pp. 264–287.

Eberhard, A., Foster, V., Briceno Garmendia, C., Ouedraogo, F., Camos, D., Shkaratan, M. 2008. *Underpowered: The State of the Power Sector in Sub-Saharan Africa*. Report for Africa Infrastructure Country Diagnostic (AICD). World Bank.

EDI Holdings, n.d. *Approach to Asset Distribution Management (ADAM) Turnaround to Ensure Improved Reliability and System Sustainability Business Plan.*

Eskom. 2012. *Revenue application: Multi-year price determination 2013/14 to 2017/18*. Available at http://www.eskom.co.za/CustomerCare/TariffsAndCharges/Documents/Tariff_submission _MYPD_3_17_October_2012a1.pdf

ESMAP [Energy Sector Management Assistance Program], 2014. *A new multi-tier approach to measuring energy access*. Available at: http://www.esmap.org/sites/esmap. org/files/DocumentLibrary/Multi-tier%20BBL_Feb19_Final_no%20annex.pdf.

Financial and Fiscal Commission. 2013. Challenges, constraints and best practises in maintaining and rehabilitating water and electricity distribution infrastructure. In 2014/15 Technical report submission for Division of Revenue.

Foster, V. and Steinbuks, J. 2009. Paying the price for unreliable power supplies: in-house generation of electricity by firms in Africa. Policy Research Working Paper 4913, World Bank.

Franks, L and Prasad, G. 2014. Informal electricity re-selling: Entrepreneurship or exploitation? Energy Research Centre, University of Cape Town, Cape Town, South Africa.

Gallie, W.B., 1956. Essentially contested concepts, *Proceedings of the Aristotelian Society*, 56: 167-198.

Gevaart-Durkin, a, Swart, D. & Chowdhury, Z., 2014. A study of energy-related injuries from hospital admissions among children and adults in South Africa. *Burns : Journal of the International Society for Burn Injuries*, 40(6): 1209–18.

GEA, 2012: *Global energy assessment – Toward a sustainable future.* Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria.

IEA [International Energy Agency]. 2011. Energy for all: Financing access for the poor, Special early excerpt of the World Energy Outlook. Paris: International Energy Agency.

IEA [International Energy Agency]. 2012. *World energy outlook – Methodology for energy access analysis*. Paris: International Energy Agency.

King, R., Amponsah, O. & Nyamekye, A., 2012. The contribution of slums to commercial electricity transmission losses in Ghana. In *1st Applied Research Conference in Africa (ARCA) Conference:* 29–31.

Kimemia, D. & Annegarn, H., 2011. An urban biomass energy economy in Johannesburg, South Africa. *Energy for Sustainable Development* 15(4): 382–387.

Kimemia, D. et al., 2014. Burns, scalds and poisonings from household energy use in South Africa: Are the energy poor at greater risk? *Energy for Sustainable Development* 18: 1–8.

Küfeoğlu, S. & Lehtonen, M., 2015. Interruption costs of service sector electricity customers, a hybrid approach. *International Journal of Electrical Power & Energy Systems* 64: 588–595.

Leggett, T. 2004. *No one to trust. Preliminary results from a Manenberg crime survey*. South African Crime Quarterly. Published by the Institute for Security Studies.

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.

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

Matinga, M.N., Clancy, J.S. & Annegarn, H.J., 2014. Explaining the non-implementation of health-improving policies related to solid fuels use in South Africa. *Energy Policy* 68: 53–59.

Muller, E. et al., 2003. Health risk assessment of kerosene usage in an informal settlement in Durban, South Africa. *Atmospheric Environment* 37(15): 2015–2022.

Nahman, J., Vlajic-Naumovska, I. & Salamon, D., 2014. Evaluation of supply interruption costs for residential sector in Serbia. *Electric Power Systems Research* 110(0): 39–44.

National Treasury. 2009. *Discussion Document: A Strategy to Address Municipal Performance Failures*. Pretoria: National Treasury.

Newbery, D. & Eberhard, A., 2008. *South African Network Infrastructure Review: Electricity*. Report for National Treasury and the Department of Public Enterprises.

Niëns, L.M. et al., 2012. Practical measurement of affordability: An application to medicines. *Bulletin of the World Health Organization* 90(3): 219–27.

Nussbaumer, P., Bazilian, M., Modi, V., 2012. Measuring energy poverty: Focusing on what matters, 2012. *Renewable and Sustainable Energy Reviews* 16: 231–243

Pachauri, S., 2011. Reaching an international consensus on defining modern energy access. *Current Opinion in Environmental Sustainability* 3(4): 235–240.

Pachauri, S. & Spreng, D., 2011. Measuring and monitoring energy poverty. *Energy Policy* 39(12): 7497–7504.

Peters and van Niewwenhuyzen, H. 2012. *Understanding the dynamics of the capacity challenge at local government level*. In Technical Report Submission for the Division of Revenue. Financial and Fiscal Commission.

Posel, D. & Rogan, M., 2013. Measured as poor versus feeling poor: Comparing objective and subjective poverty rates in South Africa. Paper prepared for ESSA Conference, September 2013.

Palmer, I. & Jooste, M., 2013. Review of the impact of inclining block tariffs for electricity on poor households. Palmer Development Group, Cape Town.

Practical Action, 2013. *Poor people's energy outlook 2013: Energy for community services*, Rugby, United Kingdom: Practical Action Publishing.

Rogers, P. 2008. Using Programme Theory to Evaluate Complicated and Complex Aspects of Interventions. *Evaluation* 14(1):29 – 48.

Roux, L.J. Le & 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.

Serwaa Mensah, G., Kemausuor, F. & Brew-Hammond, A., 2014. Energy access indicators and trends in Ghana. *Renewable and Sustainable Energy Reviews* 30: 317–323.

Sovacool, B.K., 2011. Security of energy services and uses within urban households, *Current Opinion in Environmental Sustainability*, 3 (4): 218-224.

Statistics South Africa. 2011. *National Census 2011*. Pretoria, South Africa.

Sustainable Energy Africa, 2014. *Tackling Urban Energy Poverty In South Africa*. Cape Town, South Africa.

Tait, L. 2013, Investigating the current and future role of paraffin in South Africa. Energy Research Centre, University of Cape Town.

UNDP [United Nations Development Programme]. 2000. *World energy assessment: Energy and the challenge of sustainability*. United Nations Development Programme.

UNDP [United Nations Development Programme] International Poverty Centre, 2006. *What is poverty? Concepts and measures*. United Nations Development Programme

UNDP [United Nations Development Programme]. 2011. *Towards an energy plus approach for the poor: A review of good practices and lessons learned from Asia and the Pacific*. United Nations Development Programme.

Yu, D. 2013. Some factors influencing the comparability and reliability of poverty estimates across household surveys. Stellenbosch Economic Working Papers: 03/13. Stellenbosch University.