A pilot study on the influence of educational interventions on domestic electricity consumers

by

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DECLARATION

I declare that

A pilot study on the influence of educational interventions on domestic electricity consumers

is my own work and that all sources that I have used and quoted have been indicated and acknowledged by means of complete references.

SIGNATURE
(Mr. T. Bukula)

DATE

ABSTRACT

This pilot study consists of two parts. The first part investigates the extent to which the domestic electricity consumers intend to use and use energy efficiently using the Theory of Planned Behaviour. The second part investigates the extent to which the Energy @ Home educational intervention changed the domestic electricity consumers' behaviour. For the first part of the study an advertisement was published and a convenience stratified sample of 61 domestic electricity consumers were selected from the 290 respondents. Data was collected from the domestic electricity consumers via a questionnaire and a telephone response log. The co-relational research design was used to investigate the relationship between the predictor variables the independent variables in the constructs of the Theory of Planned Behaviour. Simple linear regression analysis resulted in F statistic for the predicted behavioural intention was 29.74 with a p value less than 0.0001 which indicates significant statistical evidence of a linear relation between the predictor variables and the independent variables. The r^2 of 0.87 implies that data points that fall closely along the best fit line. Therefore the predictor variables were good predictors of the response variable. All the participants that intended to use electricity efficiently confirmed via the telephone that they were using electricity efficiently. In the second part of the study 11 out of the 61 participants were chosen to participate in the Energy @ Home educational intervention and television program. Data was collected via the Energy audit log and the electricity consumption log. The participants intended to save between 2% and 35% of their electricity consumption and the actual electricity consumption savings were between 2% and 30%.

KEYWORDS

Energy efficiency, domestic electricity consumers, Energy @ Home educational intervention, behaviour, behavioural intentions, electricity consumption, Theory of Planned behaviour, energy audit, technological advances and convenience stratified random sample.

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GLOSSARY OF TERMS

Base load: The electricity load that is supplied for more than 95% of the time by the electricity utility.

Domestic electricity consumers: Electricity customers and consumers that use electricity in their house hold, sometimes called residential customers of electricity.

Dynamic load: The load that changes rapidly that is due to the domestic electricity consumers when they switch appliances or devices on and off during the course of the day.

Energy efficiency: The use of electricity more efficiently or in reduced amounts – in other words, doing the same with less. In technical terms it is the improvement in practices and products that reduce the amount of energy necessary to provide energy services such as lighting, cooling, cooking and heating.

Energy @ Home educational intervention: The educational intervention on energy efficiency that was conducted during the production of Energy @ home program that included video recording of the participants for a television program.

Load factor: It is the characteristic of the load defined by the amount of time it uses electricity during the day or over a period that determines the amount of electricity that must be generated to feed the load.

Load shedding: The process of disconnecting or shedding load when the generation capacity is constrained in order to avoid a total collapse of the power supply system.

Power shortages: The shortage of electricity or power supply due to the electricity demand exceeding the electricity supply.

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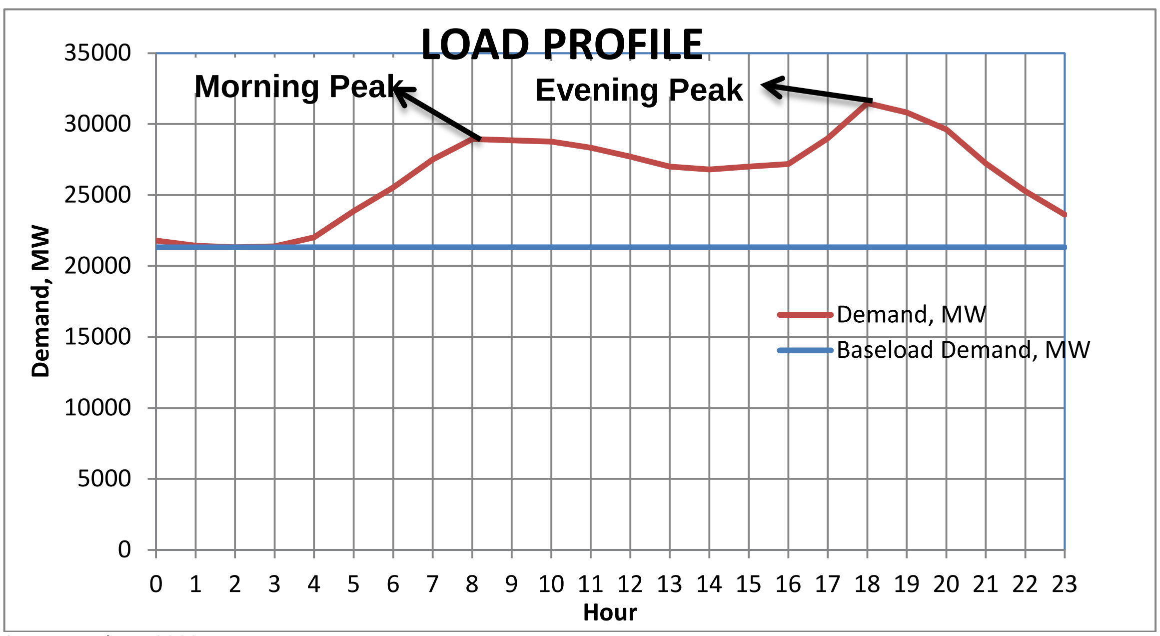
LIST OF ABBREVIATIONS

c/kWh	Cents per kilowatt hour
kW	Kilowatts (10^3 watts or 1000 watts)
MW	Megawatts (10^6 watts or 1000 000 watts)
CFL	Compact Fluorescent Light
LED	Light Emitting Diode
H	Hour
Eskom	The South African electricity utility that generates, transmits, distributes and retails electricity
NEEA	The National Energy Efficiency Agency that is responsible for the promotion of energy efficiency in South Africa.
NERSA	The National Energy Regulator of South Africa that regulates the electricity supply industry

Chapter one: The research

1.1 Introduction

In South Africa domestic electricity consumers account for approximately 19% of the total electricity consumption and the industrial, mining, manufacturing, agricultural and commercial sectors account for the remaining 81% (Eskom, 2009). In comparison to the United States of America (USA), domestic consumers account for up to 21% of the total electricity consumption whilst in the European countries domestic consumers account for approximately 20% of the total electricity consumption (EIA, 2008). The electricity consumption profile across all regions of South Africa has two daily peak demand periods, namely in the mornings between 06:00 and 09:00 and in the late afternoon to the evening between 18:00 and 21:00 as shown in Figure 1.1 (NERSA, 2005).



Source: Eskom 2009

Figure 1.1: A typical 24 hour South African load curve

During the peak demand periods the electricity consumption increases by up to 15% (Eskom Annual Report, 2009). These daily peak demand periods correspond to the activities of domestic consumers such as, lighting, water heating, cooking and space heating or cooling during the mornings as well as the late afternoons and/or evenings. The available electricity generation capacity may not adequately meet the electricity demand unless additional generation capacity is built or the demand is reduced (NERSA, 2009). It can take up to 8 years to build a thermal power station whilst reductions in the electricity demand or consumption by using electricity efficiently can be implemented immediately.

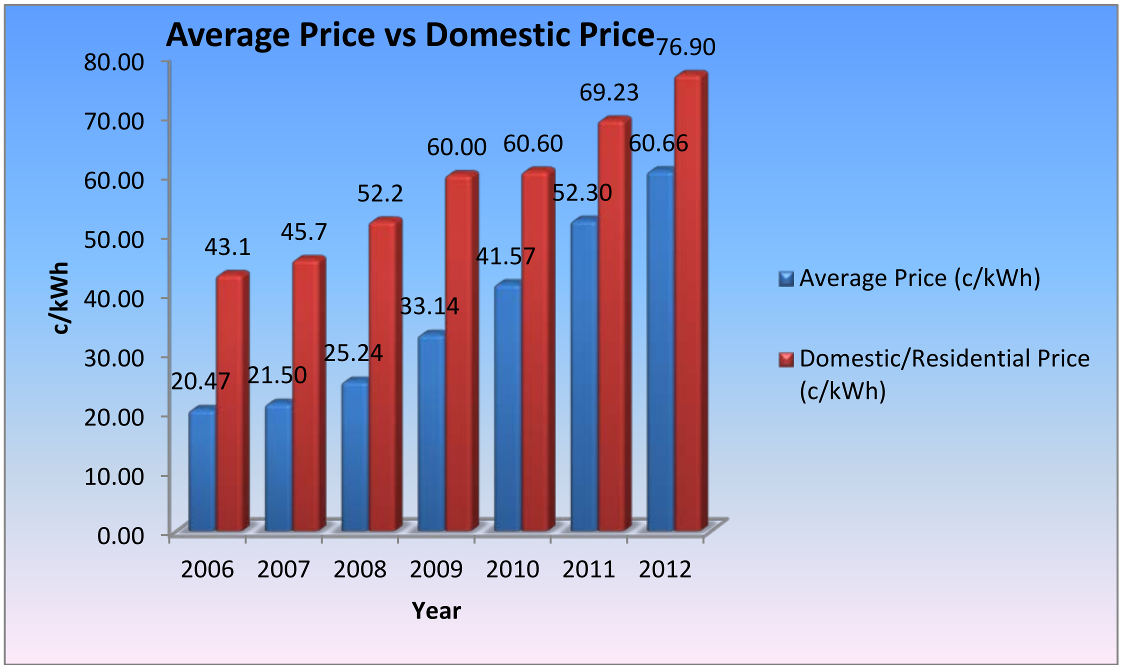
The potential savings in electricity consumption by all consumers (i.e. domestic, commercial and industrial consumers) is estimated to be above 20% whilst domestic consumers alone can reduce by up to 30% of their electricity consumption by using advanced energy efficiency technologies or devices, such as, compact fluorescent lights (CFL's), light emitting diodes (LED's) and low flow shower heads and changing their behaviour (Darby, 2006). A 30% reduction in electricity consumption by South African domestic consumers (or 20% reduction by all customers) can yield the following benefits:

- At least 30% reduction in electricity costs or a 30% savings resulting in an increase in the disposable income by the domestic consumers or reallocation of consumer spending.
- A 20% reduction in the electricity consumption for all consumers.
- The postponement of building an additional power station resulting in lower electricity prices.
- The reduction in electricity generation, transportation and distribution costs resulting in lower electricity prices.
- Economic growth without additional investments on power generation and transportation infrastructure.
- Saving of the resources used for electricity generation, in particular, coal reserves resulting in a reduction in mining costs and an extension of the mine's useful life.

- Less pollution due to less electricity production thus contributing towards saving the environment.

Since the power shortages that were experienced in January 2008 in South Africa, Eskom, the electricity utility in South Africa, has been running a number of initiatives aimed at reducing the electricity consumption and/or shifting the consumption by all electricity consumers to less generation output constrained times, such as during the late evening. For domestic electricity consumers the focus was on reducing the demand during peak demand periods via messages that would appear on various South African TV channels. These messages would appeal to the domestic electricity consumers to switch off unused appliances when there is a shortage or potential shortage of electricity supply to meet the electricity demand. Other interventions by Eskom and other electricity suppliers included the replacement of the incandescent lamps with Compact Fluorescent Lights (CFL's), replacement of conventional geysers with solar water heaters as well as replacement of electric stoves with gas stoves. Although these measures achieved reductions in the electricity consumption during the 2008 power shortages period, more still needed to be done (Eskom, 2009). The preliminary assessment of the effect of the TV adverts and electric stoves replacement initiatives indicate limited success (NERSA, 2009). These initiatives cost more than R1 billion per annum but achieved less than the targeted savings (Eskom, 2009).

In the early 1990's electricity prices in South Africa were amongst the cheapest in the world, the average price was less than 10c/kWh (Eskom, 1995). In 2006 the average electricity price was 20c/kWh and still amongst the lowest prices in the world (NERSA, 2010). However between 2007 and 2011 the average electricity prices in South Africa more than doubled as shown in Figure 1.2.



Source: NERSA 2012

Figure 1.2: The electricity prices in South Africa over the 7 years

The domestic electricity consumers' average prices are now comparable to some of the highest electricity prices in the world (Eskom, 2010). Even though the industrial tariffs are still comparable to some of the lower prices in the world as they are on the lower quartile of international tariffs, the country may lose its competitive advantage of having the lowest cost produced electricity.

In the early 1980's Canada decided to enforce the reduction of electricity consumption of the residential customers to mitigate the effects of energy scarcity (McDougall & Mank, 1982). One of the main contributors to this enforcement of electricity consumption reductions was the behaviour of consumers, specifically their resistance to energy conservation because of their deeply entrenched ways of thinking and behaviour with respect to energy use. This entrenched behaviour could be attributed to an era of inexpensive energy. Similarly, in South Africa even when the prices have doubled, there is no evidence that suggests that domestic consumers, in particular, use energy efficiently. It could well be that the South African domestic consumers have their own entrenched behaviours and thinking towards energy efficiency that emanate from the times of inexpensive electricity. Higher prices alone may not bring about the desired behaviour (McCalley, 2006). This research study examines the following:

(i) the extent to which domestic electricity consumers can reduce or intend to reduce their electricity consumption by changing their behaviour towards energy efficiency, and

(ii) the extent to which specific educational interventions can influence their behaviour towards energy efficiency.

1.2 Context

The current available electricity generation capacity in South Africa is 42 194 MW. The recorded maximum peak demand is 38 564 MW resulting in a spare capacity (reserve margin) of about 8% versus the 19% spare capacity that is the South African target and recommended benchmark world-wide (Eskom, 2009). According the Eskom (2009) the first additional power station will only produce power in the last quarter of 2013. It is anticipated that before the first additional power station is brought into operation the maximum demand is likely to equal or exceed the available electricity generation capacity resulting in load shedding or power shortages.

The electricity consumption patterns commonly known as load factors of the mining and industrial electricity consumers are generally constant throughout the day (24 hours) with limited spurious high demands. Domestic electricity consumer patterns on the other hand are generally low during the day and peak in the mornings between 06:00 and 09:00 and in the afternoons/evenings between 18:00 and 21:00 due to water heating, cooking and space heating requirements (see Figure 1.1). The electricity consumed during the off peak periods is called base load. Domestic consumers have fairly limited base load such as fridges, freezers and water heaters.

In South Africa about 95% of the electricity is generated from coal fired power stations and less than 2% from gas or diesel fired power stations and the rest from nuclear, hydro and pumped storage power stations. The coal fired, nuclear and hydro power stations are used mainly to meet the base load demand whilst the gas or diesel fired stations are used for peak demand periods. Because of the design nature of the coal fired power stations they are not the appropriate and efficient way of responding or following the load. On the other hand, the gas or diesel fired power stations can start rapidly they are best suited to follow dynamic loads, such as the domestic load. For example it can take up to 48 hours to start up a coal fired power station and up to two weeks to get it to run at its full generation capacity. Similarly, it can take up to 48 hours to get a nuclear power station to run to its full generation capacity. In contrast, it takes seconds to start up a gas or diesel fired power station to run to its full generation capacity. The operating cost of a gas or diesel fired power station is about 3 times that of running a coal fired power station due to the high costs of gas or diesel and the capital costs are comparable (Eskom, 2009). The capital cost of establishing a nuclear power plant are approximately 5 times those of a coal plant whilst the operating costs are comparable (EIA, 2008).

In essence the cost of meeting the peak demand periods, which is mainly due to domestic electricity consumers, is 3 times the average cost of producing electricity via the coal fired power stations. The alternative is to run the coal fired power stations at no load when the domestic consumers are not consuming, so as to meet the peak demand. This alternative will not be sustainable as tons of coal will be wasted, and additional operating and maintenance expenses will be unnecessarily incurred due to the additional operation of the power stations during the off peak periods. Further, additional generation capacity will thus be required to ensure a secure electricity supply and adequate reserve or spare capacity to cater for any generation unit failures. In the meantime ways of reducing the electricity demand have to be found by all electricity consumers and domestic electricity consumers have significant role to play.

1.3 Statement of the problem

South Africa has a shortage of power generation capacity to adequately meet its growing electricity demand (Eskom, 2009). According to the Eskom (2009) additional generation capacity will only come on stream by the last quarter of 2013. At the very least the only measures that will ensure that there are no power shortages or load shedding are conservation of electricity and efficient use of electricity. These measures have the potential of reducing the current demand to energy efficiency (EE) load as shown in Figure 1.3.

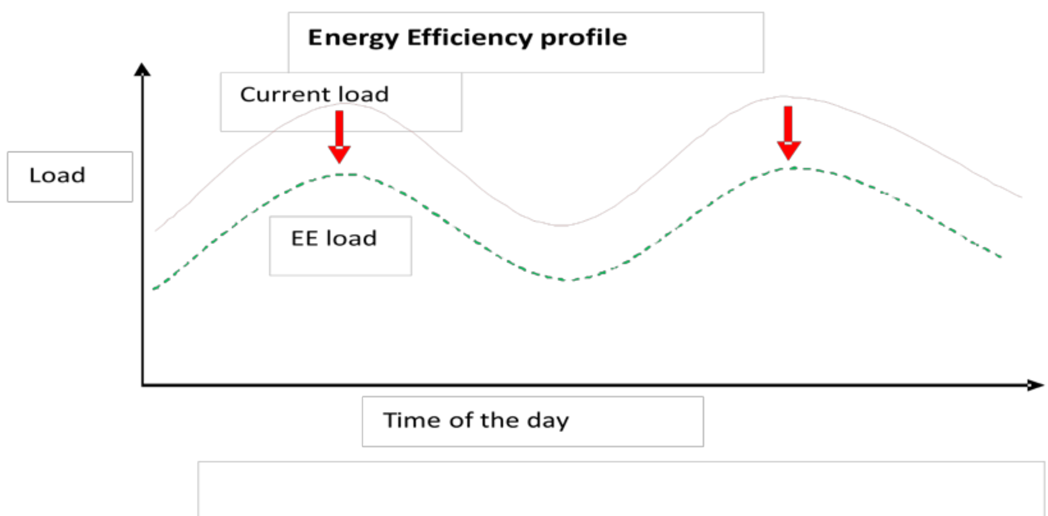
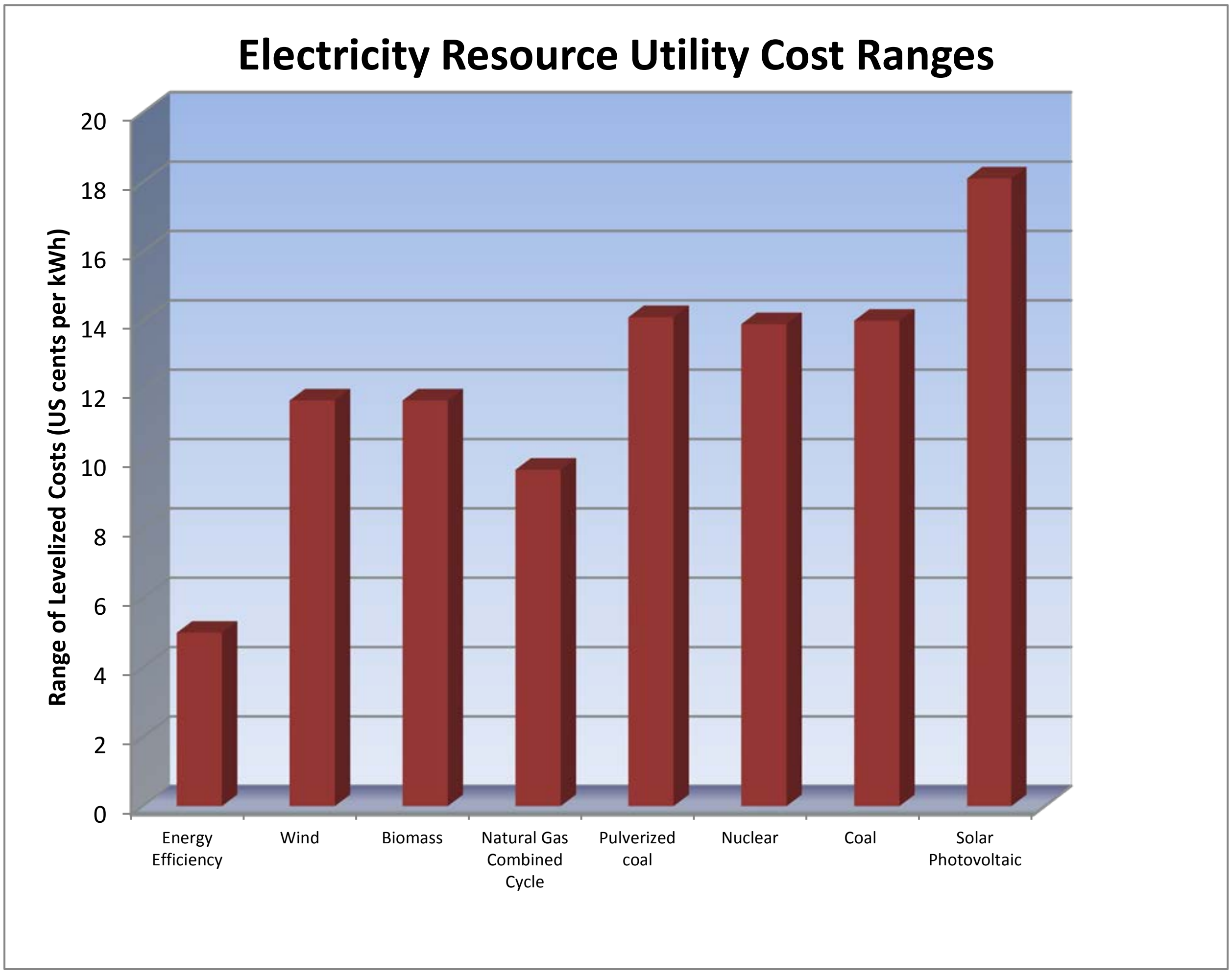


Figure 1.3: The required energy efficiency profile to mitigate power shortages

The current costs of energy efficient measures are lower than the costs of generating electricity from any of the electricity sources such as, wind, biomass, natural gas, coal, nuclear and solar as shown in Figure 1.4.



Source: American Council for an Energy-Efficient Economy

Figure 1.4: The cost ranges of the different electricity sources

Energy efficiency measures, such as installing energy efficient technologies, appliances or devices, cost less 6 (US) cents per kWh whilst the other electricity sources cost between 9 and 17.9 (US) cents per kWh. It appears that more can be achieved by investing less money in energy efficiency than by investing more money in additional generation. Therefore energy efficiency measures that require no additional investments such as saving energy by changing behaviour (e.g. switching off unused appliances, boiling only the required amount of water or reducing the temperature setting of the washing machine or geyser) can yield even more economic benefits. This is because the cheapest unit of electricity is the one that has not been generated.

The energy efficiency interventions or measures that have been undertaken in the past have yielded less than the expected or anticipated results (NERSA, 2009). For example, in 2008 Eskom undertook the following interventions in South Africa:

1. Replacement of incandescent lights with CFL's.
2. Replacement of electric cooking stoves with gas stoves.
3. Replacement of electric geysers by solar water heaters
4. Issuing of geyser blankets
5. TV adverts requesting domestic consumers to switch off unused appliances
6. Radio and other media forms giving tips on how to save electricity

On the main, these interventions have focused on using the energy efficient technologies, appliances or devices as a means of reducing electricity consumption with limited focus on changing the behaviour of the domestic consumers towards energy efficiency. There is therefore a need to explore further the opportunities for energy efficiency that exist when there are the necessary changes in behaviour as well as different forms of providing the information or tips about being energy efficient.

1.4 Objective of the study

The main aim of this pilot study is to investigate the extent to which domestic electricity consumers intend to use and use electricity efficiently using the Theory of Planned Behaviour (developed by Ajzen & Fishbein, 1980) and evaluate the extent to which the Energy @ Home educational intervention changed the domestic consumers' behaviour.

1.5 Research problem and research questions

A number of research reports indicate that there is considerable potential for domestic consumers to save electricity and the concomitant costs that has not been realised (Granade, Hannah, Creyts, Derkach, Farese, Nyquist, & Ostrowski, 2009). A simple way of improving energy efficiency within a household is to change behaviour (ACEEE, 2011). Considering the limited success of the current energy efficiency initiatives in making the domestic electricity consumers use their electricity efficiently, this study aims to answer the following research questions:

Research question 1:

To what extent do domestic electricity consumers intend to use and use electricity efficiently?

Research question 2:

To what extent did the Energy @ Home educational intervention change the domestic electricity consumers' behaviour towards energy efficiency?

The null hypothesis for the first research question is:

H_0: The behavioural intentions of the domestic electricity consumers towards energy efficiency do not affect their actual behaviour.

1.6 Significance of the study

A number of energy efficiency initiatives promise significant savings but results that have been obtained do not seem to reach the full potential (Granade, et al, 2011). The literature review discussed in Chapter 2 suggests different ways of achieving the desired energy efficiency results from domestic consumers that emphasis behaviour and/or behaviour change (Gardner & Stern, 2002). This study seeks to explore some of the claims in the abovementioned literature with respect to the behavioural intentions and/or behaviour of the domestic consumers as well as evaluate the effectiveness of a focused educational intervention (i.e. Energy @ Home educational intervention) in getting the domestic electricity consumers to reduce their electricity consumption. The study will also contribute to the body of knowledge about the behaviour of domestic electricity consumers and the determinants of such behaviour with respect to energy as well as the type of educational interventions that can yield the desired energy efficiency results. The results of this study will be used by the author in influencing or designing some of the educational interventions that will be implemented in South Africa.

1.7 Limitations of the study

There were a few challenges that this study experienced which are discussed below. The study initially had a sample of 290 people spread across the Gauteng Province of South Africa, which may not be completely representative of the South African population as a whole. The sample was then reduced to 61 people residing in the Johannesburg area due to the financial, human resources and security constraints of administering the Energy @ Home educational intervention. Only 11 of the 61 selected participants were taken through the Energy @ Home educational intervention. Although the sample may not be representative of the South African population steps were taken to represent as many types of household as possible from the available sample.

This study could not establish a control group and experimental group, because the energy efficiency information could not just be limited to the control group as it was being provided to all domestic consumers via the television adverts and other media forms. Even those participants that were requested to be used as the control group felt that they were being deprived of opportunities to save costs and receiving useful information.

Securing access to the households as the research required the owners or the persons heading the household, such as the parents required careful planning. As a result the educational interventions were either conducted at night or during the weekends depending on the availability of the participants. Therefore the educational interventions focused on the owners only and excluded the other occupants of the household due to the time constraints and availability of the other people in a household.

The intrusive nature of the educational intervention as it required being in the homes of the participants and obtaining detailed information the activities they use electricity for, such as, whether they use a bath or a shower as well as the number of times they do so, sometimes made the participants to provide inaccurate answers if they felt uncomfortable with revealing the required information.

This study did not evaluate the effect of the number of people and/or children within a household and its effect on the perceived behavioural control in particular. The Theory of Planned Behaviour indicates that the significant others that the participants will be required to express their normative beliefs on need to be performing the actual intended behaviour for this measure to be effective. In this study the actual behaviour of the significant others was not evaluated first and therefore may not have had the intended influence. According to Laquatra, Pierce & Helmholdt, (2010) adults already know some concepts that can be used to build on and demonstrate the main principles of electricity consumption and saving. For instance they already know some concepts that can be used to demonstrate the key principles of electricity consumption, such as the effort required to ride a bicycle uphill and/or on level ground (Laquatra, Pierce & Helmholdt, 2010). However the study did not evaluate whether the educational level and other factors or characteristics of the participants plays a significant role in the behaviour of the participants

Another limitation of the study is that it did not allow sufficient time for the participants of the Energy @ Home to implement all the necessary measures. Participants were only given four weeks to implement the changes required in their behaviour. The current behaviour may have required additional time to be changed. The study also did not monitor whether the behaviour change and electricity consumption reductions are being sustained in the long-term.

Some literature emphasise the importance of making electricity consumption visible by proposing electricity meters that are placed at areas that will enable the domestic consumers to see their consumption, such as in the kitchen or living room. Although there was information collected on the types of electricity meters participants used (i.e. Prepaid or Conventional meters) this study did not evaluate the effects of the type and location of the electricity meter with respect the households' electricity consumption or behaviour.

The presence or absence of tariffs or electricity prices (and the effects thereof) that are based on the time of use for the domestic consumers that are used as energy saving measures (Gardner & Stern, 2002) in other countries was also not evaluated. It has been reported that such tariffs or price structures promote the behaviour of shifting some activities such as swimming pool pumps, water heating via geysers, etc to times of the day where the electricity system is not constrained, such as midnight to early morning (Lam 1999).

Finally the study did not take into consideration the Hawthorne effect (Darby, 2006) which states that participants improve or modify an aspect of their behaviour being experimentally measured simply in response to the fact that they know they are being studied, not in response to any particular experimental manipulation. Even so the study suggests that it is possible for South Africa to avoid power shortages in the short-term, postpone future unnecessary investments in the electricity generation infrastructure whilst providing enough electricity to enable economic growth by implementing appropriate energy efficient measures.

1.8 Outline of the chapters

The report consists of the following chapters:

Chapter one

This chapter contains the introduction and background to the research, followed by the context of the research, the statement of the problem, the objective of the study, research questions hypothesis, significance and limitations of the study.

Chapter two

This chapter contains the literature research for behaviour evaluation approaches, technological advances, the educational interventions and energy efficiency implementation reports.

Chapter three

This chapter describes the research method and design, the sample, instruments used and data collection for the two parts of the research.

Chapter four

This chapter presents the results, analysis and findings of the study.

Chapter five

This chapter discusses the findings then draws conclusions and makes recommendations as well as the implications of the study.

1.9 Summary of the chapter

Chapter one provides an outline of the study. The **introduction** (section 1.1) provided of the current South African electricity supply and demand situation which is constrained and the need to use electricity efficiently as one of the most important measures that must be undertaken in order to avoid power shortages. The **context** (section 1.2) of the study focused on the contribution of domestic electricity consumers to the electricity demand and the challenges of meeting the dynamics of their load. The **statement of the problem** (section 1.3) emphasised the importance of energy efficiency in order to reduce the demand in the absence of additional generation capacity and the costs of implementing energy efficiency relative to the costs of additional generation from different electricity sources. The **objective of the study** (section 1.4) addresses the theoretical framework that will be used to establish the behaviour and/or behavioural intention as well as the evaluation of the effectiveness of the Energy @ Home educational intervention with respect to the reduction of the electricity consumption of the domestic consumers. The **research problem and research questions** (section 1.5) address the extent to which the domestic electricity consumers intend or use electricity efficiently as well as the extent to which the Energy @ Home educational intervention influences their actual electricity consumption. The **research hypothesis** for research question 1 evaluates the effect of behaviour and/or behavioural intentions on the actual electricity consumption of the domestic consumers. The **significance of the study** (section 1.7) discusses the additional knowledge the study will add to the body of knowledge in energy efficiency implementation as well as the shaping of future energy efficiency educational interventions. **The limitations of the study** (section 1.8) address the challenges of establishing the required control and experimental groups, access to homes, financial, security and time constraints experienced during this study. The **outline of the chapters** (section 1.9) provides the summary of the contents of the five chapters of this study.

Chapter 2: Literature review

2.1 Introduction

The focus on energy efficiency can be traced back to the 1970’s oil and energy crisis (Gardner & Stern, 2002). There was a lapse of focus on energy efficiency in the 1980’s until the late 1990’s. The research that has been conducted in the early 2000’s on this topic has a range of aspects to be considered, such as behaviour or behaviour change, technological advances and necessary educational interventions. The literature review conducted in this chapter addresses the abovementioned areas of research with a particular focus to energy efficiency.

The literature review consists of five parts, namely, the theoretical framework, the technological advances, the educational interventions, other factors that may affect behaviour towards energy efficiency and energy efficiency empirical studies. The literature review on the theoretical framework considers the behaviour or behaviour change approaches and selects the appropriate approach for this study followed by the review of the chosen approach and its determinants of behaviour. The review of the literature on the technological advances focuses on the latest and available energy efficient devices and/or appliances. The review of educational interventions literature looks at the energy efficient interventions, the scientific knowledge required and the relevance of the current South African National curriculum for learners with respect to energy efficiency. The literature review on other factors considers other factors that may have an influence on the behaviour towards energy efficiency such as legislation and habits. The final part of the literature review looks at the empirical studies and investigations that have been conducted on energy efficiency.

2.2 Behaviour and/or behaviour changing theories and/or approaches

Changing behaviour is sometimes oversimplified and yet it a complex process (Gardner & Stern, 2002). The literature review on behaviour or behaviour change theories and/or approaches yielded more than 40 theories and/or approaches (Aunger & Curtis, 2007). Some of these theories or approaches focus at the individual psychological level, some at the level of the environment, others consider target groups whilst others propose processes aimed at designing effective educational interventions. For simplicity and completeness, the grouping or classification of the approaches developed by Aunger and Curtis (2007) is used. The selection of the appropriate approach to be used for this study together with the justification thereof is based on the behaviour change objectives and key assumptions of the approaches. Aunger and Curtis (2007) set out the following classification or grouping of the theories and methods:

1. Single Construct approaches
2. Multi-Construct approaches
3. Segmentation approaches
4. Multi-level approaches
5. Community-Based approaches
6. Process approaches

A brief description of the approaches with specific focus on the behavioural change objective and key assumptions is given below. It includes examples of typical approaches that fall into the different classifications.

2.2.1 Single construct approaches

Single construct approaches assume that changing a single aspect of the person's psychology can have the desired effect on the target behaviour (Aunger & Curtis, 2007). In effect, these approaches consider a single construct and ignore other factors or constructs that may influence the behaviour. Typical examples of single construct theories are the Operant Conditioning methods developed by Skinner, (1938), the Cognitive dissonance method developed by Festinger (1957), the Social Norms method developed by Perkins (2003), the Effort-Reward Imbalance method developed by Siegrist (1996) and the Implementation Intentions method developed by Gollwitzer (1999). These approaches are generally simple and effective as shown by empirical evidence from the Social Norms approach (Perkins, 2003) but their application can be limited or restricted to problem behaviours that have a single cause (Aunger & Curtis, 2007).

Most of the Single-Construct approaches are simple and some, such as the Social Norms model and Implementations Intentions method have shown notable success (Perkins, 2003, Aunger & Curtis, 2007). They identify the real motivation that people are likely to have and automatically engage in: the need to be similar to others. However, according to Aunger and Curtis (2007), the Single-Construct approaches do not provide a clear means of deciding upon an intervention strategy because the message “to be the same as others” is too broad for this particular study. These approaches will require, for example, first establishing the “model” domestic electricity users that will then be used as the examples of how to use electricity efficiently, which was not done and hence will not be suitable for this study.

2.2.2 Multiple-Construct approaches

Multi-construct approaches predict behaviour by postulating relationships among various psychological constructs and behaviour, recognising the roles of a number of constructs and the impact on behaviour (Aunger & Curtis, 2007). In essence, they are aimed at determining which psychological constructs are significantly correlated to the target behaviour and assume that the behaviour can be determined from its causes. Examples of multi-construct approaches range from the Health Belief Model developed by Hochbaum (1956), the Theory of Reasoned Action and Theory of Planned Behaviour developed by Ajzen and Fishbein (1980), the Social Cognitive theory developed by Bandura (1998), the Information-Motivation Behavioural Skills model developed by Fisher and Fisher (1993) and the Elaboration Likelihood Model by Petty and Cacioppo (1986).

Although there is considerable variation between the theories with respect to what may be considered important or critical determinants of behaviour there are overlaps in some of the methods. For example, the Health Belief Method, the Theory of Planned Behaviour and the Social Cognitive Theory consider almost similar behaviour determinants to be important. Even with the variations, there is consensus about the importance of beliefs, attitudes, norms, intentions and environmental barriers as a whole (Aunger & Curtis, 2007). Multi-Construct approaches generally exhibit broader applicability and there is considerable empirical evidence for the utility of some of the methods and implementations based on these approaches are commonly viewed as effective (Bandura, 1998). The suitability of these approaches for this study is discussed in section 2.3.

2.2.3 Segmentation approaches

Segmentation approaches are concerned with identifying different portions of the target populations which are at different likelihoods of changing their behaviour by segmenting the population into a variety of classes (Aunger & Curtis, 2007). The most distinctive feature of the Segmentation approaches is the fact that the determinants of action vary for different individuals, depending on which segment they are in, suggesting that the most effective intervention can be quite different from one segment to another (Weinstein, 1988). Examples of Segmentation approaches are the Stages-of-Change method developed by Proschaka and DiClemente (1983) and the Diffusion of Innovation method developed by Rogers (1995). Segmentation approaches emphasise the difference in people or segments distinguished by particular features based on an existing database. Therefore the Segmentation approaches will not be suitable for this study as there is no database or segments that have already been created.

2.2.4 Multi-Level approaches

Multi-level approaches, also known as Ecological models, state that behaviour change requires simultaneous attention to psychological, physical and socio-political environmental determinants and that behaviour is highly constrained by environmental and other circumstances (Aunger & Curtis, 2007). These approaches recognise that people are embedded in their social and physical environments which impact their well-being. Examples of Multi-Level approaches include the Ecological approaches by Stokols (1992) as well as Hovell, Wahlgren and Gehrman 2002 and the Resilience approach by Bernard (2004). These approaches are empirically driven and hence they may be restricted to the database on which they are based on. According to Aunger and Curtis (2007) these approaches have not been widely used or tested and thus require additional exploration to verify their effectiveness.

2.2.5 Community-Based approaches

Community-Based approaches are concerned with the role of interventions that should be directed at increasing group-level solidarity or the introduction of organisations to foster the desired behaviour (Aunger & Curtis, 2007). Examples of Community-Based approaches include the Community Coalition Action Theory developed by Butterfoss and Kegler (2002), the Participatory Action Research developed by Kemmis and McTaggart (1988) and the Community Building and Organisation developed by Minkler and Wallerstein (2002). There is however limited evidence with respect to the fact that community participation leads to higher programme effectiveness and recent reviews of such community-led interventions have achieved limited results (Nilsen, 2006, Butterfoss, 2006). However, because Community Based approaches require the creation of organisations which can foster the change, focusing on how to engage in the interventions to the exclusion of outcomes (Aunger & Curtis, 2007), they are therefore not suitable for this study as there are no organisations that have been created.

2.2.6 Process approaches

Process approaches are concerned with specifying how the design and implementation of population level interventions should take place as well as going through the right steps in order to achieve the desired behavioural change (Aunger & Curtis, 2007). Examples of the process methods include the Social Marketing method by Kotler, Roberto and Lee (2002) and the Population Studies International ‘Bubbles’ Model by Chapman & Patel (2004). Implementation of the Process approaches requires both extensive formative research, monitoring and evaluation procedures for completeness, which can be expensive and time consuming (Aunger & Curtis, 2007). Process approaches requires six elaborative steps for formative research, monitoring and evaluation procedures which consume additional time and additional resources which may not be available for this study and hence the process approaches are not suitable for this study.

2.3 Selection of the appropriate approach

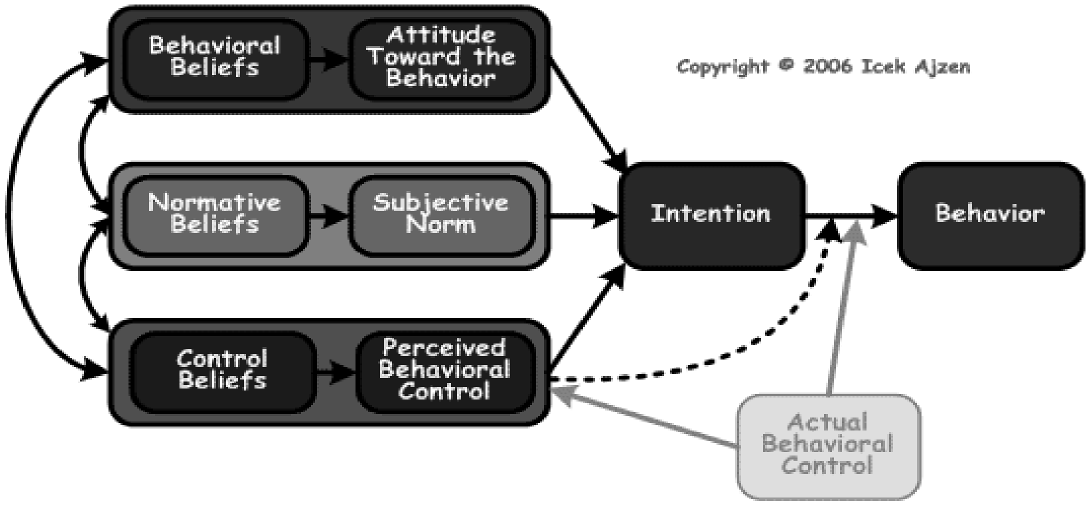
Multi-Construct and Multi-level approaches have some similarities in that Multi level approaches consider most of the Multi-Construct determinants including the environmental aspects. For example, in a 1991 National Institute of Mental Health (NIHM) workshop a distinct model of behaviour change which distilled insights (regarding the different methods) of participants through an undisclosed process was produced (Aunger & Curtis, 2007). The model that emerged suggested that three conditions are necessary and sufficient to determine behaviour, namely a strong intention, a lack of environmental constraints and having the necessary skills

(Fishbein, Bandura, Traiandis, 1992). The resulting model looked similar to the Theory of Planned Behaviour developed by Fishbein and Ajzen (1975).

The Theory of Planned Behaviour was thus selected for this study as the approach that incorporates most of the determinants of behaviour in the various Multi-Construct and Multi-Level models. The Theory of Planned Behaviour aims to establish correlations between the different determinants of behaviour (see section 2.4). It must be noted that measuring psychological constructs that are internal to the mind and thus not directly observable, is difficult, as such factors often exist below consciousness (Aunger & Curtis, 2007).

2.4 The Theory of Planned Behaviour as the theoretical framework for this study

The theory of planned behaviour developed by Ajzen (1996) as well as Ajzen and Fishbein (1975), is shown in Figure 2.1. It states that, human action is guided by three kinds of considerations, namely; behavioural beliefs (i.e. beliefs about the likely consequences of the behaviour), normative beliefs (i.e. beliefs about the normative expectations of others) and control beliefs (i.e. beliefs about the presence of factors that may further or hinder performance of the behaviour).



Source: Ajzen, 1980

Figure 2.1: The Theory of Planned Behaviour

In their respective aggregates, behavioural beliefs produce a favourable or unfavourable attitude towards behaviour; normative beliefs result in perceived social or subjective norm and control beliefs give rise to perceived behavioural control, the perceived ease or difficulty in performing a specific behaviour (Fishbein & Ajzen, 1975). In combination, attitude toward the behaviour, subjective norm and perception of behavioural control lead to the formation of a behavioural intention (Ajzen, 1996).

As a general rule, the more favourable the attitude and subjective norm, and the greater the perceived control, the stronger should be the person's intention to perform the behaviour in question (Fishbein & Ajzen, 1975). According to Ajzen, (1996), given a sufficient degree of actual control over the behaviour, people are expected to carry out their intentions when the opportunity arises. Intention is thus assumed to be the immediate antecedent of behaviour (Hrubes, Ajzen & Daigle, 2001). The following sections review the literature that focuses on the determinants of behaviour as indicated by the Theory of Planned Behaviour.

2.4.1 Behavioural beliefs and attitude toward the behaviour

Behavioural beliefs are beliefs about the likely outcomes of the behaviour and the evaluation of the outcomes and in their respective aggregates they produce a favourable or unfavourable attitude toward the behaviour (Ajzen & Fishbein, 1980). This view is supported by Schafer & Tait, (1986), where it is stated that attitudes towards behaviour are not isolated, but reflect the beliefs and values that a person holds. People generally weigh the consequences of their behaviour; if rewards are expected from a particular behaviour, then that behaviour is encouraged and if there will be penalties from a particular behaviour, then that behaviour is less likely (Schafer & Tait, 1986).

People, in general, maintain a consistent relationship between their beliefs, values and attitudes (Schafer & Tait, 1986). However it is not uncommon for people to have positive beliefs about the likely outcome of their behaviour as well as favourable attitudes towards that behaviour but still behave differently (Gardner & Stern, 2002). For example, people can have positive beliefs and favourable attitudes towards the use of energy from renewable sources, such as solar water heaters, but act against the installation of such devices because the initial costs are high or because the neighbours do not approve of the appearance of these solar water heaters on the roofs in their neighbourhood (or estate). The other factors that intervene between favourable attitudes and beliefs, such as normative and control beliefs are discussed in the sections that follow.

2.4.2 Normative beliefs and subjective norm

Normative beliefs are beliefs about the normative expectations of other and motivation to comply with these expectations which result in subjective norms (Ajzen & Fishbein, 1980). This notion is also supported by other social theorists who suggest that the context of behaviour is framed not just by the environmental factors that work at the level of individual behaviour, but also by “structural factors” which can influence entire groups of people to behave in a similar fashion (Aunger & Curtis, 2007). When people believe that their significant others within the community, such as the community leader or father, will approve of their behaviour, they are more likely to behave in the expected manner (Lam, 1999). For example, when people know that littering is generally not accepted within their community, it is unlikely that they would litter. Similarly social structures can also constrain people’s behaviour (Wilkinson, 2005).

2.4.3 Control beliefs and perceived behavioural control

Control beliefs are beliefs about the presence of factors that may further or hinder performance of the behaviour which give rise to perceived behavioural control (Ajzen & Fishbein, 1980). According to Hrubes, Ajzen and Daigle (2001), the more volitional control a person has over behaviour, the less important perceived behavioural control should be in that perceived behavioural control denotes the subjective degree of control over performance of the behaviour itself. People who believe they that they neither have the resources (e.g. money or technical knowhow) nor the opportunity (e.g. availability of energy efficient devices) to perform certain behaviour are unlikely to form strong behavioural intentions to engage in it even if they hold favourable intentions, and believe that important others would approve (Lam, 1999). For example, people who have positive attitudes towards energy conservation may want to implement some of the energy efficiency measures such as lowering the geyser temperature or buy the geyser timer switch. However if the person does not know how to reduce the temperature settings or does not know where to purchase the geyser timer switch or does not know how to install the geyser timer switch or does not have the financial means to purchase the geyser timer switch and/or services of a contractor to install the timer and/or change the setting, it is unlikely that the person would perform the desired action or behaviour (Laquatra, Pierce & Helmholdt, 2010). Positive and/or favourable attitudes and beliefs are more likely to lead to the desired behaviour when strong barriers to action are removed (Gardner & Stern, 2002).

2.4.4 Intentions and actual behavioural control

The combination of attitudes, subjective norm and perceived behavioural control leads to the formation of the behavioural intention (Ajzen & Fishbein, 1980). Hrubes, Ajzen and Diagle (2001) support this view by stating that intentions are closely related to behaviour and largely mediate behaviour. It appears that strong intentions towards a certain action predict high possibilities of behaviour or behaviour change. To the extent that perceived behavioural control is veridical, it can serve as a proxy for actual control and contribute to the prediction of the behaviour in question (Ajzen & Fishbein, 1980). Lam (1999) supports this view by stating that attitudes and perceived behavioural control have a significant influence on intentions and behaviour.

2.5 Technological advances

The past decade has seen a significant improvement in the advancement of energy efficiency in household and it is estimated that the use of the best currently available technology could reduce the present energy consumption by 30% (McCalley, 2006). Figure 2.2 shows the different consumption levels per activity in a typical household assuming that the household uses electricity for all the activities mentioned.

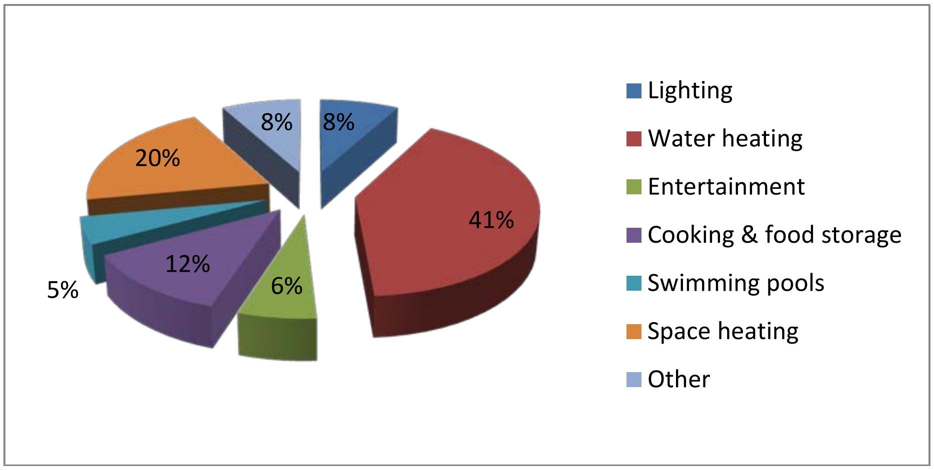


Figure 2.2: Typical consumption levels per activity in a household

The energy efficient devices listed in Table 2.1, such as, low flow shower heads, solar water heaters, heat pumps, compact fluorescent lights, have the potential to save between 10% and 40% of the electricity consumption (IEC, 2010). Despite this potential it appears that in order to "harvest" the advantages of the technical improvements it is essential to understand the fundamental principles underlying the interaction between the user and the systems (Gardner & Stern, 2002), as well as the comparison of the devices in the areas where they are used. A brief description of the devices listed in Table 2.1 is given in the subsections that follow.

Device	Use of device
Compact Fluorescent Lights (CFLs)	Lighting
Light Emitting Diodes (LED's)	Lighting
Solar Water Heater	Water heating
Instant water heaters	Water heating
Low flow shower heads	Showers
Geyser blankets	Water heating
Heat pumps	Water heating
Efficient pumps	Swimming pool and water features pumps
LED, Liquid Crystal Displays (LCD), Plasma TV's and monitors	Entertainment , security and computing
Automatic geyser controllers and timers	Water heating
Smart Meters	Electricity consumption metering
Energy efficient fridges	Food storage
Energy efficient microwave ovens	Cooking

Table 2.1 A typical list of energy efficient devices for households

2.5.1 Lighting devices

Lighting accounts for about 8% (see Figure 2.1) of a typical household's total electricity consumption when using the incandescent lights (NERSA, 2009). For ease of reference and simplicity a comparison of the different lighting devices with respect to electricity consumption, operating costs, device prices and on/off switching cycles is given in Table 2.2 (Design Recycle Incorporated, 2011) below. It is clear that incandescent lights consume more electricity and hence cost more to operate than CFL's or LED's. Figure 2.3 shows the typical lighting devices discussed.

Incandescent bulb

Compact Fluorescent Light bulb

Light Emitting Diodes (LED) bulb

Figure 2.3: Typical lighting devices

However the purchase of CFL's and LED's is between 3 and 8 times that of the incandescent lights (Design Recycle Incorporated, 2011). According to Design Recycle Incorporated (2011), LED's can produce light for up to 50 000 hours whilst incandescent lights can go up to about 1200 hours, which is approximately 42 times more lighting hours. This means that one LED light will outlast and out light 42 incandescent lights (assuming that the incandescent get replaced after failure). The purchase price of a typical LED light is about R 200 versus R 9 for the incandescent with the same lumens level (an exchange rate of USD 1 = R 8 has been used).

Measure	LED's	Incandescent bulbs	CFL's
Average lifespan **(Hours)**	50 000	1 200	8 000
Electricity consumed *(60 watt bulb equivalent)* **(watts)**	8	60	15
Electricity consumed per day – 5 hours of lighting **(kWh)**	0.04	0.3	0.075
Electricity Consumption costs per annum at R1 per kWh **(Rands)**	14.46	109.50	27.38
Purchase price per unit **(Rands)**	200	9	35
Instant lighting when switched on	Yes	Yes	There is a delay of up to 20 seconds required for warming up.
Heat emitted **(btu's/hour)**	3.4	85	30

Table 2.2 Comparison chart for incandescent bulbs, LEDs and CFL's

However 41 incandescent bulbs will be required for the same amount of lighting hours as the LED's which will cost about R 375 (assuming they were all incandescent lights were bought at R

9 each). There are other aesthetic considerations that may have an influence on the household's choice and behaviour such as the colour of the light, the type of fitting and the general look which vary from person to person. For instance some of the CFL's cannot be fitted in some of the existing light fittings and some people do not like the colour of the CFL lights.

2.5.2 Water heating

In a typical household, water heating accounts for about 40% of the total electricity consumption (NERSA, 2009). Typical devices that can be used for water heating are shown in Figure 2.4.

Water geyser Solar Water Heater Instant water heater Heat pump

Figure 2.4: Typical water heating devices

Solar water heaters, including those aided by a heating element, have the lowest operating costs even though the purchase price can be up to 5 times that of the conventional electric geyser. Heat pumps on the other hand are the most economical to operate but their purchase price can be up to 3.5 times that of the conventional electric geyser. For ease of reference and simplicity a comparison of the different devices is shown in Table 2.3 (Kwikot Limited, 2010) below.

Measure	Solar water Heater (1.4kW)	Heat pump (2.4kW)	Conventional electric geyser (4kW)	Instant water heater (6kW)
Typical Purchase price 200 liter **(Rands)**	12 000	18 000	5 000	3500
Electricity consumption (5 hours operation and 2 hours for the heat pump & instant water heater per day)*	7	4.8	20	12
Operating costs per annum at R1 per kWh ((5 hours operation and 2 hours for the heat pump & instant water heater per day)* **(Rands)**	3 577	1 460	7300	4380

***Note:** The normal operation of the heat pump and instant water heater is different

Table 2.3. *A comparison between the solar water heaters, heat pumps, conventional electric geysers and instant water heaters*

Solar water heaters have the additional advantage of being able to heat water even in the absence of electricity. In South Africa the Department of Energy is targeting to install 1 million solar water heaters by 2014 as part of the energy efficiency drive (NERSA, 2009). Instant water heaters and heat pumps may be more suitable for washing of dishes in the kitchen and can be economic to operate if they are operated for a few hours in a day because of their larger energy consuming heating element (typically 6kW). Some of the aesthetic considerations, such as the look, the location and weight of the water tank for solar water heaters that may influence the choice and behaviour of domestic consumers vary from household to household and may even be influenced by the rules and regulations of certain settlements. For example, some of the governance structures (e.g. Body Corporate of a Townhouse complex) prohibit the installation of solar water heaters in the dwellings of a particular housing complex.

Geyser controllers and timers can be as effective as the above mentioned water heating devices. For example if the domestic user switches the conventional electric geyser off in the morning approximately 2 to 3 hours after taking the bath and 2 hours before taking a bath in the morning, the water in the geyser will be heated to the set temperature, say 60 degrees Celsius. Conventional electric geysers can retain the water temperature around 50 to 55 degrees Celsius for about 6 to 8 hours (Kwikot Limited, 2010)). In this way the electricity that the geyser would consume when maintaining the temperature at the 60 degrees Celsius will be saved when the geyser is switched off. The efficiency or heat retention of the geyser can be further improved by the installation of a geyser blanket which enhances the temperature retention to up to 16 hours on a typical winter day and up to 22 hours on a typical summer day in South Africa (Kwikot Limited, 2010). Geyser controllers and timers can be set to automatically switch on and off the geyser in a manner that provides heated water as needed and save the electricity that would be otherwise used. These devices cost between R 150 and R 400 but the electricity savings they produce range from R 1200 to R 2200 per annum, assuming the operation durations indicated in Table 2.3 above (NERSA, 2009).

A typical shower with a normal flow shower head can use up to 20 litres per person showering whilst low flow shower heads can reduce the water consumption by up to 50% (CBS Interactive, 2012). A reduction in the amount of hot water used results in the reduction of hot water heated and electricity consumption. The purchase price of low flow water heads is in the same range as the cost of normal flow shower heads (Kwikot Limited, 2010)).

2.5.3 Entertainment and computing devices

Entertainment devices such as TV's or computer monitors account for between 6% and 8% of the total electricity consumption in a typical household. The different types of TV sets are shown in Figure 2.5.


CRT TV set


Plasma


LCD/LED

Figure 2.5: Typical TV sets discussed in Table 2.4

The range of TV sets considered is from 30cm to 150cm screen, but the Cathode Ray Tube (CRT) screens are limited to 80cm by design.

Measure	**LED TV**	**LCD TV**	**Plasma TV**	**CRT TV**
Power rating **(watts)**	50 – 100	60 – 200	200 – 325	80 - 390
Electricity consumption (5 hours of operation) **(kWh)**	0.25 – 0.5	0.3 - 1	1 – 1.625	0.4 – 1.95
Purchase price **(Rands)**	3 000 – 20 000	2 000 – 15 000	2 000 – 10 000	1 000 – 2 000
Operation costs for 5 hours of viewing at R1 per kWh per annum**(Rands)**	91.25 – 182	109.1 - 365	365 – 593.1	365 – 711.8

Table 2.4 A comparison of LED, LCD, Plasma and CRT TV's

Table 2.4 (CBS Interactive, 2012) above shows a comparison of the typical consumption of TV sets. Figure 2.5 shows typical TV sets being discussed in Table 2.4. Computer monitors have similar power ratings and purchase prices. The latest LED TV sets appear to have the least electricity consumption when compared to the CRT TV's that started production in the 1970's. However the purchase price of the LED TV's is more than 3 times of the CRT TV's.

2.5.4 Cooking and food storage devices

Cooking and food storage devices account for up to 12% of the total electricity consumption in typical households (NERSA, 2009). Table 2.5 (LG, 2011) is a comparison between the new and old cooking and food storage devices.

Measure	New Energy Efficient Fridge	Old Fridge	New Microwave oven	Old Microwave oven
Power rating **(watts)**	100	1000	650	1100
Purchase price 150 liter **(Rands)**	12 000	5 000	1000	600
Consumption (Fridge 6 hours per day and Microwave 1 hour per day) **(kWh)**	0.6	6	0.65	1.1
Operating costs per annum as per above usage at R1 per kWh **(Rands)**	219	2190	237.5	401

Table 2.5 A comparison of cooking and food storage devices

Although the new energy efficient fridge has a purchase price that is almost double that of the older models, the operating costs are 80% lower than the old fridge. Similarly, the purchase price of the new microwave ovens is double that of the old ones but the operating costs of the new microwave ovens are 50% less than the old microwaves.

2.5.5 Swimming pool and water feature pumps

In households with a moderate swimming pool size and a water feature the electricity consumed accounts for up to 5% of the total electricity consumption. Typical pumps are rated at between 1600 watts and 2000 watts (Eco Pools Solutions, 2011). These pumps can consume between 9.6 kWh and 12 kWh per day. The latest efficient pool pumps that are rated at 600 watts consume about 3.6 watts which is less than half the old pumps consumption. The purchase price of the new device is about R 1800 which is comparable to the price of the old devices of R 1700 (Eco Pools Solutions, 2011).

2.5.6 Electricity consumption meters

The conventional electricity meters are normally located outside the house and in some cases, outside the premises and as a result the electricity consumption is not visible to the consumer, they only get to see their consumption when they receive the electricity bill at the end of the month. From the electricity bill there is no way of telling which activity or appliance consumed what amount of electricity. Even though the prepaid electricity meters are normally located inside the house, sometimes in the kitchen area or anywhere else where they are accessible, they also do not present the consumer with the breakdown of their electricity consumption. The prepaid electricity meters just reflect the amount of electricity being consumed at any given point in time without any additional information. The latest meters with multiple functions and communication capabilities are called Smart meters. They have the capability of showing the consumption per device and can be used to switch devices on and off according to the household's requirements. With Smart meters the consumer can set the times for switching the geyser on and off. Smart meters can be set to indicate when the consumption is high and the user may decide what to switch off so as to limit electricity consumption. The Smart meters are thus capable of enabling visibility of electricity consumption and afford the domestic consumers with opportunities to control their electricity consumption. The purchase price of the Smart meters is about R 2000 and is comparable to the conventional meter purchase prices that range between R 1500 and R 2000.

2.5.7 Summary of technological advances

Most of the energy efficient devices and/or appliances have higher purchase prices when compared to the older and less energy efficient devices. However their electricity consumption levels and hence their operating costs are much lower than the older, less efficient devices. The higher initial costs have been cited as the main reason why the uptake of these technologies has not been at the expected levels (Gardner & Stern, 2002; McCalley, 2006; IEC, 2010).

2.6 Educational interventions

The literature review conducted on educational interventions was limited to the literature that specifically considered energy efficiency. Behavioural and social science research indicate that education alone or providing information is not enough to solve social problems; education can help but it is rarely sufficient (Gardner & Stern, 2002). However providing information or education plays a significant role in people's behaviour and the relevant educational interventions or information providing research is discussed below.

Individuals try to keep their beliefs and attitudes consistent, therefore providing information and changing what is believed is the first step in changing attitudes (Gardner & Stern, 2002). The challenge with changing the behaviour of people towards energy efficiency is that the actions that are required in changing the behaviour of domestic electricity consumers are sparsely spread throughout the day and thus reduce the sense of immediate action (Gardner & Stern, 2002). For example, cooking is an activity that takes place at certain times of the day, say in the morning and evenings whilst water heating by the geyser (that is not switched off) happens throughout the day without the domestic consumer necessarily knowing. When the information about the actions to be taken that will result in changes in the electricity consumption is infrequent the required behavioural change will not necessarily take place (Gardner & Stern, 2002). To change energy behaviour the information about what consumption results from what action (i.e. feedback) needs to be sufficiently frequent, specific and it may be more effective if it is available immediately before and after the action to save energy (Darby, 2006). Therefore immediate or properly timed feedback about the results of a particular action is essential in changing the behaviour.

Gardner & Stern (2002) concluded that providing information or education alone does not necessarily lead to a change in behaviour, other factors such as the socio-economic situation of the participants of the individuals must be considered. For example when low income consumers are required to fit CFL's which cost more than the incandescent bulbs, without any financial assistance, it is unlikely that they would change even though they have the information and/or knowledge about the efficiency of CFL's.   Even when information is provided barriers to action, such as financial constraints, must be removed for the required action and behaviour to take place.

The manner and language that is used to provide the information must be aligned with their everyday language of the domestic electricity consumers for it to be effective (Winett & Ester, 1983). Framing of the message, such as using words like "efficiency" or "saving" instead of "conservation" or "wasting" is as important and critical as the message. For example, an intervention conducted by Egan, Kempton, Lord & Payne (2000), where domestic electricity consumers were provided with information about the consumption of energy efficient households similar to theirs, consumers could not make the necessary comparisons because of the way the information was presented. Graphical displays of the comparison information may not necessarily be the most effective form of presentation as it is not necessarily framed or packaged in the language and manner that is understandable to the domestic electricity consumers.

In another study conducted by Gardner and Stern (2002) domestic consumers were sent information by mail, on what actions they have to take to save energy and thus reduce their electricity consumption. There was no statistically significant difference between those who were provided with the information and those who were not provided information with respect to changes in their behaviour and/or energy consumption. Their study recommended that a trained person such as an energy auditor or analyst should provide the information and/or explain the recommendations and answer the domestic consumer's questions for the educational intervention to achieve the required results.

2.6.1 Summary of the educational interventions

In summary, although the literature review was limited to energy efficiency educational interventions, it appears that education and providing information can play a meaningful role in behaviour change. For example, one of the impediments to action or behaviour change may be the lack of knowledge or information on what needs to be done and how it should be done (Gardner & Stern, 2002). Therefore the manner in which the information is provided, the language used in communicating the information, the source of the information as well as the timing of the information are important factors to consider in designing and implementing educational interventions.

2.7 Scientific knowledge necessary to understanding energy/electricity consumption

Children, in particular, those who still attend school, contribute significantly to the electricity consumption in a household (Darby, 2006). It is estimated the involvement of children in energy efficiency at home can result in consumption reduction of up to 30% and children also play an influential role in helping their parents or adults change their behaviour (Laquatra, Pierce & Helmholdt, 2010).

In South Africa the Curriculum and Assessments Policy Statement (CAPS), 2012 issued by the Department of Basic Education for grades R to 12 serves the purpose of equipping learners, irrespective of their socio-economic background, race, gender, physical ability or intellectual ability, with the knowledge, skills and values necessary for self-fulfilment, and meaningful participation in society as citizens of a free country. In the CAPS for Natural sciences for grades

R – 12, energy, and in particular electricity is prescribed from Grades 5 to 12 and energy efficiency is prescribed from Grades 6 to 12. The Grade 5 to 12 curriculums for natural sciences and physical science requires learners to understand the concept of energy, including electrical energy, machines, energy systems, electric circuits as well as solving electric circuit problems. Providing knowledge and information is important for changing behaviour towards energy efficiency (Gardner & Stern, 2002).

Adults who may not necessarily have the required scientific knowledge to understand electricity consumption already know some concepts that can be used to demonstrate the key principles of electricity consumption, such as the effort required to ride a bicycle uphill and/or on level ground (Laquatra, Pierce & Helmholdt, 2010). The triggering of people's attention to attitudes and beliefs that they already have, but may not be connecting to the situation they are in, is also supported by Gardner and Stern (2002). For example, the Energy Bike shown in Figure 2.6, is used as a generator to power up different electrical appliances (e.g. incandescent bulbs and compact fluorescent lights (CFL's), a hair dryer, a fan and a small television) can be used to build on the already existing knowledge of adults about the effort required when riding a bicycle. By showing the amount of effort required to light up an incandescent bulb versus a compact fluorescent light bulb, the concept of consumption, efficiency and conservation can be linked to an already known concept of pedalling a bicycle.

Figure 2.6: The Energy Bike

2.7.1 Summary of the scientific knowledge necessary to understand energy efficiency

In summary it is important to establish the current and existing scientific knowledge of the individuals especially adults in order to build onto the already known or existing concepts, such as, pedalling a bicycle. Children can play a role in the changing of behaviour towards energy efficiency as well as the implementation of energy efficient measures or behaviour. The current South African Curriculum and Assessments Policy Statement (CAPS), 2012 caters for energy efficiency and physical science education for Grades 5 to 12 and needs to cater for the Grades R to 4 in order to increase the understanding of energy efficiency even in the lower grades.

2.8 Other factors

People are embedded in social, political and physical environments that impact and influence their lives (Aunger & Curtis, 2007). Therefore changes in their social, political and/or physical environment can bring about changes in their behaviour. The changes in legislation, such as, banning of incandescent light bulbs or restrictions in the amount of electricity a household can consume may affect the behaviour of domestic electricity consumers. Similarly, learned automatism or habits, such as, switching on lights before opening curtains or blinds in room when people wake up in the morning contribute to the behaviour of domestic electricity consumers towards energy efficiency. The literature review that follows evaluates these factors.

2.8.1 Habits

Habits or learned automatisms are also an important determinant of behaviour. According to Aunger and Curtis (2007), about half of our everyday activities are performed habitually. For example, the switching on of lights as a person walk into a room and leaving the lights on as they walk out is a habit that does not use electricity efficiently. According to Webb & Sheeran (2006) habit performance is cued by the environment, so changes in attitudes and beliefs, for example, through informational messages, have little effect on health related behaviours likely to be performed habitually. Therefore successful programmes to change habitual behaviours will have to rely on changing the environmental context of behaviour (Aunger & Curtis, 2007).

2.8.2 Legislation

During the power shortages in January 2008, Eskom requested customers to reduce their consumption by at least 10% (Eskom, 2009). Although this was not a new law, it was a mandatory order which was obeyed by most customers especially the large consumers of electricity; they reduced their consumption by up to 11%. It is a common practice that when there are shortages, be it water or food, governments promulgate laws or regulations that are aimed at limiting or rationing the consumption of the items in shortage. For example, in the Netherlands, Germany and Denmark, the production or use of devices such as incandescent lights has either been limited or prohibited, because they are not energy efficient (IEC, 2010). People are known to change their behaviour rapidly when under duress; therefore constraining one’s choice can change behaviour (Young, 1993). In South Africa, for instance, it will compulsory for household consuming more than 1000 kWh per month to install electricity meters that have advanced functions that can limit the consumption in a household by only switching on essential appliances (Department of Energy, 2009).

In South Africa, prices of electricity are administered or regulated by government through its agencies. Some economics theories postulate that price increase is another parameter that can be used to reduce electricity consumption (McDougall & Mank, 1982). McCalley (2006) also considered the use of higher electricity prices as a way of discouraging wasteful use of electricity. Both authors conclude that even though higher prices can induce the desired behaviour and result in reduced electricity consumption, it is however the least preferred option by both domestic consumers and regulatory authorities because it is likely to only affect the low income consumer's non-discretionary spending and income.

2.8.3 Summary of other factors

In summary habits play a role in behaviour as human beings habitually perform up to half of their everyday activities. Changes in legislation such as the prohibition of certain devices, such as incandescent light bulbs, can bring about the required behaviour change.

2.9 Empirical studies on energy efficiency

Research on behaviour of consumers towards energy efficiency is scattered among the literature with a few approaches that hardly moved beyond the techno-engineering and economic approaches (Davis, Cohen, Hughes, Durbach, & Nyatsanza, 2010). The lack of research in this field can be traced to the historical focus on the technical engineering of supply-side (i.e. additional generation capacity) solutions to the society's energy needs. Some of the energy efficiency measures, such as the replacement of electric stoves by gas stoves, have not been properly documented but were implemented as short-term solutions to the power shortages that were experienced in 2008 (Eskom, 2009).

In a study conducted by Davis, et al, (2010) in the Eastern Cape and Western Cape, South Africa on the extent to which energy efficiency improvements get lost due to subsequent behaviour changes they concluded the following:

- Some of the factors impacting residential energy consumers' preferences – and thus their behavioural response to technology- include:
    - Awareness and attitudes of consumers towards energy consumption, and the associated feedback on their own consumption.
    - The derived benefit of energy efficiency usefulness for the consumer
- Consumers are not perfectly informed about energy efficiency, even where they are informed, they do not necessarily make perfectly rational choices on minimised costs.
- The availability of technical fixes, such as installation of compact fluorescent lights or solar water heaters, that would not require behaviour change does not guarantee their take up, even when they are guaranteed to result in money savings.
- The durability of the technology is as important as the durability of attitudes and behaviour.
- A major contribution of the research has been to highlight the importance of taking into account the behavioural response to energy efficiency as well as the need to conduct further research in this area.

In another investigation report by ACEEE (2011), it is acknowledged that even though the implementation of energy efficiency measures in the Cincinnati Region (USA), show considerable potential consumer energy cost savings, there is still limited implementation of relatively simple and inexpensive energy efficiency measures by residential consumers. The barriers to energy efficiency implementation, such as uncertainty about the level of savings that will result from certain actions or the higher upfront costs of energy efficient devices/appliances, may well be the reason for the lower uptake of energy efficiency across all residential sectors. The report further suggest that innovative programs and innovative program delivery methods must be developed for implementing the energy efficiency measures and further research is required in this area.

The review of the literature from the Behaviour, Energy and Climate Change (BECC) conference held in September 2011 in the United States of America, Foster and Mazur-Stommen (2012) provided the following summary of insights from the proceedings of the conference:

- There are new ideas and advances in behavioural sciences that require further exploration for the implementation of energy efficiency to succeed.
- Real-world interventions using behavioural techniques such as feedback, commitments, rewards, competitions, prompts, social norms and networks, can improve or enhance the implementation of energy efficiency, but more work still needs to be done to customise these techniques for each audience.
- The use of policy to influence behaviour at local, state and federal levels is proving to be effective in enhancing the implementation of energy efficiency measures by residential electricity customers.

Other countries such as Mexico, the United States of America, South Africa started programs of exchanging the old devices, such as fridges, incandescent lights with new devices either for free or at favourable rates. Some countries, such as Brazil, the United States of America, Norway, Germany, Denmark and Australia have started banning the use inefficient devices such as incandescent lights (IEC, 2010). In these countries, the empirical evidence shows that there is indeed a reduction of the order of 5% to 7% in the domestic consumers' consumption during the night time (IEC, 2010).

2.9.1 Summary of the empirical studies on energy efficiency

In summary, there appears to be limited research that has been done in South Africa on the behaviour of domestic electricity consumers towards energy efficiency and there is a need to do more. Research and reports from the Cincinnati region in the USA suggest innovative ways of implementing energy efficiency measures in the residential sector.

2.10 Summary and Conclusion

The literature review behaviour change methods and techniques, technological advances, other factors, scientific knowledge required to understand energy efficiency and empirical studies on energy efficiency indicate the following:

1. The **Theory of Planned Behaviour** (section 2.3 and 2.4) incorporates most of the components that affect behaviour and combines a number of the strategies that other behaviour change methods, approaches or techniques use and thus the appropriate theoretical framework for this study.

2. **Technological advances** (section 2.5) in areas such as, lighting, water heating and entertainment have produced devices that are energy efficient, with a potential of reducing the domestic electricity consumption by up to 30%. Most of the energy efficient devices/appliances have higher purchase prices when compared to the older and less energy efficient devices/appliances. However their electricity consumption levels and hence their operating costs are much lower than the older, less efficient devices/appliances.

3. Although the literature review was limited to energy efficiency **educational interventions** (section 2.6), it appears that education and providing information can play

a meaningful role in behaviour change. There are a number of educational interventions that have been used to influence the behaviour of domestic consumers including provision of information in a certain manner or format or language and/or the use of energy auditors or experts. No single strategy is sufficient by itself, the key issue is not how much can be accomplished by education alone, but what the place of education is, in a comprehensive strategy to change behaviour.

4. Although there may be a requirement for some kind of **scientific knowledge** (section 2.7) to facilitate the understanding of electricity consumption and energy efficiency the concepts that people already have can be used to demonstrate and build the required understanding of energy efficiency. Children can play a meaningful role in promoting energy efficiency, however the South African Curriculum and Assessments Policy Statement prescribes energy efficiency for Grades 5 to 12 and thus exclude the younger children in lower grades.

5. **Other factors** (section 2.8) such as habits play a role in behaviour as human beings habitually perform up to half of their everyday activities. Changes in legislation such as the prohibition of certain devices, such as incandescent light bulbs, can bring about the required behaviour change.

6. There appears to be limited **empirical studies** (section 2.9) or research that has been done in South Africa on the behaviour of domestic electricity consumers towards energy efficiency and there is a need to do more.

Chapter three: Research methods

3.1 Introduction

This chapter describes the research methods and procedures that were used in this study, such as, the research design and method, the population and sample, instruments used for data collection, the reliability and validity of the instruments, ethical considerations and the educational intervention.

This pilot study consists of two parts. In the first part, the extent to which the domestic electricity consumers intend to use and use energy efficiently was investigated using the Theory of planned behaviour. In the second part the extent to which the Energy @ Home educational intervention changed the domestic electricity consumers' behaviour towards energy efficiency was explored.

3.2 Part 1: Research question 1

Part 1 addresses research question 1, namely;

To what extent do the domestic electricity consumers intend to use and use electricity efficiently?

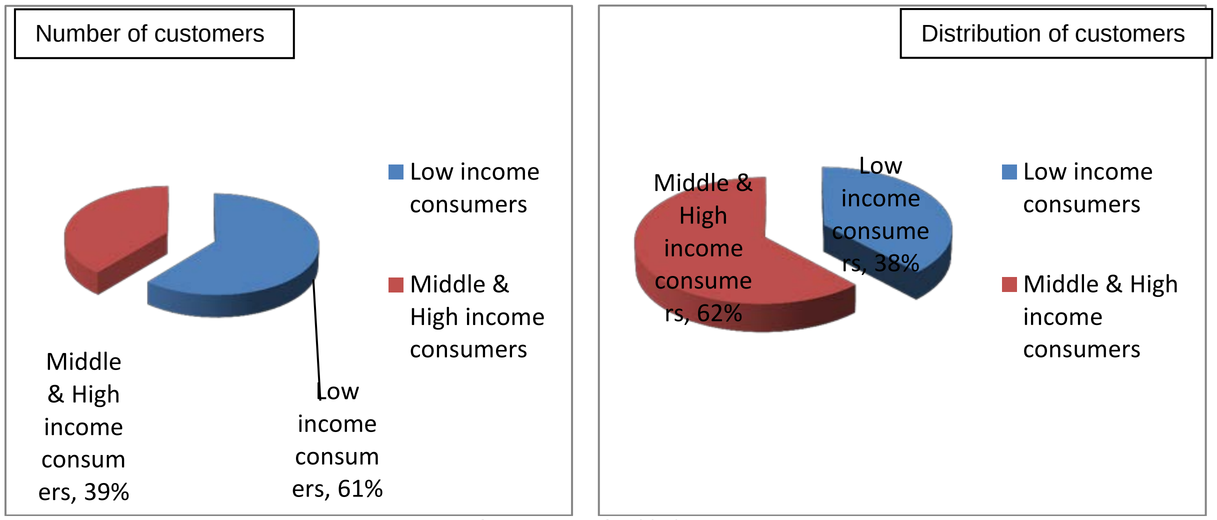
3.2.1 Research design

A co-relational research design was used to investigate the relationship between predictor variables and independent variables in the constructs of the Theory of Planned Behaviour. In this study the predictor variables are the attitude, subjective norm and perceived behavioural control while the independent variable is the behavioural intention.

3.2.2 Population and sample

There are approximately 10 million domestic electricity consumers in South Africa and more than 6 million of these consumers are located in the Gauteng Province (NERSA, 2009). Approximately 61% of the domestic electricity consumers are classified as low income consumers and the remaining 39% are classified as middle to high income consumers (see Figure 3.1).

Low income consumers account for about 38% of the total domestic electricity consumption and the remaining 62% is used by the middle to high income consumers. Low income consumers typically use up to 105 kWh per month whilst middle to high income use a minimum of 200 kWh per month. In most cases low income consumers use electricity mainly for lighting and entertainment (i.e. television, radio, music players), but rarely use electricity for cooking, except using the microwave oven and the kettle to boil water either for cooking or washing dishes or bathing (NERSA, 2009). Middle to high income consumers use electricity for a range of activities including cooking, lighting, space heating and/or cooling, water heating, swimming pool pumps and other water features.



Source: NERSA 2010

Figure 3.1: The current number and distribution of electricity consumption of the South African domestic consumers

This study was conducted in the Gauteng province. An advert, attached as Appendix 3.1 was sent out between 1 and 22 March 2009 via newspaper, radio and television adverts requiring people to participate in the Energy @ Home programme. There were 290 domestic electricity consumers that responded to the Energy @ Home advert. More than 75% of the respondents were located in the in the Johannesburg, Pretoria, Sedibeng and Midrand areas. The convenience stratified random sampling method was used to select 61 participants (out of the 290 respondents. A convenience stratified sample is drawn from whichever members of the population available, whether the sample is representative or not (Groves, 2010). The selection of the participants for convenience stratified samples was based on the knowledge of the population (i.e. author's own knowledge) as well as the knowledge of experts from Eskom and NEEA (Kraft & Furlong, 2007). In this study the participants who consumed more than 200 kWh per month were selected because they use more energy per month when compared to the low income participants and were seen to have the potential to reduce their electricity consumption.

From the 61 participants 42 were contacted in order to determine the participants' actual behaviour. The author only managed to contact the 42 participants due to the fact that the telephone contact was made a year after intervention and some of the contact details had changed.

3.2.3 Instruments

Two instruments were used for this part of the research study, namely; a questionnaire and a telephone response log.

3.2.3.1 Questionnaire

The questionnaire (see Appendix 3.2) was designed using the manual for developing the Theory of Planned behaviour questionnaire by Francis, et al, (2004). The manual specifies that the questionnaire must be designed for a specific target population, who will be performing a specific action, in a specific context and within a given time period. In this study the target population are the domestic electricity consumers, who will be required to use energy efficiently in their homes or households all the time.

The questionnaire consists of 46 questions and is divided into Section A and B. Section A deals with the general or background information about the participant such as the current costs of electricity consumption, the activities electricity is used for, the number of people in a household, the type of electricity meter used, whether information or tips about energy efficiency was received, cost of consumption per unit or month (see Appendix 3.2). Section B of the questionnaire which is based on the Theory of Planned Behaviour, has 4 subsections that use the 7 point Likert scale as well as negative and positive scale with a range between -3 and + 3 (effectively 7 points) which are discussed below.

The first subsection measures the behavioural intentions direct (BID) towards energy efficiency and is labelled BID1 in the questionnaire. Although the Theory of Planned behaviour shows that the behavioural intention is an aggregated sum of the attitude, subjective norm and perceived behavioural control, in some instances it is possible to observe the actual intended performance directly and this direct measurement is a useful tool for comparing the results (Francis, et al, 2004).

The second subsection measures attitudes (AD) and subjective norm (SND) and perceived behavioural control (PDCD) directly and are labelled as AD1, SND1 to 4 and PBCDS/C1 to 3 respectively. The attitude direct measurement uses bipolar adjectives such as *worthless or useful,* where *worthless* has a score of 1 and *useful* has a score of 7 on the Likert scale. The subjective norm direct (SND) measurement uses statements requiring responses such as *strongly disagree* or *strongly agree*, where *strongly disagree* has a score of 1 and *strongly agree* has a score of 7. The perceived behavioural control direct measurement uses bipolar adjectives such *difficult* or *easy*, where *difficult* has a score of 1 and *easy* has a score of 7. The perceived behavioural control measurement is divided into two sub-parts as recommended by the manual for developing the Theory of planned behaviour questionnaire (Francis, et al, 2004), namely; the self-efficacy and controllability measurement in order to assess the following,

- Self-efficacy measurement: The person's perception about the difficulty of performing the task and the confidence of performing the task.
- Controllability measurement: The factors beyond the person's control that determine the behaviour.

The third section of the questionnaire measures the indirect measurement of attitudes (AIBB = Attitude Indirect Behavioural Belief), subjective norm (SNINB = Subjective Norm Indirect Normative Belief), perceived behavioural control (PBCIB = Perceived Behavioural Control

Indirect Belief). The perceived behavioural control was not split in the indirect measures. This was done in order to limit the length of the questionnaire. The indirect attitude measurement (AIBB) is obtained by using statements that require responses such as *unlikely* or *likely*, where *unlikely* has a score of 1 and *likely* has a score of 7. The indirect subjective norm measurement (SNI) uses statements that require responses such as *strongly disagree* or *strongly agree*, where *strongly disagree* has a score of 1 and *strongly agree* has a score of 7. The perceived behavioural control use statements that require responses such as *less likely* or *more likely,* where *less likely* has a score of 1 and *more likely* has a score of 7.

The fourth section of the questionnaire measures the outcome evaluations of the indirectly measured attitude (i.e. AIOE = Attitude Indirect Outcome evaluation), the subjective norm (i.e. SNIOE = Subjective Norm Indirect Outcome Evaluation), the perceived behavioural control strength (i.e. PBCIS = Perceived behavioural control strength). The outcome evaluations are evaluations of the expected attitude when a certain attitude is adopted. For example, AAIE1 is the outcome evaluation of the attitude AIBB1 in subsection 3 above. The attitude outcome evaluation (AIOE) used statements that required responses such as *bad* or *good,* where *bad* was assigned a score of -3 and *good* was assigned a score of +3. The -3 to +3 scale is used instead of 1 to 7 to enable the participants to express their positive or negative expectations is recommended by the manual for developing the Theory of planned behaviour questionnaire (Francis, et al, 2004). The subjective norm outcome evaluation (SNIOE) used statements that required responses such as *not at all* or *a lot*, where *not at all* was assigned a score of -3 and *a lot* was assigned a score of +3. The perceived behavioural control strengths (PBCIS) used statements that required responses such as *strongly disagree* or *strongly agree*, where *strongly disagree* has a score of -3 and *strongly agree* has a score of +3.

3.2.3.2 The telephone response log

The telephone response log (see Appendix 3.2.1) was developed to triangulate the behavioural intentions indicated by the participants in section B of the questionnaire. The participants were required to indicate what their current electricity costs are and whether they implemented the energy efficiency measures they intended to implement.

3.2.4 Reliability and validity

Reliability and validity are two fundamental elements in the evaluation of measurement instruments. Reliability is concerned with the ability of an instrument to measure consistently whilst validity is concerned with the extent to which an instrument measures what it is intended to measure (Tavakol & Dennick, 2011). The reliability of the research results does not depend on the trustworthiness of the participants' answers but on the validity of an instrument used to measure. Hence an instrument cannot be valid unless it is reliable (Tavakol & Dennick, 2011).

The questionnaire was pre-tested with 6 NERSA employees and 15 domestic consumers based in Johannesburg. However because the number of participants was not large enough to perform simple linear regression analysis the reliability of the instrument was taken at face value.

As part of ensuring that the questionnaire measures what it intends to measure the questionnaire was sent to two experts in the field of mathematics, science and technology education that have experience in the use of the Theory of Planned behaviour based questionnaire. The experts provided model questionnaires of studies they had conducted that used the Theory of Planned Behaviour that were used to enhance this questionnaire. The suggestions, additional information and insights as well as the model questionnaires provided by the experts improved the structure of the questionnaire. With the suggested modifications and additions the experts' views were that the questionnaire will measure what it intends to measure.

The telephone response was validated against the current electricity costs of the participants and electricity units used. The participants provided the electricity costs and the electricity consumption per month at the time of making the telephone call, which was a year after the Energy @ Home program, as indicated in their electricity bills. These units were compared with the units that were indicated at the start of the Energy @ Home program to confirm the reductions in electricity costs and consumption. The reliability and validity of the Telephone response log of the electricity costs and consumption was taken at face value. This was done because the participants were not always available at times when the author could verify the electricity bills.

3.2.5 Data collection

The questionnaire was mailed and/or hand delivered to the 61 participants. Some of the participants requested assistance in completing the questionnaire and others completed the questionnaire telephonically. The telephone response log was used during the telephone conversations to record the responses of the 42 participants that were contacted.

3.2.6 Data analysis

Section A of the questionnaire presents the percentages of the participants that fall into the different groupings and categories. Some of the data is presented in bar charts.

Section B of the questionnaire is analysed by using the simple regression analysis technique and calculation of the mean and standard deviation where applicable. The computer software used for both the simple linear regression analysis and calculation of mean and standard deviation is the Statistics Analysis Software (SAS). Simple linear regression and sometimes multiple co-relational analyses is an appropriate method to be used when analysing the results of the questionnaire (Lam, 1999). Simple linear regression analysis is used to determine if there is a linear relationship between the continuous variables (i.e. the predictor variables and the response variable). In this study attitude, subjective norm and perceived behavioural control were predictor variables and behavioural intention the response variable. The best-fit (i.e. least squares) linear regression equation is calculated such that the distance between the observed data points and the predicted values estimated by the regression equation are minimised. Simple linear regression technique was applied to the results obtained from the direct measurements of attitude, subjective norm and perceived behavioural control (i.e. the second subsection of section B of the questionnaire) and the results obtained from the indirect measures (i.e. third and fourth subsection of the questionnaire).

The data was screened for errors and responses that may be outside the allowed ranges. All the scales that had the negative and positive scale such as, -3 to + 3 were re-coded to 1 to 7, where -3 was re-coded to 1 and +3 re-coded to 7. All the products obtained from the indirectly measured attitude, subjective norm and perceived behavioural control were normalised to fall between 1 and 7 (where 1 denotes *weak* and 7 denotes *strong)*, for comparison with the scores from the directly measured attitude, subjective norm and perceived behavioural control.

The data from the telephone response log were analysed by comparing the behavioural intentions with actual behaviour of the participants over the one year period. For example, the participants who indicated that they will implement measures such as installing CFL's were required to confirm that they indeed installed the CFL's. Participants were also required to provide details from their latest electricity bill (or units bought for prepaid customers), such as the monthly electricity units consumed or average monthly consumption as reflected in the electricity bill and the costs for the month or average monthly costs. The data is presented in bar charts.

3.3 Part 2: Research question 2

Part 2 of this study addresses research question 2, namely:

To what extent did the Energy @ Home educational intervention change the domestic consumers' behaviour?

This part of the pilot study was conducted mainly in the Johannesburg area of the Gauteng province of South Africa over a 13 weeks period starting on 1 March 2010 ending on 31 May 2010, alongside a television program called Energy @ Home. The Energy @ Home television programme was an Eskom and the National Energy Efficiency Agency (NEEA) sponsored project. The Energy @ Home programme in itself was used as the educational intervention for selected participants.

3.3.1 Research design

In this part of the research the participants were required to complete the Energy audit before and after the educational intervention as well as record their electricity consumption before and after the educational intervention.

3.3.2 Sample

Out of the 61 respondents to the questionnaire, the convenience stratified random sampling method described in section 3.4.2 was used again to select participants for the Energy @ Home educational intervention. The 11 respondents selected, represented the typical categories of domestic consumers with respect to the number of occupants in a household, the income and consumption levels were as follows:

1. A large family (2 parents and 4 children)
2. A young couple
3. A home business
4. A retired couple
5. A commune
6. A single mother (with children)
7. A small family living in a large house
8. An extended family
9. A family with teenagers
10. A family living in a cluster
11. A family without children.

The selection of the participants to the Energy @ Home educational intervention was done by the author, the Energy auditor and experts from Eskom and NEEA, based on their knowledge and experience/expertise. The participants chosen for the Energy @ Home television programme were those whose households have the opportunity to reduce their consumption if they act by either installing energy efficient devices or appliances and/or by changing their behaviour. (It must be noted that also the low income consumers can install energy efficient devices or appliances or change their behaviour towards energy efficiency). Further, the ease of access to the households and the availability of the participants during the proposed times of the intervention was also a contributing factor in the choice of the participants. Due to financial and time constraints the Energy @ Home program decided to only focus on the respondents in the Johannesburg area.

3.3.3 Instruments

There were two instruments used in this part of the study, namely; the Energy audit log (see Appendix 3.3.1) and the Electricity consumption log (see Appendix 3.3.2).

3.3.3.1 The Energy audit log

The Energy Audit log consists of the Energy audit results before and after the Energy @ Home educational intervention. For example, the calculations from the Energy auditor for the energy efficient CFL versus the incandescent light switched on for 5 hours (which is typically the time period lights are on for in a room) are as follows:

Electricity consumption CFL per day per light bulb	=	11 watts x 5 Hours
	=	55 watt-Hour (or 0.055 kWh)
And the electricity costs per day per light bulb	=	0.055 kWh x 0.6 c/kWh
	=	0.033 c
Therefore, electricity costs per month per light bulb	=	= (0.033 c x 30days) = 0.99 c

In comparison with the incandescent lights the costs are:

Electricity consumption incandescent light	=	60 watts x 5 Hours
	=	300 watt-hour (or 0.3 kWh)
Electricity costs per day per light bulb	=	0.3 kWh x 0.6 c/kWh
	=	0.18 c
Therefore electricity costs per bulb per month	=	(0.18 c x 30) = 5.4 c

The tariffs used are the tariffs that were applicable in 2010.

Therefore by using a CFL's can save up to 4.41 c (or 82%) per month per bulb. In a typical household there are at least 5 light bulbs that are switched on for a period of approximately 5 hours per day. Another example that was used was the low flow shower head that uses 60%

less water than the normal shower head. The geyser therefore heats up 60% less water and therefore saves electricity.

3.3.3.2 The Electricity consumption log

The Electricity consumption log (see Appendix 3.3.2) was developed to represent the weekly recorded readings of electricity consumption by the participants from their electricity meters. The Electricity consumption log contains a total of 7 readings of weekly electricity consumption discussed in section 3.3.4.

3.3.4 Reliability and validity

The comparison of the current monthly bill with the Energy Audit before the Energy @ Home educational intervention as well as the comparison with the actual weekly readings was used for the reliability and validity of the instruments. The reliability and validity of this instrument was taken at face value and supported by the Eskom and NEEA experts' opinion of the validity of the results.

3.3.5 Data collection

For the Energy audit log participants were required to complete both the audits before and after the Energy @ Home educational intervention. The data captured by the Energy audit for each household indicated the consumption per activity or appliance as well as the total consumption of the household for both Energy audits was calculated as follows:

Electricity costs (cents) = Power rating of the appliance (kW) X Electricity unit costs (c/kWh) x usage time (hour)

Where kW is kilowatts.

The results of the total consumption per household were then captured in the Energy Audit Log.

For the Electricity consumption log the participants were required to record their electricity consumption on the Electricity consumption log three weeks before the intervention so as to establish their base consumption. After the Energy @ Home educational intervention the participants were required to take weekly readings for four weeks. In total there were at least 7 electricity meter readings that were taken from each household. Participants also sent their electricity meter readings to the author for record keeping.

To determine the extent to which the Energy @ Home educational intervention had changed the participants' behaviour, the amount of electricity saved in kWh, which was converted to the monetary amount using the current charges and/or tariffs for electricity as reflected in the household's electricity bills were used to calculate the amount of money spent by the participants.

3.3.4 Data analysis

The results from the Energy audit before the Energy @ Home educational intervention were compared with the results of the Energy audit after the intervention and the difference was then taken to be the intended savings from using electricity efficiently. Also the data that is captured in the first audit was used to indicate to the households' areas or activities in their consumption where they could save electricity either by changing behaviour or installing energy efficient devices or appliances or both (see section 3.4.2)

The average weekly consumption obtained from the Electricity consumption log for the period before the Energy @ Home educational intervention was calculated from the three electricity meter readings and the average weekly reading after the Energy @ Home educational intervention was calculated from the four electricity meter readings taken. The difference between the average weekly consumption taken before and after the educational intervention per household was then either the savings in electricity consumption if positive or increase in electricity consumption if negative.

3.4 The Energy @ Home educational intervention

The Energy @ Home educational intervention was conducted over the 13 weeks duration of the Energy @ Home program and consisted of a total of up to 5 hour educational intervention sessions per participant or household. The two educational interventions sessions (i.e. Session 1 and Session 2) which are discussed in section 3.5.1 and 3.5.2 were conducted as two separate sessions for each household. The educational intervention was focused on the owners of the household (i.e. parents, partners, owners) and rarely included other people within the household. In order to design an appropriate educational intervention to fit with the level of education of the participants the selected participants were asked additional questions via a questionnaire attached as Appendix 3.4.1. The participants completed this questionnaire and returned it before the start of the Energy @ Home educational intervention. The additional information required in this questionnaire related to the following aspects:

- Level of physics education of the participant
- Level of physics education of the parents
- Voltage level of the electricity supply in South Africa

The educational intervention was then customised for each participant to fit with the level of education the participants indicated.

3.4.1 Session 1 *(2 hours 30 minutes per household)*

In session 1 the participants were required to complete the Energy Audit of the household. The Energy Auditor, developed by Eskom, calculates the electricity consumption of a household.

Each household was required to provide a reasonable estimate of their usage of all appliances in the household in terms of time (i.e. minutes or hours). For example the participants were required to indicate how many times they boil water per day in a kettle and how much water they boiled; or how many times a day they take a bath or shower; or whether the geyser is switched on/off at certain times and what the temperature setting of the geyser was. By requiring reasonable estimates of their usage of electricity per activity or appliance, the participants were being made aware of what they were consuming and whether there is an opportunity to alter their level of consumption by changing their behaviour or appliances. The participants were also required to provide the power rating of the different appliances (which are written on the appliances) they use in the household. By so doing the participants were being made aware of another important feature they must consider when they purchase appliances.

The results were presented to the participant showing the different consumption levels of the different devices or appliances, as shown in Appendix 3.3.1. At the end of session 1, each participant was shown the areas or activities in their consumption where they can use electricity efficiently and thus reduce their electricity consumption either by installing energy efficient devices or changing their behaviour or both. Each participant was then required to consider actions they should take in order to reduce their consumption and prepare for the second session and second energy audit.

3.4.2 Session 2 *(2 hours 30 minutes per household)*

In this session the participants were shown some of the energy efficient technologies such as, CFL's and LED lights and low flow shower heads. The participants were shown via the Energy auditor the differences in consumption between the energy efficient lights and the incandescent lights as well as the difference in the amount of water that low flow shower heads use when compared to the normal flow shower heads. Further, participants were shown the amount of electricity that can be saved by reducing the usage time. For example, the participants were shown the amount of electricity that can be saved by switching off lights in unused rooms (without compromising the safety and security of the household) and by lowering the geyser temperature by at least one degree. Other demonstrations of changes in behaviour or lifestyle included the following activities:

- A comparison of water used when taking a bath compared to the water used when taking a shower with a low flow shower head as well as the concomitant electricity usage reductions. For example, by showering using a low flow shower head instead of taking a bath, both the water and electricity consumption can be reduced by more than 20%.
- The amount of electricity consumed by a kettle when boiling water when it is full and when it is half full by measuring the time it took to boil a filled kettle versus a half filled kettle.

Other participants who had air-conditioners were also shown the reductions in energy consumption that can be achieved by lowering the air-conditioners' temperature by a degree or two and still derive the same comfort levels as well as the advantages of better insulation around the house.

The participants then completed the second energy audit after they were provided with information and tips on how to save electricity, indicating the areas and activities where they intended to reduce their consumption either by changing their behaviour and/or install energy efficient devices or appliances. The participants indicated possible savings they intend to implement ranging from the change in behaviour, such as showering instead of taking a bath or switching off the geyser and towel heaters in the bathrooms during the day, switching off lights in unused rooms, reducing their pool pumps operating times, opening curtains in the mornings instead of switching on lights and so on.

The participants were then required to complete the second Energy audit showing the changes they intended to make. Participants were then required to implement the energy efficiency measures they indicated in this Energy audit.

All participants were given a “power pack” which consisted of compact fluorescent bulbs (up to 5), a geyser blanket, a low flow shower head, solar power outdoor lights (up to three). The participants that had already installed CFL’s chose the low flow shower heads instead. Two of participant who were already in possession of the items contained in the “power pack” were given a solar cooker and an electronic display meter (called the Eco Eye that indicates the instantaneous consumption in the house at any given time).

At the end of this session participants were asked the following questions (see Appendix 3.4.2):

- Whether the participant checked the Energy audit calculations for correctness
- The lessons learnt from the Energy @ Home educational intervention
- Whether they would suggest that the information they received should be given to others
- Whether their electricity consumption was reduced after the Energy @ Home educational intervention.

3.5 Ethical considerations

The notion of ethics is a complex construct, imbued with particular values and beliefs that influence how we approach research (Graham & Fitzgerald, 2010). Researchers need to be aware of the general agreement about what is proper and improper in scientific research (Gordon, Levine, Mazure, Rubin, Schaller & Young, 2011). Research ethics are at their simplest, “principles of right and wrong conduct” that can be conceived as a set of moral principles and rules of conduct woven through every aspect of research, shaping the methods and findings (Powell, 2011). The participation of the participants in the Energy @ Home program was voluntary. All participants agreed and consented, in writing, to being video recorded and that the video recordings would be broadcast to a wider audience across South Africa. None of the participants were forced to participate and they completed the questionnaires on their own, with the exception of one participant who required assistance. The participants were informed about the purpose of the study via a letter that was attached to the questionnaire and all participants voluntarily participated. The findings revealed in this study were the true results of the study. The study was conducted in a manner that would avoid harm to any of the participants.

3.6 Summary of the chapter

This chapter provided details of the co-relational research design for the first part of this study, the **population and sample** that was selected using the convenience stratified random method. The **questionnaire** that was based on the Theory of Planned Behaviour, **the telephone response log, the Energy audit log** and **the Electricity consumption log** are the instruments used to collect data research question. The **data analysis** used the simple linear regression analysis technique for the first part of the study and evaluation of the differences in the intended electricity consumption reductions and actual electricity consumption reductions. The **Energy @ Home educational intervention** created the awareness and provided information about the electricity consumption of each household per activity via the **Energy audit** as well as possible areas of reducing electricity consumption either by installing energy efficient devices or by changing behaviour. As part of the **ethical considerations** all the participants consented to the use of their information as well as the videos that were recorded during the Energy @ Home intervention.

Chapter 4: Results and Findings

4.1 Introduction

This chapter presents the results from the collected and analysed data for each of the research questions. The results are presented in terms of Research question 1 results and Research question 2 results. The final part of the chapter answers the research questions and tests the hypothesis. However for the completeness of presenting the information gathered additional information obtained during the Energy @ Home intervention regarding the lessons learnt and the results of the energy audits before and after the Energy @ Home educational intervention is presented in section 4.8.

4.2 Results - Part 1: Research question 1

Research question 1 deals with the extent to which the domestic electricity consumers intend to use and use electricity efficiently. There were 61 participants in this part of the study. The results that were obtained from the questionnaire are presented as follows:

Section A – The general information

Section B – The Theory of Planned Behaviour constructs

The results obtained from the Telephone response log are presented in Section C – The Telephone response log.

4.2.1 Questionnaire: Section A – The General Information

Section A contains the general information of the participants regarding the following measures:

- The average monthly electricity costs.
- The activities electricity is used for.
- The number of people per household.

- The type of electricity meter used.
- Whether energy efficiency information is received or not.
- The monthly average electricity usage
- Whether there has been a decrease or increase in the electricity consumption over the past 12 months (prior to the Energy @ Home program).

The results for each of the measures mentioned above are discussed in the sections that follow.

4.2.1.1 The average monthly electricity costs

Out of the 61 participants, 18% (i.e. 11) have monthly electricity costs that exceed R 2000, while 21% (i.e. 13) participants pay between R 1000 and R 2000 per month. Participants that pay between R 500 and R 1000 per month accounted for 35% (i.e. 21) of participants compared to the 26% (i.e. 16) who paid between R 100 and R 500 per month as depicted in Figure 4.1.

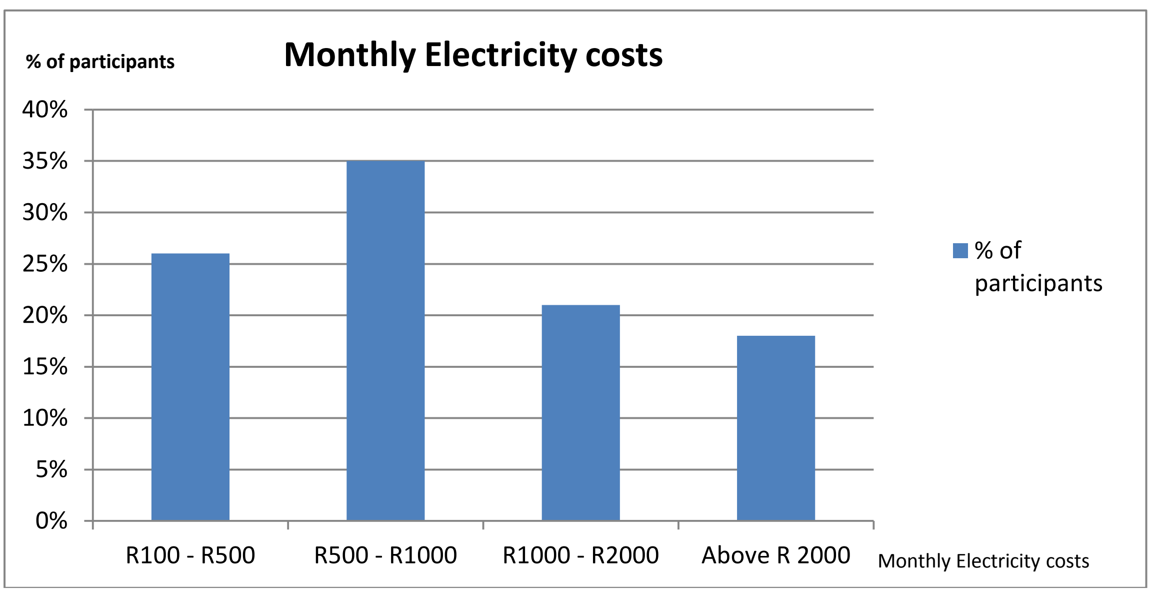
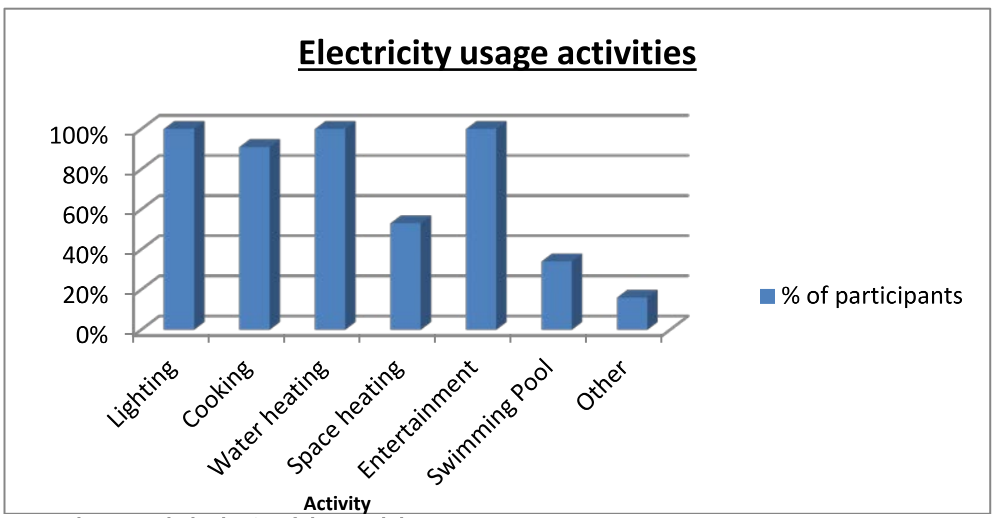


Figure 4.1: Monthly electricity costs of participants

In this study participants were not required to indicate their monthly income nor what the percentage of their electricity cost is to their total expenditure. In the literature review there was no emphasis placed on the percentage electricity costs relative to the total expenditure.

4.2.1.2 The activities electricity is used for

The participants used electricity mainly for lighting, cooking and entertainment. Approximately 91% (i.e. 55) of the participants use electricity for water heating as shown in Figure 4.2. Space heating was used by 53% (i.e. 32) of the participants compared to 34% (i.e. 21) who use electricity for swimming pools and/or other water features. At least 16% (i.e. 10) of the participants use electricity for home offices and other activities.



Note: The y – axis is the % of the participants

Figure 4.2: Electricity usage activities of participants

Electricity is used for similar activities by domestic or residential consumers in most countries with the exception of space heating, water heating and cooking which is done by gas in the developed countries (IEC, 2010)

4.2.1.3 Number of people per household

In this study 64% (i.e. 39) of the participants were from households with 2 to 5 people in the household and 11% (i.e. 7) were from households with more than 5 people as shown in Figure 4.3. Participants with 1 and 2 people in their households accounted for 9% (i.e. 5) and 16% (i.e. 10), respectively.

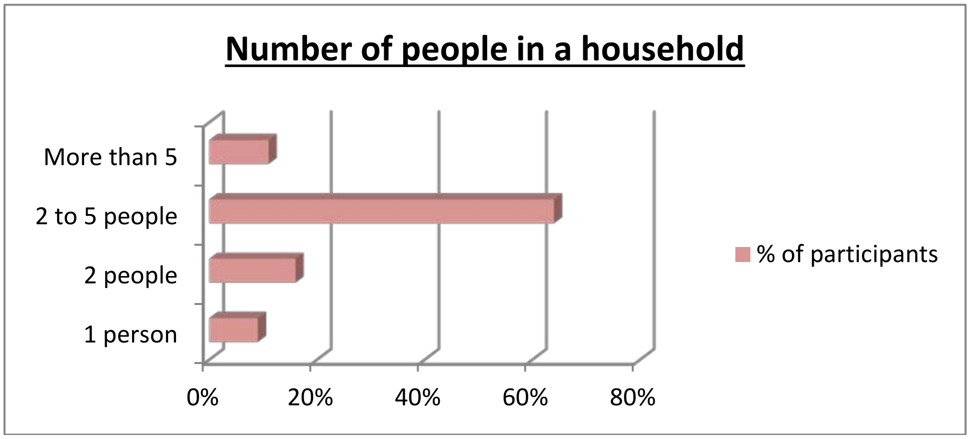


Figure 4.3: The number of people per household

These results are comparable to the results of most countries around the world where there are two parents and a child or children in a household (EIA, 2010).

4.2.1.4 Type of electricity meter used

Conventional meters, that are remotely located from the house and the premises in some cases, are installed in 70% of the households who participated in this study whilst Prepaid meters that are normally located inside the house, are installed in 30% of the households as depicted in Figure 4.4.

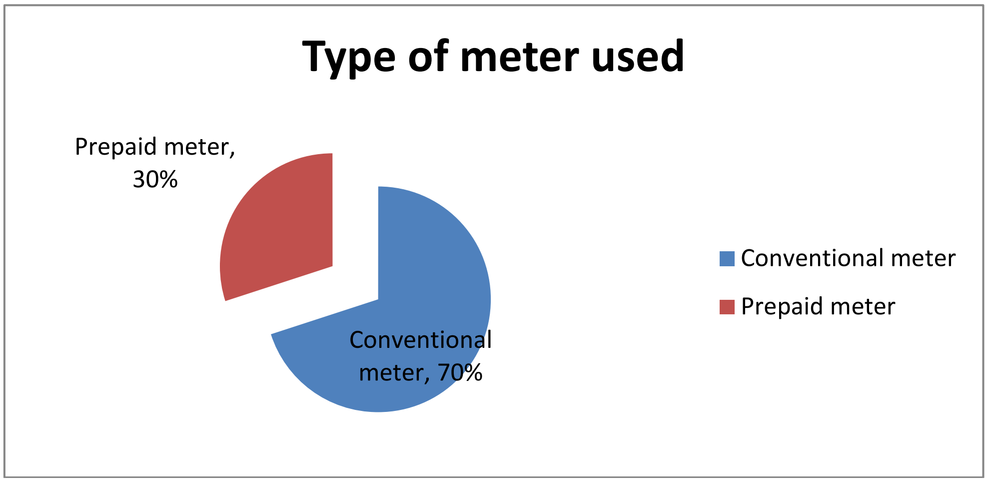


Figure 4.4 The type of electricity meter used in the household

There is a migration from conventional electricity meters to advanced metering technologies in the developed countries and an increase in the prepaid meters in the developing countries (IEC, 2010)

4.2.1.5 Whether energy efficiency information is received or not

As much as 75% of the participants received information or tips about energy efficiency compared to 18% that did not receive the information.

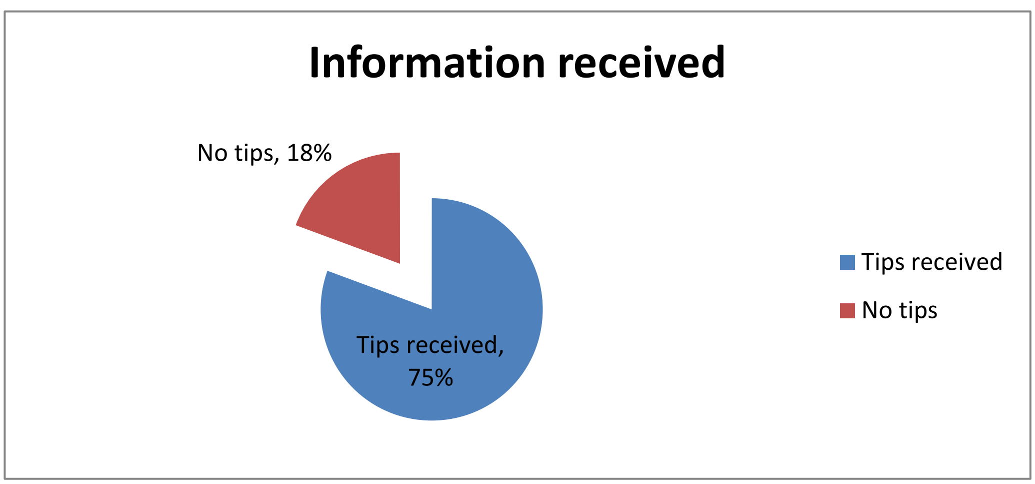


Figure 4.5: Information about energy efficiency received or not received

The information referred to above is about energy efficiency. This usually is available via flyers or brochures that are included in the electricity bills as well as the adverts in the different form of media and/or billboards. In other countries information about energy efficient devices or appliances is made available at the appliance stores or appliance catalogues (IEC, 2010).

4.2.1.6 Monthly average usage

Approximately 60% (i.e. 37) of the participants knew the number of units they consumed compared to the 40% (i.e. 24) who did not know.

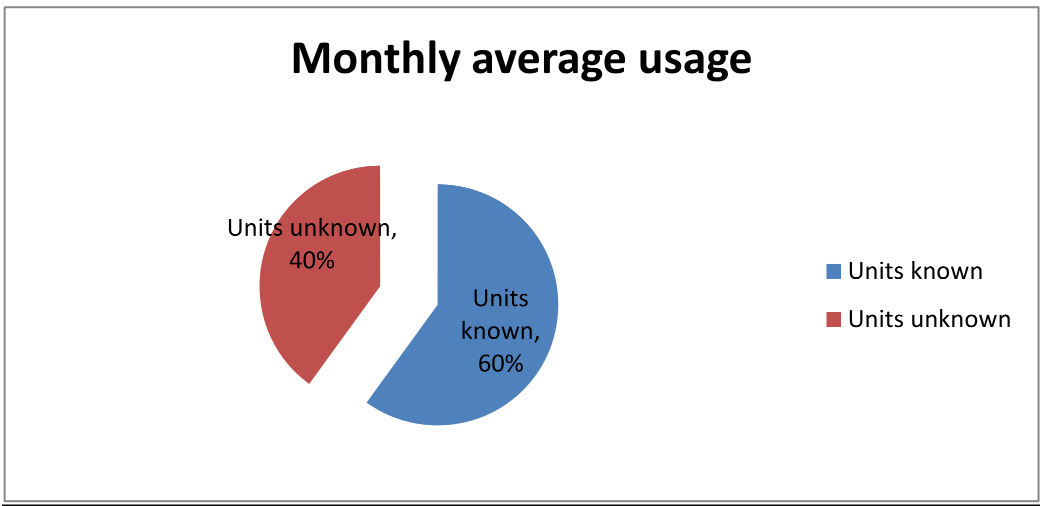


Figure 4.6: Other general information measures

All the participants who were selected for the Energy @ Home educational intervention were aware of the number of electricity units used. However the characteristics of the participants who knew or did not know the number of electricity units could not be established in this study and there was no reference to this aspect in the literature review.

4.2.1.7 Decrease or increase in the electricity consumption

In this part of the research study the analysis determined whether there was a decrease or increase in the electricity consumption over the past 12 months. An increase in consumption over the past 12 months was reported by 32% (i.e. 20) of the participants compared to 61% (i.e. 37) who indicated a decrease as shown in Figure 4.7. Only 7% (i.e. 4) who experienced no changes in electricity consumption levels.

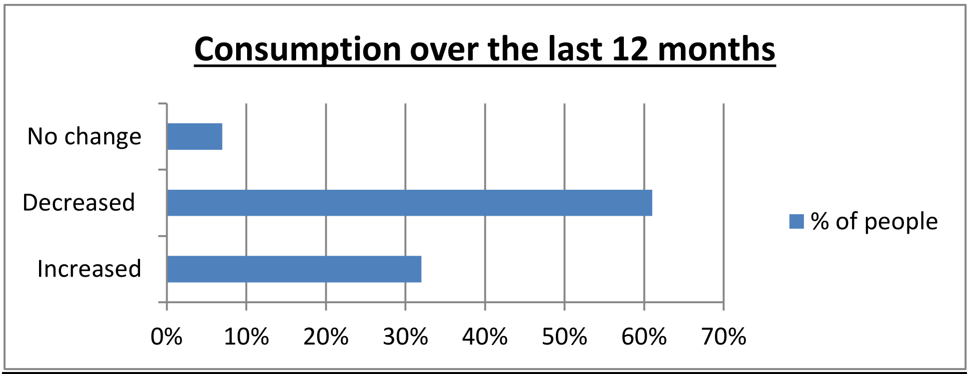


Figure 4.7: Consumption levels over the last 12 months period

This question was meant to establish whether the participants were already engaging in some form of energy efficiency that was resulting in the reduction of their consumption. All the participants of the Energy @ Home educational intervention indicated a reduction in their electricity consumption over the last 12 months prior to the Energy @ Home educational intervention.

4.2.2 Section B - The Theory of Planned Behaviour constructs

The results of the different components of the Theory of Planned Behaviour questionnaire are presented below. According to the Theory of Planned behaviour, human action is guided by three kinds of considerations; namely behavioural beliefs, normative beliefs and control beliefs. In their respective aggregates, the behavioural beliefs produce favourable or unfavourable attitude toward the behaviour; normative beliefs result in subjective norm; and control beliefs result in the perceived behavioural control. The combination of attitude towards the behaviour, subjective norm and perceived behavioural control leads to the formation of a behavioural intention. The results of this section are presented as follows:

1. The Behavioural Intentions Direct (BID) measure.
2. The Behaviour intention derived from the direct measures of attitude, subjective norm and perceived behavioural control
3. The Behavioural intention derived from indirect measures of attitude, subjective norm and perceived behavioural control and their expected outcomes.

4.2.2.1 The Behavioural Intentions direct (BID) measure

The measurement of the behavioural intentions is for the purpose of comparing it with the behavioural intentions score obtained from the behavioural intentions measured both directly and indirectly for compatibility and consistency.

The results of the Behavioural Intentions Direct measurement are shown in Table 4.1. Up to 81% (i.e. 49) of all the participants intended to switch off all unused appliances, 74% (i.e. 45) planned to boil the required amount of water with the kettle, 62% (i.e. 38) intend to install solar water heaters and 58% (i.e. 35) intend to fit Compact Fluorescent Lights (CFL’s). Installing a geyser timer and switching the geyser off was intended by 41% (i.e. 25) and 44% (27) respectively. Switching off the pool and using gas stoves were the least activities intended with average scores of 16% (i.e. 10) each. Approximately 44% (i.e. 27) of participants that intend to fit a timer, whilst 35% (i.e. 21) intended to lower the geyser temperature, 16% (i.e. 10) intended to switch off air conditioners and 42% (i.e. 26) intended to switch off the pool pumps or water features. Other activities such as installing a gas stove or gas heater were selected by 16% (i.e. 10) of the participants.

Activities of efficient use of energy	% Total participants *(N = 61)*
Switching off unused appliances	81
Low Flow shower heads	47
Lowering geyser temperature	35
Switching off geyser	41
Installing geyser timer	44
Fitting Compact Fluorescent lights (CFLs)	58
Installing a Solar water heater	62
Air con off during peak times	16
Pool & water features off peak times	42
Boiling only the required amount in kettle	74
Cooking with proportional plate size	58
Other (gas stove/heater)	16

Table 4.1: Activities selected by participants as those intended to be implemented

The mean score of the behaviour intentions generalised, shown in Table 4.2, is 5.65 and a standard deviation of 1.90. This indicates that the participants selected approximately 5.65 or 47% of the 12 listed energy efficiency activities that they intend to implement.

Predictor Variables	*N = 61*	
	Mean (M)	Standard deviation (SD)
Behavioural Intentions Generalised (BIG)	5.65	1.90

Table 4.2: The Mean and Standard Deviation of the Behaviour intentions Direct

4.2.2.2 The Behaviour intention derived from the direct measures

The results (i.e. the Mean and Standard Deviation) of the direct measurements for the attitude, subjective norm and perceived behavioural control (both self-efficacy and controllability) are shown in Table 4.3. The results shows a Mean score for the directly measured attitude (AD) of 5.46 out of 7 (or 78%), a Mean score of 5.40 out of 7 (or 77%) for the subjective norm and Mean scores of the perceived behavioural control for both self-efficacy and controllability of 4.10 (or 59%) and 4.94 (or 71%), respectively. The Standard Deviation of the direct measures is between 1.56 and 1.65.

Predictor Variables	N = 61	
	Mean (M)	**Standard deviation (SD)**
Attitude Direct (AD)	5.46	1.56
Subjective Norm Direct (SND)	5.40	1.65
Perceived Behavioural Control Direct Self-efficacy (PBCDS)	4.10	1.65
Perceived Behavioural Control Direct Controllability (PBCDC)	4.94	1.58

Table 4.3: The mean and standard deviation predictor variables direct measurements for all groups

The positive mean score of the attitude, subjective norm and perceived behavioural control indicate positive or favourable attitudes, subjective norm and perceived behavioural control of the participants.

A simplified version of the Theory of Planned Behaviour using the direct measures to depict the results in Table 4.3 is shown in Figure 4.7. The simplified aggregation of the Behavioural Intention for the Theory of Planned Behaviour, assuming that the attitude, subjective norm and perceived behavioural control contribute in equal proportions to the behavioural intention, is shown be in Equation 1. This implies that the attitude (AD), subjective norm (SND) and perceived behavioural control (PBCD) contribute about a third each to the sum total of Behavioural Intention (BI_{EE},), where BI_{EE} is the behavioural intention to use energy efficiently. For simplicity, only the perceived behavioural control direct controllability Mean score is used in Equation 1, the result from using the mean score for self efficacy is also given.

Behavioural Intention (BI_{EE}) = 0.33(AD) + 0.33(SND) + 0.33(PBCD)…………… (1)

Hence, (BI_{EE}) = (0.33 x 5.46) + (0.33 x 5.40) + (0.33 x 4.94)

$(BI_{EE}) = 5.21$ (or 4.94 if the self efficacy score of 4.10 is used)

The Behavioural Intention (BI_{EE}) of 5.21 out of 7 (i.e. 74% strength) calculated from Equation 1 is also positive towards energy efficiency.

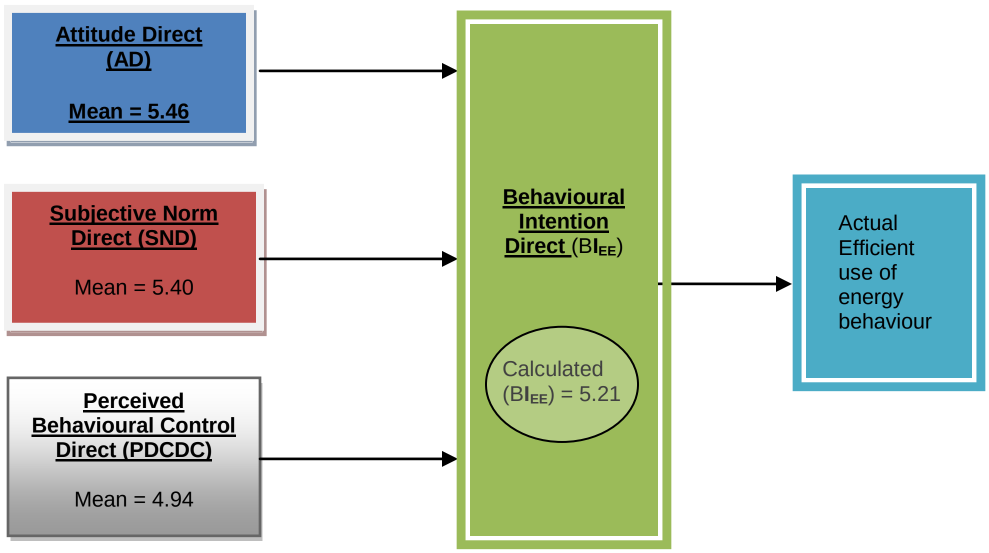


Figure 4.7: Simplified Graphical representation of the Theory of Planned behaviour using direct measures only

The participants show positive attitude, subjective norm and perceived behavioural control towards energy efficiency and hence a positive behavioural intention.

4.2.2.3 The Behavioural intention derived from indirect measures

The results obtained from the third and fourth subsections of the questionnaire are used to make composite measures of the attitude, subjective norm, perceived behavioural control as follows:

Attitude = Behavioural beliefs **x** Expected outcomes,

Subjective norm = Normative beliefs **x** motivation to comply, and

Perceived behavioural control = Control beliefs **x** influence of the control beliefs.

The predicted probability, F-statistic of 29.74, p-value less than 0.0001, the r^2 of 0.87 and the adjusted r^2 shown in Table 4.4, are derived from the simple linear regression analysis procedure. The Mean score of attitude of 5.86 out of 7 (i.e. 84%), Subjective norm of 4.42 out of 7 (i.e. 63%) and perceived behavioural control of 4.38 out of 7 (63%) indicate favourable attitudes, subjective norm and perceived behavioural control.

Predictor variables	**Mean (M)**	**Predicted Probability**	**F-Statistic and P-value**	**r^2**	**Adjusted r^2**
Attitude (A)	5.86	0.19	29.74 <0.0001	0.87	0.79
Subjective norm (SN)	4.42	0.24			
Perceived Behavioural Control (PBC)	4.38	0.29			

Table 4.4: Simple linear regression analysis of the energy efficiency behaviour of the participants

The simple linear regression analysis equation used to calculate the Behavioural Intention to use energy efficiently ($\mathbf{I_{EE}}$) is shown in Equation 2:

$\mathbf{I_{EE}} =$ 0.3846 + 0.1897 (A) + 0.2415 (SN) + 0.2894 (PBC) ……………………………….(2)

$\mathbf{I_{EE}} =$ 3.83

From Equation 2 the calculated behavioural intention ($\mathbf{I_{EE}}$) to use energy efficiently yields a value of 3.83 out of 7 (i.e. 55% strength) which indicates a positive behavioural intention. Although the behavioural intention is positive it is relatively weak when compared to the one obtained via the direct measures. The scores of the subjective norm (4.42 or 63%) and perceived behavioural control (4.38 or 62.5%) in Table 4.4 are also relatively weak when compared with the attitude score of (5.86 or 84%) The graphical representation of equation 2 is provided in Figure 4.7.

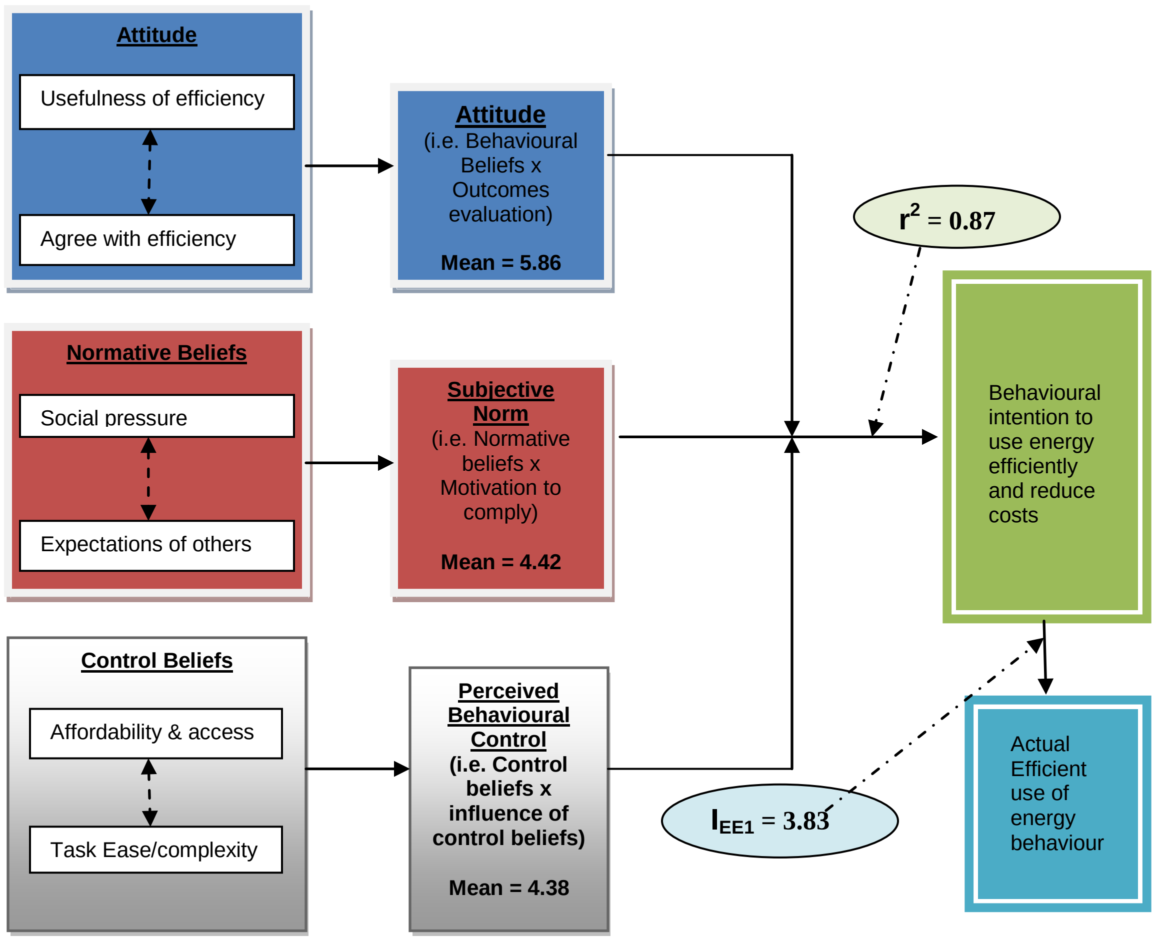


Figure 4.7. Graphical representation of the theory of planned behaviour as used in this study

The F-statistic of 29.74 with p value less than 0.001 and r^2 of 0.87, shown in Table 4.4, indicates that there is significant statistical evidence for the linear relationship between the predictor variables (i.e. attitude, subjective norm and perceived behavioural control) and the response variable (i.e. behavioural intention). The r^2 value of 0.87 implies that 87% of the data points fall closely along the best-fit line and that the predictor variables are good predictors of the response or dependent variable.

4.2.3 Section C – The Telephone response log

The results obtained from the Telephone response log (see Appendix 3.2.1) are shown in Table 4.5. Out of the 61 participants, 42 provided responses to the telephone response log about their implementation or non-implementation of the energy efficiency they intended to implement.

Number of Participants who responded	Number of participants who intended to implement energy efficiency measures	Number of participants who implemented the intended energy efficiency measures	Number of participants who did not intend to implement the energy efficiency measures
42	42	42	0

Table 4.5: The Telephone response log

The participants who intended to implement the energy efficiency measures implemented the energy efficiency measures. In comparison to the 11 participants of the Energy @ Home educational intervention who intended to use electricity efficiently, 9 out of 11 (or 82%) used electricity efficiently while the two participants could not provide the required electricity meter readings (see section 4.3.2).

Therefore the participants showed positive behavioural intention with their generalised behavioural intentions; their directly measured behavioural intentions and their indirectly measured intentions implemented the energy efficiency measures they intended to implement. This result is consistent with the Theory of Planned Behaviour in that positive or favourable behavioural intentions resulted in the implementation of the intended behaviour.

4.3 Results - Part 2: Research question 2

Part 2 presents the results that address the second research question. Here the aim was to determine the extent to which the Energy @ Home educational intervention changed domestic electricity consumers' behaviour. The results that are presented in this section are those of the Electricity log attached as Appendix 3.5.

4.3.1 The Energy audit log results

Approximately 82% (or 9 out of 11) of the participants indicated that they intended to reduce their electricity consumption by implementing various energy efficiency measures. The measures include such as changing behaviour and/or installing energy efficient devices and/or both. The participants indicated intended savings of between 2% and 30% as shown in Figure 4.8.

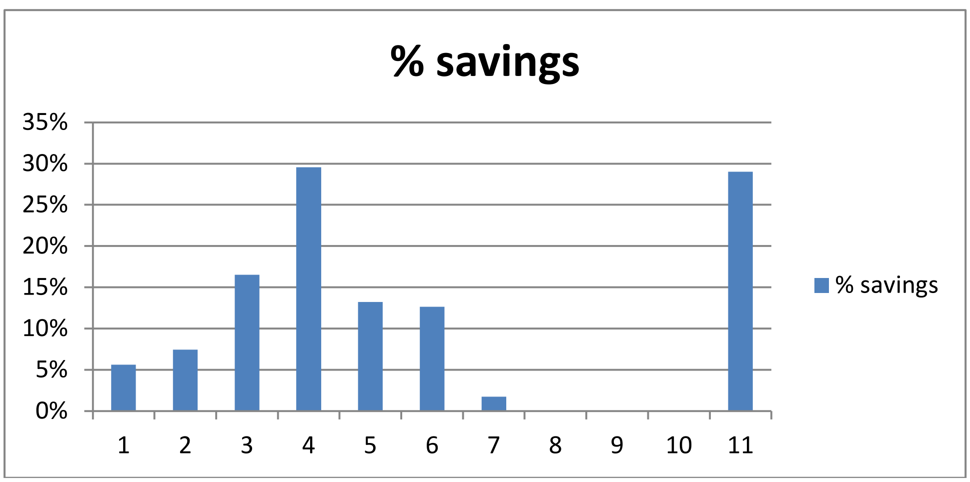


Figure 4.8: The intended savings per household

4.3.2 The Electricity consumption log results

Up to 82% (i.e. 9 out of 11) participants recorded their weekly consumption for the 7 weeks period and provided the required information. The reductions in electricity consumption of between 2% and 30% were achieved as depicted in Figure 4.9. It must be noted that the average weekly consumption corresponds to the monthly consumption that was used in the energy audit (i.e. in this study the electricity consumption calculations were based on 1 month = 4 weeks).

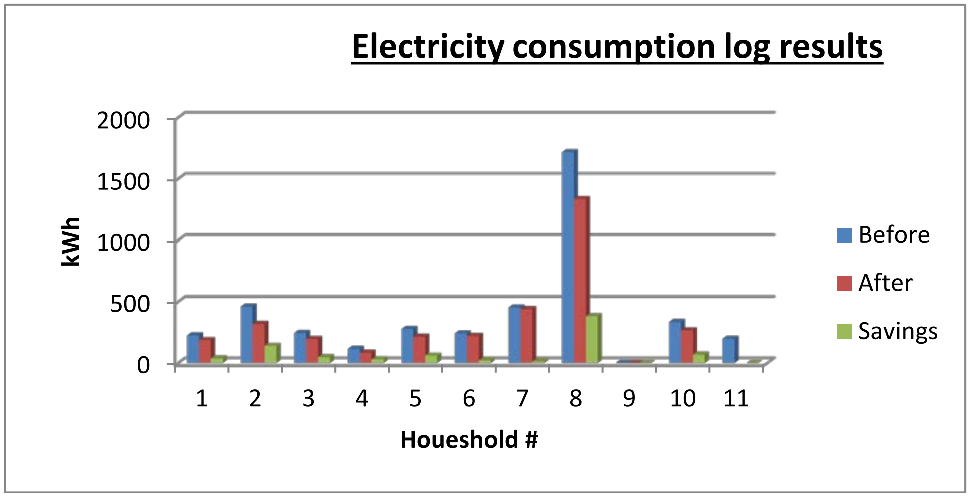


Figure 4.9: The Electricity consumption log results

The results of the Electricity consumption log indicate that the participants reduced their electricity consumption after the educational intervention. The domestic electricity consumer that consumed more than 1600 kWh per month made the most savings of about 30% of electricity consumption. Even domestic consumers that consumed less than 100 kWh per week made savings of up to 2% of their electricity consumption. The savings of up to 30% are consistent with the potential savings indicated in the literature review by McCalley (2006); Darby (2006) and IEC (2010).

4.4 Evaluating Research question 1

Research question 1 is: "to what extent the participants intend to use and use energy efficiently?" Participants showed positive behavioural intentions direct (BID) of implementing energy efficiency measures with a Mean of 5.65 from 12 measures that were listed in the questionnaire. Further the behavioural intention from the indirect measures of 3.83 (or 55%

strength) and 5.21 (74%) from the direct measures indicates favourable behavioural intentions towards energy efficiency. However the strength of the behavioural intention from the indirect measures of 3.83 is relatively weak. The F statistic of 29.74, p value less than 0.0001 and the r^2 of 0.87 indicates the statistical significance of the linear relation between the predictor variables and the independent variable. The 42 participants listed in the Telephone response log, who had previously indicated intentions to implement energy efficiency measures, confirmed that they implemented the energy efficiency measures. As predicted by the Theory of Planned Behaviour individuals who have favourable intentions are likely to implement their favourable intentions when given an opportunity to do so (Ajzen, 1980).

4.5 Testing the hypothesis

The null hypothesis H_0 states that the behavioural intentions of domestic electricity consumers towards energy efficiency do not affect the actual behaviour. The implementation of the favourable behavioural intentions by the 42 participants who responded to the telephone response log indicates that the behavioural intentions of the domestic electricity consumers affect their actual behaviour and therefore the null hypothesis is rejected.

4.6 Research question 2

Research question 2 is: “to what extent to which did the Energy @ Home educational intervention change domestic electricity consumers’ behaviour?”. The Energy at Home participants were part of the participants that had favourable behavioural intentions towards using energy efficiently. The results of the Energy audit log indicate that the participants had positive and favourable intentions to implement energy efficiency measures that would reduce their electricity consumption by between 2% and 30%. The Electricity consumption log showed reductions in the actual electricity consumption of between 2% and 30%. Therefore the Energy

@ Home educational intervention changed the behaviour of the domestic electricity consumers and resulted in the reductions in their electricity consumption.

4.7 Summary

This chapter evaluated the data collected from the Theory of Planned Behaviour based **questionnaire, the Telephone response log, the Energy audit log and the Electricity consumption log**. The results of **general information** of the participants indicate that the targeted participants were selected from the sample. The results of the **behavioural intentions direct** with a Mean of 5.65 (SD = 1.9) indicate the participants intention to use energy efficiently by implementing a number of the energy efficiency measures. The scores of **behavioural intentions** from both the direct measures and indirect measures indicated that the participants have positive and favourable intentions towards energy efficiency. The implementation of the intended **behaviour** by the respondents to the Telephone response log indicates the correct prediction by the Theory of Planned Behaviour. The **Energy audit log** showed that most of the participants intended to implement energy efficiency measures that will result in reductions in consumption. The reductions in the actual electricity consumption indicated by the **Electricity consumption log** revealed that the participants' electricity consumption was influenced by the educational intervention.

Chapter 5: Discussion of findings, Conclusion and Recommendations

5.1 Introduction

This chapter discusses the findings of this study with respect to each of the research questions, then the conclusion followed by the implications of the study and the recommendations.

5.2 Summary of the study

The aim of this pilot study was:

(i) to investigate the extent to which domestic electricity consumers intend to use and use electricity efficiently, using the Theory of Planned Behaviour, and

(ii) to investigate the extent to which the Energy @ Home educational interventions changed their behaviour towards energy efficiency.

Data was collected from the domestic electricity consumers in the Gauteng Province, mainly in Johannesburg and Pretoria, via a questionnaire, the Telephone response log and the Electricity consumption log. There were 61 domestic electricity consumers that were selected from the 290 respondents to the Energy @ Home advert. Out of the 61 respondents, 11 were chosen to participate in the Energy @ Home educational intervention and television program. The data collected via the questionnaire was analysed using the simple linear regression analysis procedure.

5.3 Discussion of the findings

The findings of this study are discussed for each research question. The discussions of each research question findings include literature review to support the findings.

5.3.1 Research question 1 discussion

This pilot study showed that participants have intentions of using electricity efficiently in activities such as lighting, water heating, space heating and cooling and cooking. The significance of this finding is that in all these activities there is a potential to save electricity either by changing behaviour or installing energy efficient appliances. The abovementioned activities have seen significant developments and technological advances in the last 2 to 5 years that are aimed at reducing the electricity consumption of the existing devices (see section 2.6). For example, by just using efficient lighting devices the total electricity consumption of a household can be reduced by up to 2% (i.e. 80% reduction of about 8% of the total household consumption, see section 2.6.1). As the technologies mature it is expected that the purchase prices of the new energy efficient devices. It is therefore possible that the use of these devices will then increase.

The behavioural intentions direct revealed that a high number of the participants intended to implement the kinds of measures that required little or no additional costs or extra effort. This involves activities such as switching off unused appliances; boiling the required amount of water; or cooking with the proportional size plate; and installing the Compact Fluorescent lights. This finding is consistent with previous findings by Gardner & Stern (2002) that generally speaking as the kind of energy saving activity moves from being easy and inexpensive to difficult and costly the less likely it is to be performed. Further, the tasks that are perceived or considered by participants to be difficult or complex and/or expensive options such as installing low-flow shower heads, lowering the geyser temperature, were selected by fewer participants. Thus the barriers to implementing energy efficiency measures such as the complexity or costs of the task retard the implementation of energy efficiency measures.

The indication by the participants to implement various energy efficiency measures is consistent with the Theory of Planned Behaviour in predicting that positive and favourable attitudes, subjective norm and perceived behavioural control towards a behaviour yield positive and favourable behavioural intentions. The favourable behavioural intentions in turn lead to the implementation of the intended behaviour.

5.3.2 Research question 2 discussion

Up to 9 (i.e. 81%) achieved savings in their electricity consumption of between 2% and 30%. These savings are consistent with the targets set in the second Energy audit which also had savings ranging between 2% and 30%. The Energy @ Home educational intervention motivated the participants to set targets for themselves on where they could reduce their electricity consumption. The Energy @ Home educational intervention used one of the techniques of providing appropriate information during the educational interventions discussed by Gardner and Stern (2002). The results of the Electricity consumption log that show reductions in electricity consumption after the Energy @ Home educational intervention are consistent with the findings contained in the literature review in that:

- when domestic electricity consumers are provided with information about energy efficiency (i.e. removing the barrier of information) and
- the necessary resources to implement energy efficiency measures or behaviour (i.e. removing financial constraints),

the domestic electricity consumers are likely to show the required behaviour or tasks (Gardner & Stern, 2002; Lam, 1999; IEC, 2010; Darby, 2006 & ACEEE, 2011.

5.3 Conclusions

This study demonstrated that the Theory of Planned Behaviour has considerable attributes in predicting behavioural intentions towards energy efficiency from the attitudes, subjective norm and perceived behavioural control of domestic electricity users. The use of the Energy auditor to create awareness amongst the domestic users about the amount of electricity used by each appliance was one of the valuable lessons in the Energy @ Home educational intervention. The provision of the power pack also limited or removed the barrier to action associated with the affordability of some of the energy efficient devices or appliances. The actual reductions in the electricity consumption indicated by all the participants imply that reductions in electricity consumption by using energy efficiently, either by changing behaviour and/or installing energy efficient devices is possible.

5.4 Implications of the study

The study was conducted in the Gauteng Province and mainly in the Johannesburg area and thus excluded a number of other areas, such as, rural, semi urban and informal settlements. Although the selection of the convenience stratified sampling method was used to select this study revealed the role that energy efficiency can play and the reductions that can be achieved. The educational intervention requires up to 5 hours to provide meaningful inputs and preferably with each household or a group of households with similar characteristics. The nature of the educational intervention is intrusive and may be construed as a disruption to the participants' normal way of living. As such additional resources, such as, energy auditors, energy efficient devices for demonstration, etc, may be appropriate when conducting the educational intervention on a large scale so as to reduce the time requirements.

This study revealed that the potential to reduce electricity consumption by using electricity efficiently exists. This means that suitable measures, such as educational interventions and incentives for efficient use of electricity should be developed. Although the Energy @ Home educational intervention was conducted to only 11 people, there is scope for expanding the this to a larger audience.

The potential savings that can be realised when domestic electricity consumers use energy efficiently can assist in postponing investments into additional generation capacity. Such capacity will result in lower electricity prices whilst reducing the costs associated with producing electricity. One spin-off of this is that it may facilitate economic growth.

5.5 Recommendations

The study provides insights to the factors that influence the behaviour of domestic electricity consumers. In view of the implications and limitations of this study, it is recommended that:

1. An in-depth study that evaluates other aspects, such as the level of education, the role of children within a household and the sustainability of the educational intervention, that must be considered when designing an educational intervention that is aimed at influencing the behaviour of domestic electricity consumers.

2. Modification of the educational intervention, including providing the information in different languages, as guided by the abovementioned in-depth study so that it can be customised for the different types of domestic electricity consumers.

3. A review of the existing electricity pricing structures with a view of designing pricing structures that encourage efficient use of electricity, such as electricity prices that are different for the different times of the day for domestic consumers.

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APPENDICES

Appendix 3.1 – Eskom Energy at Home: Call to enter- Selecting the families

Overview:

- At home there are several basic steps you can take to save electricity. .
- Electricity consumers, whether they are major commercial, industrial users or householders, play a crucial role in achieving energy efficiency in South Africa.
- By examining how energy is used, taking steps to save power where we can, and even controlling use of appliances it is easy to conserve energy and simultaneously save money.
- Based on the above, The Home Channel would like to recommend the following tactical, uniquely developed opportunities, that will serve to educate consumers about the energy various appliances within the home consumed, therefore allowing them to make key choices about when and how much energy to consume.
- 1)A series of 2 minute inserts that are tactically linked to South Africa's seasons (**flighting from 12th October 2009-31st March 2010)**
- 2) A 24 Minute locally produced programme that educates and demonstrates "real energy efficiency".

Energy @ Home Synopsis

- ***13 x 24 Minute Episodes***

- The show will seek to cover and analyse 13 different "Lifestyle" groups from working moms, to bachelors to Retirees and provide pertinent information on how one can and should be saving electricity in their own homes.
- We envisage the programme in the following way;-

- **Segment 1 – Meet the family**
  - Meet the family and observe how they use energy and what their interests are etc.
  - Look at their latest bill **(This is important to determine their monthly kWh tariff which will be punched into the energy calculator & audit tools)**
  - Presenter Simon Gear and Eskom's Energy Expert will measure their general consumption by conducting an energy audit using the Eskom **Comprehensive Energy Audit tool** (very interesting activity) Film the family doing this, and in discussion with presenter/energy expert.
  - ***Note: The presenter/expert would have to have a laptop & 3G card with him in order to log onto the Eskom DSM website to conduct the energy audit***
  - We will conclude the episode with a couple of quick handy tips and hints.

- **Segment 2 –Energy Guzzlers**
  - The presenter/energy expert analyses the report and then gets back to the family with the results.
  - The presenter/energy expert highlights what consumes the most energy by logging on to the **Energy Calculator** to show how much each appliance uses.
  - The presenter/expert and providing savings tips **(based on the theme of the episode)** i.e. "Cut here, change this and install this kind of light bulb as a beginning to the process. "

A POWER PACK is given to help the families do this. This will contain:

- ➢ CFLs
- ➢ Energy & Water saving shower heads
- ➢ Geyser blanket (if needed) etc.

- Solar Garden Lights
- Programmable appliance timer
- Sign the Power Pledge

- **Segment 3 –The Solution**
  - ➢ Short discussion with family as to what they can do and how to do it.
  - ➢ Film the replacing of the old & installation of new energy efficient appliances/ technologies in the household (relevant to the episode theme – e.g. shower heads, geyser blankets, Solar water heating)
  - ➢ ***Note: for the installation of a solar water heater, the current solar AV should be used as it doesn't favor any particular supplier***
  - ➢ The presenter/energy expert returns to the house and has a short discussion with the family as to what energy savings advice & tips they have applied in their household
  - ➢ The presenter/energy expert once again conducts the energy audit, now based on the new technologies and tips.
  - ➢ The report shows how much energy they have saved.
  - ➢ ***Note: it is important that the results not only focus on the monetary savings but also on the kWh savings***
  - ➢ Each family receives X amount of money based on savings achieved. (This can be calculated based on a predetermined scale e.g. R 1000 for savings of 10 kWh – 20 kWh, R1 500 for 21 kWh – 30 kWh etc.)

Call to Entry- Selecting the Families

Be on TV and WIN! With Energy at Home

Is your electricity bill burning a hole in your pocket? Want to stand the chance of winning 1 of 3 solar water heater installations?

The Home Channel is looking for 12 households willing to take the energy pledge and be featured in our new Energy at Home Show.

So, if you feel your electricity bill is sky high and you would like some tips and pointers from our experts on how best to save electricity around the home, then send us your details.

The types of households we need are:

1. A large family (4-5 kids)
2. A young couple
3. A home business
4. A retired couple
5. A commune
6. A family with young children
7. A single mom
8. A family with teenagers
9. A family with a swimming pool
10. An extended family
11. A family living in a cluster
12. Small family living in a large house

If you are what we looking for, please send emails to energyathome@thehomechannel with Energy at Home in the subject line and provide us with the following info:

- The types of dwelling you live in (e.g. apartment, complex, 3 bedroom house etc.)
- The number of people in the household
- Your average day-to-day electricity usage
- And some info on why you are ideal for the show

Appendix 3.2 - The Questionnaire

1. What is your electricity bill per month on average?

Between **R100.00** and **R500.00**	
Between **R500.00** and **R1000.00**	
Between **R1000.00** and **R2000.00**	
Above **R2000.00**	

2. Please indicate whether you use electricity for the following

	Yes	**No**
Lighting (interior and exterior)		
Cooking (e.g. Stove, Microwave, Oven)		
Water heating (e.g. Geyser)		
Space heating (e.g. Heater)		
Entertainment (TV, Radio, Video/DVD, Play-station, etc)		
Geyser for water heating		
Swimming pool pump or other water features with pumps		
Other (please specify, e.g. Home office)		

3. Which appliances consume the most energy (in descending order)?

	Order
Lighting (interior and exterior)	
Cooking (e.g. Stove, Microwave, Oven)	
Water heating (e.g. Geyser)	
Space heating (e.g. Heater)	
Entertainment (TV, Radio, Video/DVD, Play-station, etc)	
Geyser for water heating	
Swimming pool pump or other water features with pumps	
Other (please specify, e.g. Home office)	

4. How many people are in your household?

1 person	
2 people	
Between **2** and **5** people	
More than **5** people	

5. What electricity meter is installed in your household?

Prepaid metering	
Conventional meter	

6. **Do you receive information or tips on efficient use of electricity from your electricity services provider or any other source?**

Yes	
No	

7. **What is your monthly average usage of electricity in cents/kWh or units?**

Monthly average usage (Cents/kWh or units)	
I don’t know	

8. **Has your electricity consumption increased or decreased over the last 12 months?**

Decreased	
Increased	

BID1. How many activities of efficient use of energy would you implement from the following?

1. Switching off all unused appliances
2. Fitting low-flow shower heads
3. Lowering the temperature setting on your geyser to less than 55 degrees
4. Switching off the geyser during the day
5. Installing a timer to switch on and off the geyser at certain times
6. Fitting Compact Fluorescent lights (CFL's) or LED lights
7. Fitting a Solar Water Heater (SWH) for heating water
8. Switching off the air conditioners during the morning and afternoon peak periods
9. Running the pool pump and other water feature pumps for during off-peak periods
10. Boiling only the required amount of water when using a kettle
11. Cooking with a plate that is proportional to the size of the pot or frying pan
12. Other methods (please specify, e.g. gas heaters, gas stoves, etc)…………………………….

0	1	2	3	4	5	6	7	8	9	10	11	12

AD1. Using energy efficiently is:

Beneficial	1	2	3	4	5	6	7	Harmful
Unpleasant	1	2	3	4	5	6	7	Pleasant
Worthless	1	2	3	4	5	6	7	Useful
Affordable	1	2	3	4	5	6	7	Expensive

BIG1. I expect to use energy efficiently.

Strongly agree	1	2	3	4	5	6	7	Strongly disagree

BIG2. I would like to use energy efficiently

Strongly agree	1	2	3	4	5	6	7	Strongly disagree

BIG3. I intend to use energy efficiently

Strongly agree	1	2	3	4	5	6	7	Strongly disagree

SND1. Most people who are important to me think I should use energy efficiently.

Strongly disagree	1	2	3	4	5	6	7	Strongly agree

SND2. It is expected of me that I should use energy efficiently.

Strongly disagree	1	2	3	4	5	6	7	Strongly agree

SND3. I feel under social pressure to use energy efficiently.

Strongly disagree	1	2	3	4	5	6	7	Strongly agree

SND4. People who are important to me want me to use energy efficiently.

Strongly disagree	1	2	3	4	5	6	7	Strongly agree

PBCDS1. I am sure and confident that I can use energy efficiently

Strongly disagree	1	2	3	4	5	6	7	Strongly agree

PBCDS2. It will be easy for me to use energy efficiently.

False 1 2 3 4 5 6 7 True

PBCDS3. I can afford the equipment and appliances required for efficient use of energy

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

PBCDC1. The decision to use energy efficiently is under my control

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

PBCDC2. Using energy efficiently is entirely up to me

Difficult 1 2 3 4 5 6 7 Easy

PBCDC3. I can find the energy efficient appliances, equipment and contractors to install.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

AIBB1. If I use energy efficiently, I will feel that I am doing something positive.

Unlikely 1 2 3 4 5 6 7 Likely

AIBB2. If I use energy efficiently, I will reduce my electricity consumption and save money.

Unlikely 1 2 3 4 5 6 7 Likely

AIBB3. If I use energy efficiently, I will negatively affect my quality of life

Unlikely	1	2	3	4	5	6	7	Likely

AIBB4. If I use energy efficiently, I will contribute positively towards climate change.

Unlikely	1	2	3	4	5	6	7	Likely

AIBB5. If I buy and install energy efficient appliances, it costs more.

Unlikely	1	2	3	4	5	6	7	Likely

AIBB6. If I use energy efficiently, I will reduce the overall cost of electricity.

Unlikely	1	2	3	4	5	6	7	Likely

AAOE1. Doing something positive is:

Bad	-3	-2	-1	0	+1	+2	+3	Good

AAOE2. Reducing my electricity consumption and saving money is:

Punishing	-3	-2	-1	0	+1	+2	+3	Rewarding

AAOE3. Negatively affecting my quality of life is:

Extremely undesirable	-3	-2	-1	0	+1	+2	+3	Extremely desirable

AAOE4. Contributing positively towards climate change is:

Extremely undesirable | -3 | -2 | -1 | 0 | +1 | +2 | +3 | Extremely desirable

AAOE5. Buying and installing energy efficient appliances is:

Foolish | -3 | -2 | -1 | 0 | +1 | +2 | +3 | Wise

AAOE6. Reducing the overall costs of electricity is:

Useless | -3 | -2 | -1 | 0 | +1 | +2 | +3 | Useful

SNINB1. My neighbours use energy efficiently

Strongly disagree | -3 | -2 | -1 | 0 | +1 | +2 | +3 | Strongly agree

SNINB2. My friends and family think that I should use energy efficiently

Strongly disagree | -3 | -2 | -1 | 0 | +1 | +2 | +3 | Strongly agree

SNINB3. The community leaders think that I should use energy efficiently

Strongly disagree | -3 | -2 | -1 | 0 | +1 | +2 | +3 | Strongly agree

SNIOE1. Doing what my neighbours do is important to me.

Not at all | 1 | 2 | 3 | 4 | 5 | 6 | 7 | very much

SNIOE2. What my friends and family think I must do matters to me.

Not at all | 1 | 2 | 3 | 4 | 5 | 6 | 7 | A lot

SNIOE3. What the community leaders think about me matters to me.

Not at all | 1 | 2 | 3 | 4 | 5 | 6 | 7 | A lot

PBCIB1. My family and/or community or country obligations force me to use energy efficiently

False | 1 | 2 | 3 | 4 | 5 | 6 | 7 | True

PBCIB2. For me the tasks I am expected to perform in order to use energy efficiently are complex.

Strongly disagree | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Strongly agree

PBCIB3. The penalties or high bills for not using energy efficiently encourage me to conform.

Unlikely | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Likely

PBCIS1. Family, community or country obligations will make me use energy efficiently

Strongly disagree | -3 | -2 | -1 | 0 | +1 | +2 | +3 | Strongly agree

PBCIS2. The complexity of the tasks does not encourage me to energy efficiently

Strongly disagree | -3 | -2 | -1 | 0 | +1 | +2 | +3 | Strongly agree

PBCIS3. Penalties or high bills for inefficient use of energy force me to use energy efficiently

Less likely | -3 | -2 | -1 | 0 | +1 | +2 | +3 | More likely

Legend

AD – Attitude Direct---

AI – Attitude Indirect

AIBB – Attitude Indirect Behavioural Beliefs

AIOE – Attitude Indirect Outcomes evaluation

BID – Behavioural Intentions Direct

BIG – Behavioural Intentions Generalised

SND – Subjective Norm Direct

SNI – Subjective Norm Indirect

SNINB - Subjective Norm Indirect Normative Beliefs

SNIOE - Subjective Norm Indirect Outcomes Evaluation

PBCD – Perceived Behavioural Control Direct Self-efficacy

PBCDC - Perceived Behavioural Control Direct Controllability

PBCIB - Perceived Behavioural Control Indirect Beliefs

PBCIS - Perceived Behavioural Control Indirect Strength

Appendix 3.2.1 – The Telephone response log

Participant	Number of activities intended for implementation	Activities implemented
1	5	ALL
2	6	SOME
3	7	ALL
4	7	ALL
5	7	SOME
6	5	SOME
7	7	ALL
8	6	ALL
9	6	SOME
10	6	ALL
11	6	ALL
12	5	SOME
13	5	ALL
14	4	ALL
15	4	SOME
16	4	ALL
17	5	ALL
18	4	SOME
19	4	SOME

20	4	ALL
21	4	ALL
22	4	ALL
23	5	SOME
24	5	ALL
25	4	ALL
26	4	ALL
27	5	SOME
28	5	SOME
29	6	SOME
30	6	ALL
31	5	ALL
32	5	SOME
33	6	ALL
34	3	ALL
35	6	SOME
36	5	SOME
37	5	ALL
38	5	SOME
39	4	ALL
40	4	ALL
41	3	ALL

Appendix 3.3.1 – The Energy Audit Log

Household #	Energy audit 1 (R)	Energy Audit 2 (R)	Target savings (R)
1	1654.62	1543.62	92.8
2	2371.1	1279.1	176.3
3	1363.46	1182.46	225
4	1363.68	1229.68	403
5	4036.36	3759.36	533
6	972.01	907.01	123
7	2273.3	2153.3	40
8	0	0	0
9	0	0	0
10	4344.76	4146.76	0
11	1372.21	1004.21	398

Appendix 3.3.2 – Electricity consumption log

Household 1	**Before (kWh)**	**After (kWh)**
Week 1	51 195	51 759
Week 2	51 410	51 966
Week 3	51 554	52 158
Week 4	-	52 381
Ave weekly	225	187
Actual savings	R38 per week	
Amount saved	R91 for the month	

Household 2	**Before (kWh)**	**After (kWh)**
Week 1	6 621	8 034
Week 2	7 208	8 254
Week 3	7 785	8 654
Week 4	-	8 961
Ave weekly	460	320
Actual savings	140kWh per week	
Amount saved	R655 for the month	

Household 3	**Before (kWh)**	**After (kWh)**
Week 1	16 047	16 746
Week 2	16 322	16 944
Week 3	16 534	17 966
Week 4		17 341
Ave weekly	245	197
Actual savings	29kWh per week	
Amount saved	R116 for the month	

Household 4	**Before (kWh)**	**After (kWh)**
Week 1	93 692	94 010
Week 2	93 814	94 106
Week 3	93 923	94 184
Week 4	-	94 256
Ave weekly	115	85
Actual savings	30kWh per week	
Amount saved	R80	

Household 5	**Before (kWh)**	**After (kWh)**
Week 1	20 906	21 981
Week 2	21 183	22 187
Week 3	21 477	22 408
Week 4	-	22 630
Ave weekly	277	216
Actual savings	61kWh per week	
kWh saved	R166 for the month	

Household 6	**Before (kWh)**	**After (kWh)**
Week 1	53 504	54 200
Week 2	53 748	54 425
Week 3	53 990	54 646
Week 4	-	54 880
Ave weekly	243	222
Actual savings	21kWh per week	
kWh saved	R39 for the month	

Household 7	Before (kWh)	After (kWh)
Week 1	10 642	10 935
Week 2	10 748	11 018
Week 3	10 840	11 107
Week 4	-	11 202
Ave weekly	453	440
Actual savings	40kWh per week	
kWh saved	R24 for the month	

Household 8	Before (kWh)	After (kWh)
Week 1	17 764	21 228
Week 2	19 482	22 563
Week 3	21 199	23 902
Week 4	-	25 291
Ave weekly	1717	1335
Actual savings	383kWh per week	
kWh saved	R917 for the month	

Household 9	**Before (kWh)**	**After (kWh)**
Week 1	-	-
Week 2	-	-
Week 3	-	-
Week 4	-	-
Ave weekly		
Actual savings		
kWh saved		

Household 10	**Before (kWh)**	**After (kWh)**
Week 1	-	-
Week 2	-	-
Week 3	-	-
Week 4	-	-
Ave weekly		
Actual savings		
kWh saved		

Household 11	**Before (kWh)**	**After (kWh)**
Week 1	46 993	48 334
Week 2	47 337	48 620
Week 3	47 673	48 848
Week 4	47 998	49 063
Ave weekly	335	266
Actual savings	69kWh per week	
kWh saved	R220 for the month	

Appendix 3.4.1: Additional questions for the Energy @ Home educational intervention

1. **To what grade did you do physics at school or at tertiary level**

Grade 9	
Grade 12	
Tertiary level	

2. **To what grade did your parents/guardian or family members do physics**

Grade 9	
Grade 12	
Tertiary level	

3. **At what voltage level is the electricity supply in South Africa**

110 Volts	
220 Volts	
330 Volts	

Appendix 3.4.2: Additional questions for the Energy @ Home educational intervention

1. **Have you checked the calculations on your consumption done by the Energy auditor for correctness?**

Yes	
No	
I did not understand the calculations	

2. **What lessons have you learnt during the Energy @ home programme?**

How to calculated my energy consumption	
How to calculate the costs per appliance	
How my consumption affects the environment	
How much I can save by changing my behaviour	
Other	

3. **Would you suggest that the information provided to you be given to other people?**

Yes	
No	
I do know	

4. **Has you electricity consumption decreased since the Energy @ Home intervention, if so by how much (give an estimate)**

Yes	
No	
I do know	