Analysing the South African residential sector's energy profile

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Highlights

- This paper evaluates the evolution and characteristics of energy consumption in the South African residential sector.
- Emphasis was given to the behaviour of households in using energy for cooking, lighting and heating.
- Around 70% of low-income households rely on sources of energy other than electricity to satisfy their basic energy needs.
- Around 10% of low-income households are energy poor and cannot afford using electricity to cover their basic energy needs.
- Results from the NIDS dataset indicated that electricity access is reasonably high across South Africa.

Abstract

Given the significance of the residential sector in terms of energy consumption, a comprehensive understanding of households' energy consumption patterns and choices is imperative. This paper focuses on analysing and understanding the South African residential sector's energy characteristics considering their energy-use profile, and other characteristics such as their geographical distribution and demographic characteristics.

The findings show that despite poorer households who are connected to the national grid receiving 50 kW/h of free electricity per month to help them cover their basis energy needs, South African households – particularly low-income households – still use various sources of energy including wood and paraffin to satisfy their basic

energy requirements. Solid fuels are predominantly used in rural areas where around 75 percent of non-electrified households rely on solid fuels for cooking, heating and lighting. Low-income South African households consume between 5-10 percent of their total energy in lighting; space heating and cooking account for the remainder 85-90 percent of their total energy consumption.

After evaluating the relevant data regarding households' access to electricity, the type of energy used by households and households' expenditure on electricity and energy in South Africa from the NIDS dataset; it was concluded, that electricity access is reasonably high across South African households. Additionally, an increasing trend can be observed in their total expenditure on electricity. However, approximately 70 percent of households still spend on other energy sources.

Keywords: Residential sector; energy consumption; energy habits; South Africa; NIDS

1. Introduction

The U.S. Energy Information Administration defines energy consumption in the residential sector as *'…all energy consumed by households excluding transportation uses*' [1]. Residential energy consumption includes energy consumed by households for heating, cooking, lighting and water heating [1]. Total energy consumption in the residential sector is significantly influenced by different factors such as: income levels, energy prices, energy access, weather, households' characteristics, and appliances used and its energy efficiency. Therefore, the type of energy, as well as the amount of energy consumed in the residential sector differ significantly around the world, especially between developed and developing countries and between regions such as Europe and Africa [1].

The residential and the commercial sector consume a significant share of energy internationally - approximately 21 percent of the total energy delivered worldwide [2]. Thus, analysing the residential sector's energy consumption patterns is of upmost importance in predicting the challenges and opportunities on the future design and implementation of energy policy.

As shown in Figure 1, data derived from the South African Energy Balances [3], in 2014, the residential sector in South Africa was responsible for 23 percent of total electricity consumption – up from 20,1 percent in 2013 and 19,8 percent in 1994 [3].

Figure 1 highlights how the residential sector is one of the largest sectors with regards to electricity consumption in South Africa.

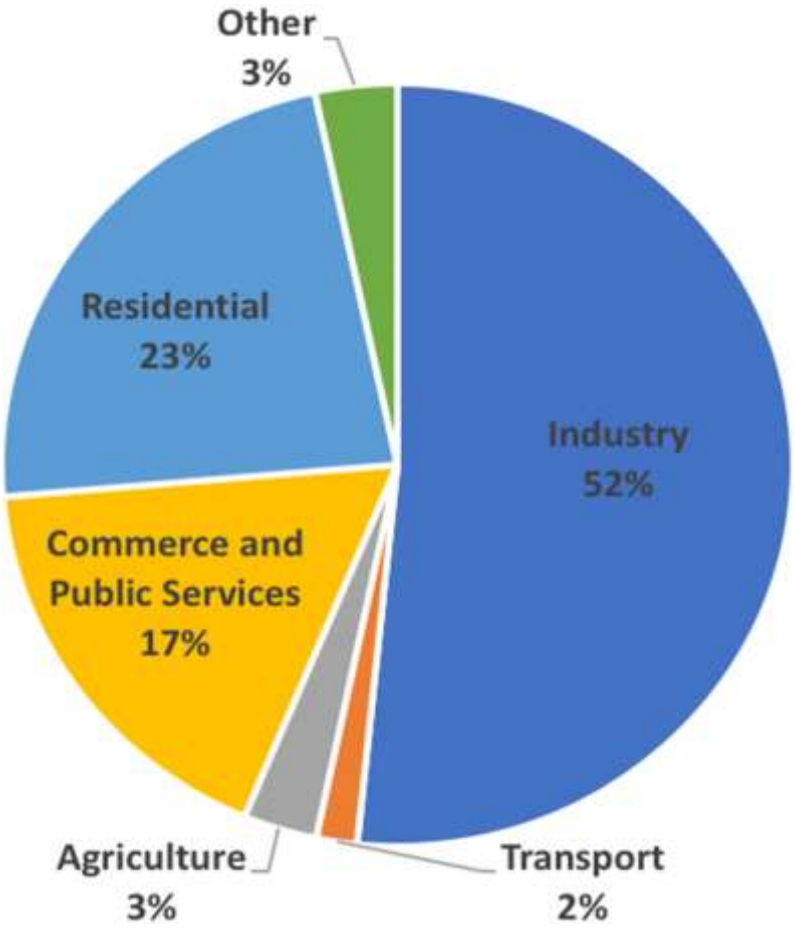

Fig. 1. South African Sectoral Electricity Consumption in 2014. Fig. shows electricity consumption in the main sector in the South African economy in 2014. It highlights how the residential sector is one of the largest sectors with regards to electricity consumption in South Africa.
Source: Adapted from [31]

As depicted in Figure 2, the amount of electricity consumed by the residential sector - along with the 'commerce and public services' sector – as a share of total electricity consumption has been increasing over time, especially since the early 2000's [3]. During this period, overall energy consumption in the South African residential sector has increased continuously along with the rise in population, number of households and real incomes. According to the 2011 census – the latest South African census – South Africa's population is over 55 million people, with around 14.5 million households [4]. The latest United Nations report on household size and composition around the world confirms that households tend to be smaller today than

in the past; adding to the global and local rise in the number of households over the last two decades [5]. As per 2015 estimates, South African households have an average size of 3.30 [6]. Additionally, energy consumption per South African household has also been increasing due to changes in consumer preferences as well as the different electrification programmes that South Africa has in place, which have provided electricity connections to over 85 percent of households in the country.

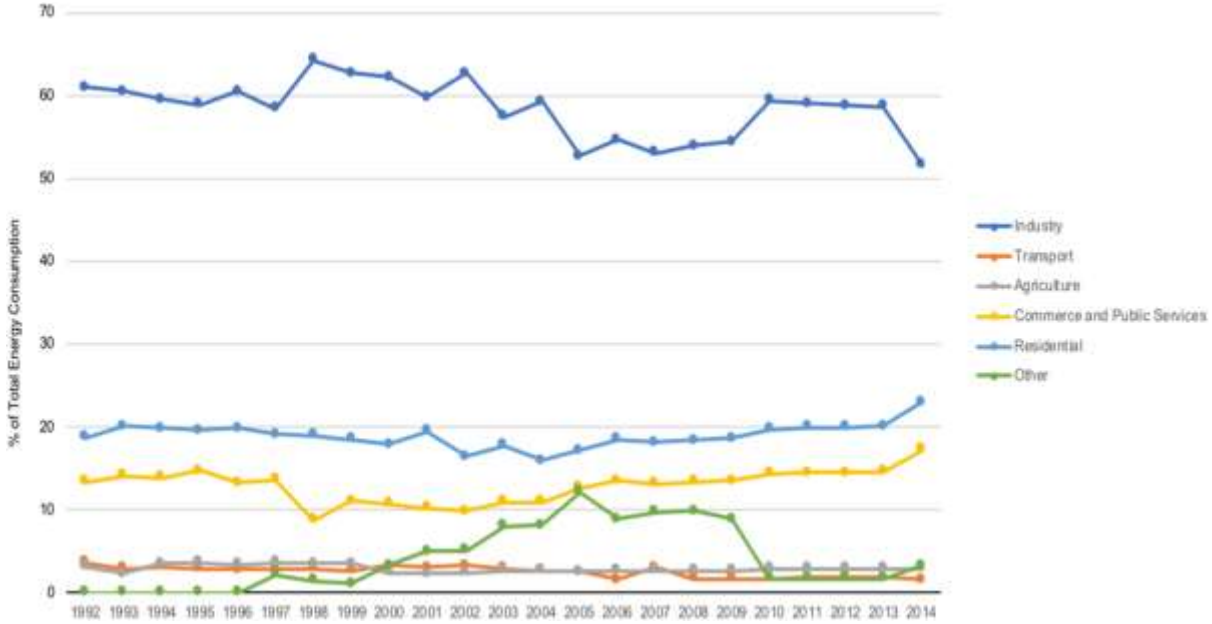

Fig. 2. South African Electricity Consumption per Sectors 1992–2014. Fig. shows the trend of sectoral electricity consumption in South Africa highlighting the share of total electricity consumption in each sector.
Source: Adapted from [31]

The main purpose of this paper is to evaluate the trends, evolution and characteristics of energy consumption in the South African residential sector. In doing so, a comprehensive view of the energy consumption patterns of the residential sector in South Africa is presented by i) evaluating the evolution of energy consumption in the residential sector in South Africa, and ii) analysing the key characteristics that influence the residential sector's energy consumption. An important question the paper aims to answer is whether there were changes in the sector's behaviour since 2008; a period that was characterised by load-shedding[1] and tariff restructuring.

This paper is organised as follows: Section 2 gives an overview of the South African literature on energy and electricity consumption in the residential sector.

[1] Load-shedding or load reduction is the South African term for electricity rationing

Section 3 provides a background on the global and South African trends in energy consumption, as well as the different energy-related South African legislation. Section 4 describes the methodology and data used in the paper. Section 5 provides the main descriptive analytics findings, including the trends and key characteristics of energy consumption in South Africa; the sectoral consumption of electricity and the patterns of electricity and energy consumption in South Africa. Section 6 concludes the paper providing some discussions, policy recommendations and the scope for future research.

2. Literature on energy consumption in the residential sector in South Africa

The international literature on energy and electricity consumption in the residential sector is vast. It includes research on factors influencing residential energy consumption, factors influencing energy efficiency in the residential sector, and different analysis including various econometric techniques that study the evolution of energy consumption in developed and developing countries [7–14].

Similarly, the electricity consumption literature in South Africa includes studies of the determinants of aggregate and sectoral electricity consumption – incorporating the industrial and residential sector [15–24]. However, research on the South African residential sector with special focus on the deeper understanding of the energy characteristics and the positioning of the sector in the rest of the world, has not been conducted in a systematic manner to date. Detailed studies on the residential sector energy consumption patterns are important towards determining appropriate policies and measurements that will allow for future increases in electricity access in the residential sector whilst working on policies aimed at reducing CO_2 emissions.

Most studies in the South African literature focus on the determinants of electricity demand – primarily on the economy in its entirety or mainly energy-intensive sectors; much less focus has been given to the residential sector [16]. An important gap in the literature is the analysis of changes over time in household energy-use characteristics. Therefore, this study focuses on literature dealing with the South African residential sector and its energy consumption patterns.

In South Africa, policies regarding access to basic services including access to electricity in rural areas were not a priority during the Apartheid era (1948 – 1991) where only a third of the population had access to electricity [16,20]. Electricity access

became a national policy priority for the South African government only post-Apartheid starting in the early 1990s and especially in 1994. Against this background, the South African literature regarding residential energy consumption post-1994 focussed on the effects of access to electricity on rural households' energy consumption and not on the trends and patterns of households' energy demand [25–28].

Davis [25] studied energy consumption patterns in rural areas in South Africa focusing particularly in identifying the effects of access to electricity on fuel choices used for everyday tasks such as cooking, heating and lighting. study found that there is evidence of an 'energy ladder', whereby as income rises, households in rural areas trend away from low-quality fuels like biomass and wood towards more convenient and modern fuels such as electricity and gas to fulfil their energy needs for basic everyday tasks. However, access to electricity was also found to influence the energy transition process. As income rises, electrified households tend to be more dependent on electricity. Additionally, the fuel choice patterns of low-income electrified households were found to be similar to that of non-electrified households; electricity is seen as an additional source of energy. Davis [25] study was very detailed with regards to energy consumption patterns in rural areas. However, there was a lack of comparison with regards to how energy consumption in rural areas compares to the rest of the country as well as the key electrification policies that were implemented in South Africa up to1998.

Thom [26] also studied aspects of electricity and energy consumption in South Africa. The study attempts to explain how access to electricity influences electrical appliance ownership in rural households. Additionally, the study described how rural households who are electrified tend to use electricity and other sources of energy for lighting, cooking and to use electrical appliances such as radios. This study was based on a project by the Energy and Development Research Centre on '*The Role of Electricity in the Integrated Provision of Energy to Rural Areas*' that secured availability of reliable and detailed data for the period 1995 to 1998. By 1999, the electrification of rural households had increased to around 46 percent, compared to 12 percent in 1994.

The main findings suggest that even though many households had become owners of electric appliances such as radios, televisions, kettles, irons and refrigerators, still the level of adoption of these technologies is low and dependent on income levels – the higher the income, the higher the use of electric appliances. Thom [26] suggests that to meet their basic energy needs, most households in rural areas

use a combination of fuels which includes paraffin and candles. It is apparent, that having access to electricity simply adds electricity to the mix of fuels used by rural households; however, it does not fully substitute the use of other fuels. Even though grid electricity is most commonly used for lighting, it was observed that rural households also use electricity for cooking. Yet, low-income households do not use electricity as the single fuel for cooking, they still rely on firewood and paraffin. The relatively low cost of paraffin has led to its continued use for cooking and water heating even after electrification.

Thom [26], highlighted how the South African electrification program has been implemented as a 'blanket' program and has failed to recognise the fact that some rural households are still not able to afford to pay for electricity beyond the free-electricity allocation, which leads to rural households still relying on other sources of energy to satisfy their basic energy needs.

Madubansi and Shackleton [28] confirmed one of the key findings by Thom [26], concluding that, regardless of widespread access to electricity in the country, households still rely on a mix of electricity and other fuels such as paraffin and firewood for lighting, cooking and thermal use. This confirms, as highlighted in the literature and confirmed by Thom [26], that households view electricity as a complement to other fuels sources instead of as a substitute. Thus, Mabudansi and Shackleton concluded that as electrification increases in rural areas, energy consumption and the total number of fuels used by households increases. However, despite the increase in expenditure on all sources of energy, the study reported that in 2003, rural households spent around 60 percent of their total energy expenditure in electricity. This is explained by the relatively high monetary value of grid-based electricity relative to alternative energy sources such as wood or kerosene.

Over the last decade, little has been done to track the South African residential sector's energy consumption patterns as well as its path through development, political and policy changes, and technological advancements. Understanding the roots of South Africa's energy behaviour will ultimately aid in prescribing appropriate policies and pressing issues for energy research. This paper aims at filing this gap in the literature.

3. Background: Global Residential Energy Consumption, the South African Electricity Market and its Energy-Related Legislation

This section presents the status of energy consumption globally and in South Africa. It also focuses on providing a brief background of the South African electricity market and the current state of electrification in the country whilst including a summary of key energy-related legislation in South Africa.

3.1. Global trends in residential energy consumption

Global primary energy needs are expected to grow by approximately 30 percent between 2017 and 2040, with renewable energy growing fast and coal use significantly reducing because of environmental concerns [2]. Despite electrification efforts being successful around the world and energy consumption shifting towards industrialising and urbanising China, India, Southeast Asia and some parts of Africa, Latin America and the Middle East; many people will still be left without basic energy services around the world in 2040 [1]. It is expected, that by 2040 access to electricity in rural sub-Saharan Africa will still be lagging by around half million people; with almost 2 billion people still depending on solid biomass such as wood as a source of energy for cooking [1].

The trend in energy sources consumed around the world is changing. OECD countries are moving from using LPG gas for heating and cooking towards using natural gas and electricity. Urbanisation in developing countries is further contributing to the movement away from biomass towards LPG gas for cooking [1]. However, in developing countries such as South Africa, alternative sources of energy including paraffin and gas both for lighting and cooking are still used (and are expected to continue) in the residential sector. Improvement in access to electricity combined with different policies aiming at replacing paraffin as a cooking fuel given its negative impact on air quality and health will lead to a decreasing trend in paraffin used by households globally [1]. Due to technological improvements in buildings – which are now using more efficient boilers and better insulation – electricity consumption in the residential sector is expected to decline worldwide despite more households using electricity for space and water heating [1].

3.2. Brief Overview of the Energy Sector in South Africa

The South African economy is reliant on many energy-intensive industries such as the mining and iron and steel industry. South Africa has one of the world's largest coal reserves which uses to meet around 75 percent of its energy needs with over 50 percent of the coal consumed in the country going towards electricity generation [29,30]. Along with Nigeria, South Africa has consistently ranked as one of the largest economies in Sub-Saharan Africa. However, South Africa has the highest energy consumption on the continent; it accounts for approximately 30 percent of total primary energy consumption in Africa [29,30].

According to the 2017 BP Statistical Review of World Energy, in 2016, 85 percent of South Africa's total primary energy consumption came from coal, followed by 26,9 percent from oil; 4,6 percent from natural gas; 3,6 percent from nuclear; 1,8 percent from renewables and less than 1 percent from hydro [31]. Due to its reliance and abundance of coal, South Africa is the leading CO_2 emitter in Africa and one of the top 15 emitters in the world [29,30].

Eskom – a state-owned electricity company which operates the national electricity grid – produces around 90 percent of South Africa's electricity. The remainder of the electricity generated in South Africa is produced by independent power producers (IPPs)[2] and municipalities [32,33]. Eskom's fleet consists of 28 power stations with a total nominal capacity of 42 810MW; the various IPPs have a total nominal capacity of 3 392MW. In 2016 Eskom's total energy output was 219 979GWh [32].

The electricity sector in South Africa is regulated by the *National Energy Regulator of South Africa* (NERSA). Regulating national electricity prices as well as promoting private investment in the form of IPPs and other off-grid technologies to secure a stable grid and promote access to electricity to all are the key objectives of NERSA [29,32].

3.3. Current State of Electrification and Key Energy-Related Legislation in South Africa

The democratic transition from the Apartheid regime in South Africa started in the early 1990s. Only then, South Africa's energy policy started developing and focusing

[2] IPPs form part of the renewable energy programme run by the South African Department of Energy that aims at promoting private and public growth in energy generation.

on providing electricity access to all. During Apartheid, South Africa's energy policy was tailored to benefit the minority of the population - the majority of the population was forced to live on the outskirts of major cities and did not have access to basic needs including access to electricity [34]. This inequality in access to electricity amongst different population groups has led to the high levels of energy poverty and reliance on other sources of energy such as wood and paraffin that is still present in South Africa especially amongst low-income households [34].

In the early 1990s, universal access to electricity was one of the priority issues identified by the government as part of the country's development policies [35,36]. Access to electricity is crucial in addressing the country's historical inequalities and helping in promoting economic growth.

'*Ensuring access to affordable, reliable, sustainable and modern energy for all'* is one of the United Nations' 17 Sustainable Development Goals that aim at ending global poverty, promoting economic growth as well as protecting the environment [37,38]. Households require electricity to perform basic daily duties which include cooking, heating, and lighting. Additionally, access to modern and reliable electricity is crucial in the provision of health care, clean water and sanitation, transportation and telecommunications [39]. Access to electricity in South Africa has increased from 35 percent of households in 1990, to 58 percent in 1996, and to over 84 percent in 2011 [40,41]. According to the Department of Energy, 86 percent of South African households were electrified by the end of 2016 [42].

The success of the South African electrification process can be attributed to the set of policies and programmes targeting the electricity sector that – as mentioned above – were drafted in the early 1990s, more specifically during the 1994-2000 period, as part of the transition from Apartheid. These energy policies focus on the energy requirements of the poor by aiming at expanding access to affordable energy services for both urban and rural households. Additionally, whilst providing access to electricity to all, the government is committed to providing cleaner and safer forms of energy to low-income households [43].

The South African Constitution of 1996 stipulates that all residents have the right to have access to energy, irrespective of geographical location, at affordable prices. Additionally, it specifies that energy should be produced and distributed in a sustainable manner, which as a whole should contribute towards enhancements in the standard of living of the population.

The key legislative and regulatory framework guiding the South African energy sector is the 1998 *White Paper on the Energy Policy of the Republic of South Africa* (referred to as White Paper hereafter). The White Paper highlights the key objectives of the government's electricity policy whose main objective is to create an electricity sector that serves as an engine for growth, development and prosperity for South Africa [44]. The White Paper recognises that energy access should be universal and that it should come from clean sources. Additionally, it emphasises the importance of households' access to adequate sources of energy for cooking, heating, lighting and communication to improve their overall living standards and to reduce poverty [44].

The Integrated National Electrification Programme (INEP) was set up in 2002 as the main electrification programme in South Africa. Through INEP, the South African government uses public sector financing for electrification. Thus, the state plays a crucial role in funding infrastructure development, particularly with regard to the electricity sector [41]. To date, INEP has been the South African energy-related policy that has had the greatest impact in facilitating energy access, especially for the poor. However, access to electricity is not the only issue faced by poor households that in spite of being connected to grid electricity are energy poor and are not able to afford the minimum amount of electricity to cover their basic energy needs.

Against this backdrop, in 2003, the government introduced the Free Basic Electricity (FBE) policy to address affordability problems related to energy and aid in reducing energy poverty in South Africa. Under the FBE policy, poor households qualify for 50kW/h of free electricity per month that is *'…deemed sufficient to provide basic lighting, basic media access, basic water heating using a kettle, basic ironing, and power for a small television set and radio'* [45]. As of March 2015, there were almost 1.2 million households in South Africa that were eligible and configured to receive FBE via installed electricity meters [45]. However, only over 900 000 customers collected their FBE vouchers [45]. Overall, this amounts to a total of 870 060MWh of FBE consumed in the 2014/15 financial year; compared to 960 348MWh FBE consumed in the 2013/14 financial year.

The electrification programme has positively impacted the welfare of the South African population. Poorer households who could not afford a connection and the basic use of electricity are now connected to the grid – or have access to other forms of energy – and are more integrated into society. However, despite the progress South Africa has made, around 11 percent of households still does not have access to

electricity [1,42,46]. Thus, as mentioned above, over 10 percent of South African households – mainly low-income ones living in rural areas – rely on substitute sources of energy which contribute to environmental degradation and present health hazards to households [1,42,46]. The following section presents the observed energy consumption trends in the South African residential sector.

4. Methodology and Data

4.1. Method: Descriptive

This paper conducts a descriptive analysis towards understanding the South African residential sector's energy characteristics. It focuses on studying the South African residential sector, emphasising the evolution of the electrification process in South Africa; the evolution of energy consumption within the residential sector; the behaviour of households in using energy to satisfy their basic needs of cooking, lighting and eating; and its geographical distribution.

The main sources of information to report on the evolution in the South African energy consumption patterns will be: i) the latest published South African General Household Survey titled *'GHS Series Volume V Energy 2002-2012: In-depth analysis of the General Household Survey data'* [46], which measures and reports on different energy sources indicators, providing an in-depth analysis of energy used in South Africa over time; and ii) the latest Survey of Energy-Related Behaviour and Perceptions[3] titled '*A Survey of Energy-Related Behaviour and Perceptions in South Africa: The Residential Sector*' [47], which gathers information about the energy related behaviour and patterns regarding energy uses, energy poverty and energy pricing in South Africa. These surveys are data intensive that were overseen by Statistics South Africa, the South African Human Science Research Council (HSRC) and the Department of Energy. Therefore, we believe that the data collected for these surveys are reliable and representative of the South African population. Details on the data collection process for these surveys can be found in the above mentioned reports [46–48].

[3] These surveys were intended to become an annual study conducted by the South African Department of Energy. However, the surveys were only conducted in 2011 and 2012 providing the latest official available data in South Africa on energy-related behaviours in the residential sector.

4.2. Data Discussion

The main data sources for this paper are the Department of Energy, the International Energy Agency, the World Bank and the different waves of the National Income Dynamics Study (NIDS) by the Southern Africa Labour and Development Research Unit. Data regarding access to electricity and electrification statistics for South Africa was gathered from the Department of Energy [42,49] and the International Energy Agency [30,50]. Additionally, key statistics regarding access to electricity for South Africa were collected from the World Bank's World Development Indicators Data [51]. The World Development Indicators report compiles data from officially recognised international sources, representing the main collection of key indicators by the World Bank [51].

This study deals with the residential sector holistically, appreciating the sector's importance to the future electricity demand of the country both directly and indirectly through its demand for other goods and services and hence, it looks at some household characteristics that might influence the electricity demand and whether these have changed after 2008. To do so, we evaluate the 4 different waves of the National Income Dynamics Study (NIDS) data. The NIDS project and survey data collection started in 2008 with the aim of closely following over 28 000 people from different backgrounds, ages and income categories over time [52]. NIDS is the first nationally representative panel study in South Africa, it aims to track *'changes in incomes, expenditures, assets, access to services, education, health and other dimensions of wealth being'* for over 28 000 individuals from 7 300 originally interviewed households [52,53].

Surveys such as NIDS are important for government, policymakers and other stakeholders since it allows them to understand and track whether individuals are making progress in the society whilst highlighting and following the elements influencing these dynamics.

The NIDS survey is repeated every two years; therefore, it follows how the members of the original 7 300 interviewed households move over time whilst examining the evolution in livelihoods of these individuals and households. It is important to note, that NIDS follows and re-interviews individuals, it does not follow households; therefore, whilst the number of individuals interviewed stays the same across waves, the number of households might increase over time [52,53].

The study is conducted by the Southern Africa Labour and Development Research Unit (SALDRU) based at the University of Cape Town's School of Economics [52]. Since 2008, there have been four waves of NIDS. The first wave of this panel – Wave 1 – was conducted in February 2008, and the data and respective report were released in July 2009 [54]. Wave 2 of NIDS was conducted during 2010, with the respective data and results released in 2011; during this wave, people from Wave 1 were re-interviewed providing a fair picture of how South African households have adapted over two years of difficult socio-economic circumstances after the global financial crisis [55]. The third wave – Wave 3 – of the survey was conducted between April and December 2012; this wave re-interviewed households from Waves 1 and 2 [56]. Fieldwork for the fourth wave of NIDS was conducted during 2014; as per previous waves, Wave 4 re-interviewed households from earlier waves, collecting information on developments in their lives over 2008-2014 period [57]. For the reduced sample to be nationally representative and to account and adjust for sample design and non-responses, the NIDS data has household level probability weights.

The NIDS panel dataset is relevant to this study since it includes questions regarding South African households' access to electricity. Additionally, it provides information about the other types of energy used by households and it gives some indication concerning household expenditure on electricity and energy in South Africa.

5. Main Findings: Descriptive Analysis

This section provides evidence of the patterns of energy and electricity consumption by the residential sector in South Africa. It includes the trends in access to electricity and how it relates to energy poverty and the main alternative sources of energy used by South African households to meet their basic energy needs. Additionally, it discusses the results gathered from evaluating the NIDS database on access to electricity, electricity expenditure and energy used.

5.1. Trends, Geographical and Demographical Characteristics of South African Households' Access to electricity:

The different electrification programmes and policies that the South African government has implemented over the years have been crucial in influencing access to electricity and energy consumption in the residential sector. Access to electricity in

South Africa increased from 60,8 percent in 1994 to 86 percent in 2016 (Figure 3) [51] [42]. The majority of non-electrified South African households reside in the KwaZulu-Natal and Eastern Cape provinces [47,48].

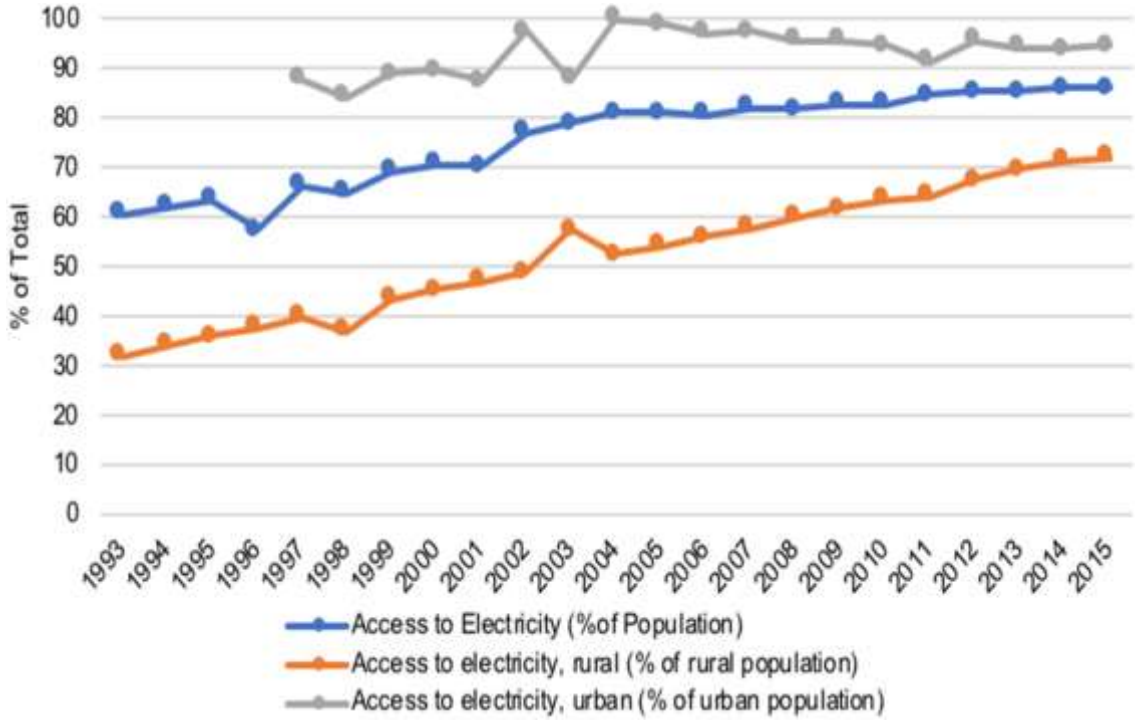

Fig. 3. South African Access to Electricity. Fig. shows access to electricity as a percentage of the total population, as a percentage of rural population, and as a percentage of urban population. It is designed to highlight the increasing trend in access to electricity in South Africa.
Source: Adapted from [37], [46]

Between 1994 and 1999, over 500 000 new connections were made annually in South Africa; this steady increase in electrification can be attributed to the national electrification programme. Between 2013 and 2016, over 890 000 new connections were made [3,42]. The progress made with regards to access to electricity in South Africa has been positive but it was not enough to achieve INEP's goal of achieving universal access to electricity by 2014. As a result, in 2011, the Department of Energy revised the timeline of INEP's commitment to achieving universal access to electricity to 2025. This is set to be attained by using a combination of both grid and non-grid technologies in the supply of electricity [47].

The proportion of urban vs rural households in a country influences economic development and access to electricity. As shown in Figure 4, the share of the rural

population as a percentage of the total population in South Africa has been declining over time. According to 2015 estimates, the rural population in South Africa represented 35 percent of the total population; in comparison, the rural population in South Africa was over 50 percent in 1994 [41,51]. This partly highlights some of the economic progress that has been achieved in the country since 1994 due to a broad range of development programmes that have been implemented [36]. Additionally, as shown in Figure 3, prices of electricity for both the rural and urban populations have been increasing over time.

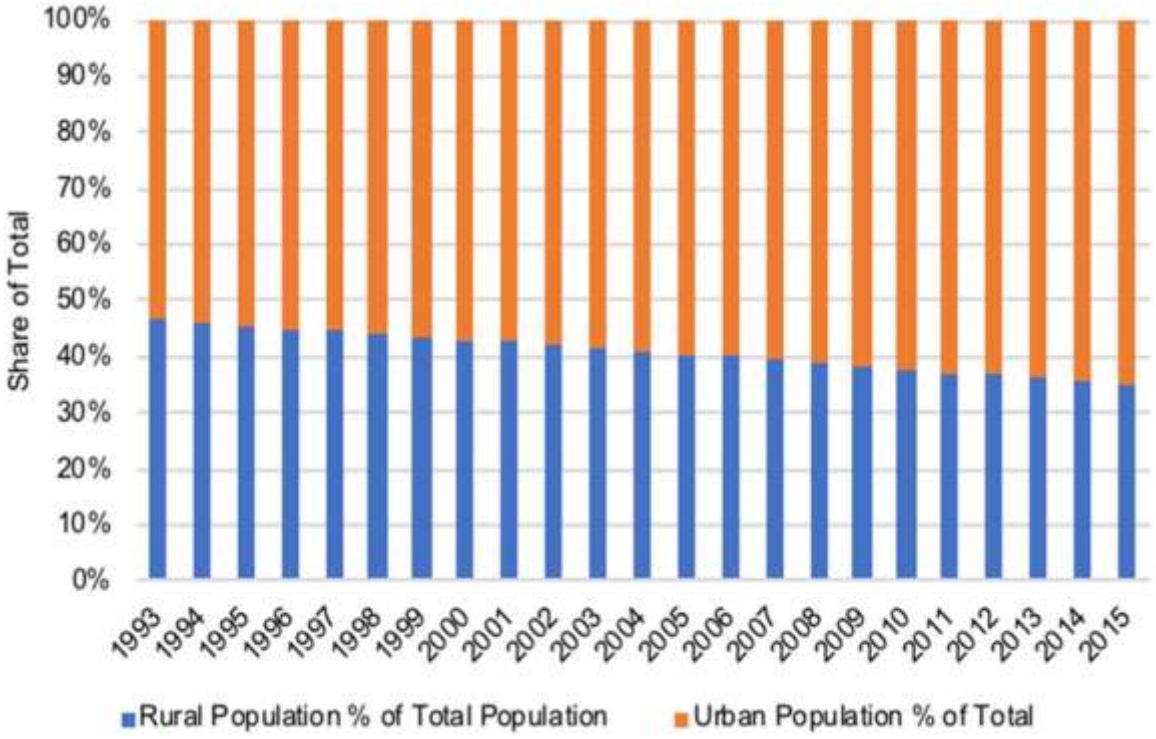

Fig. 4. South African Rural vs Urban Population Share. Fig. depicts the share of total population of both rural and urban population. It is intended to show how the share of rural population in South Africa has been declining over time.

Source: Adapted from [37], [46]

By the end of 2015, approximately 72 percent of rural households in South Africa had been connected to the grid compared to 1994 were only 34 percent of rural households were electrified (Figure 3) [41,51]. On average, households in urban areas that have access to electricity are more likely to use electricity than those in rural areas.

Data further shows that the proportion of households with access to electricity is lower in households in which the head is 'Black African' than in households in which

the head is from other population groups [46,58]. Households that are male-headed are less likely to be electrified than those headed by a female. The age of the household head is closely correlated with access to electricity; almost 90 percent of households in which the head is over the age of 60 are electrified compared to almost 75 percent of child-headed households. Poorer households – in the first income quantile – are less likely to be electrified than those in the wealthiest quantile, 78,8 and 93,8 percent respectively. As expected, nationally and across all households, formal dwellings are more likely to be electrified than informal dwellings [46].

5.2. Energy poverty:

As stipulated in the FBE programme, the 50kWh of electricity that poor households receive for free each month should be sufficient to cover their main electricity needs [44]. The implementation of the FBE programme has been influential in households' use of electricity [46,47]. Poor households that receive FBE are more likely to use electricity and less wood and other biomass for cooking than poor households that do not receive FBE and must pay for electricity. However, free access to electricity does not seem to have a significant impact on lighting. Between 2005 and 2011, only 25 percent of poor households claimed their free basic electricity quota. A reason for this may be that the majority of poor households, who qualified for FBE reported that they are not aware of the FBE policy and do not know if they are getting the service [47,48]. In 2005, out of the households receiving free basic electricity, 45,8 percent consumed extra units of electricity, compared to only 27,2 percent in 2011 [46].

Despite the FBE programme increasing the use of electricity by poor households, the energy poverty issue is still a reality for many South African households who despite being electrified do not access electricity simply because they cannot afford it. Consequently, these households are considered energy poor – spending more than 10 percent of household income on energy – and are heavily dependent on alternative sources of energy such as biomass for cooking and heating. Illegal electricity connections are a direct consequence of this reality; in 2012, 1 percent of household reported that they do have an illegal electricity connection – down from 2 percent in 2011 [47,48].

According to the latest household income and expenditure survey, South African households spent around 75 percent of their household expenditure on basic needs such as housing, electricity and water, food and transport [59]. Households in the bottom income decile spent around 6 percent of their household consumption expenditure on electricity and other fuels; compared to households on the top income decile who only spent 1,7 percent [59]. Households in the upper expenditure decile spent 1,7 percent of their household consumption expenditure on electricity and 0,1 percent on liquid fuels compared to 4,5 percent and 1,4 percent for households in the lower decile [59].

Poor households tend to pay less towards electricity in nominal terms, while that represents a larger proportion of their total monthly income: 50 percent of households nationally spent close to 5 percent of their total monthly income on electricity (2012 data). It is also shown that a significant number of households are energy poor, with almost 10 percent of households found to spend 20 percent or more of their income on electricity. According to StatsSA [46], energy poor households are most prevalent in the Eastern Cape and Gauteng. Nevertheless, the number of South African households considered energy poor declined from 47 percent in 2011 to 43 percent in 2012 [47,48]. When classified by income level, in 2012, almost 75 percent of households in the first quantile were energy poor; with only 18 percent of households in the richest quantile.

These statistics related to energy poverty explain why despite the advances made with regards to electrification in South Africa over the last 20 years, and given that historically, electricity prices in South Africa have been amongst the lowest in the world, some low income-electrified households continue to use other energy sources to meet their basic energy needs [46,47].

5.3. Electricity Consumption and Prices in the South African Residential Sector:

As shown in Figure 5, total energy consumption by the residential sector has increased significantly since 1950. Some key trends can be observed from the data on electricity consumption by the sector. Firstly, after 2003, when the FBE programme was implemented, residential electricity consumption increased steadily up to 2007. Secondly, after 2008, a period characterised by load shedding and price restructuring,

it can be seen that residential electricity consumption declined. The reasons for this change in behaviour may be attributed to: i) increased tariffs that incentivised energy savings and demand management behaviour; ii) the global financial crisis that affected the income levels of households; iii) load shedding that has given motivation to many consumers to search for alternatives, such as off-grid or self-generation (gas or solar). Offsetting this effect post-2008 was a continuation in the decline of the average size of South African households – from 3.8 in 2008 to 3.3 in 2015 – combined with an increase in the total number of households, which resulted in less occupancy but more households overall.

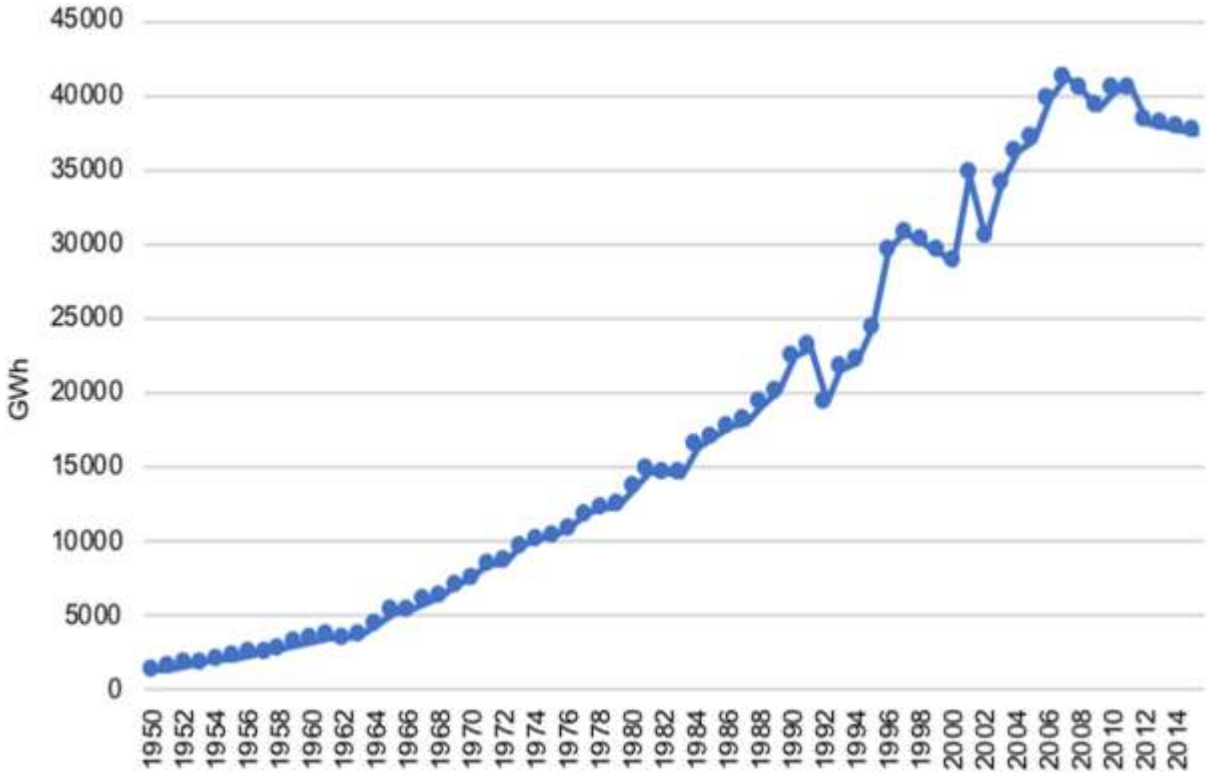

Fig. 5. South African Total Residential Electricity Consumption 1950–2015. Fig. shows how total energy consumption by the residential sector has been increasing since 1950.

Source: Adapted from [54], [55]

The demand curve for electricity is unambiguously downward sloping. However, the relationship between changing electricity prices and electricity consumption over time is often blurred by the moving of the electricity demand curve in line with economic and population growth. Up to the 2008 electricity price restructuring phase, annual increases in the nominal residential price of electricity in South Africa were on

average slightly higher than the average price adjustment of electricity. Annual changes in the nominal residential price of electricity were in line with CPI up to 2008 (Figure 6). Between 2008 and 2012, Eskom raised electricity prices at a rate far outpacing inflation. Various reasons contributed to this rapid increase in the price of electricity, including historical price factors, capital expansion and rising costs associated with supply constraints. Household consumption of electricity fell slightly during the 2008-09 period. On face value, this supports the observation that residential electricity consumption patterns in South Africa did change after the 2008 price restructuring. However, this period coincided with the aftermath of the global financial crisis and subsequent recession and care should therefore be taken in ascribing causation. Due to a combination of factors such as demand-side management, an uptake in off-grid solutions and low economic growth, growth in household consumption of electricity has remained subdued in the aftermath of the large price increases during the 2008-2012 period. In general, real consumption of electricity has closely followed the pattern of low economic growth during the 2013-2015 period (Figure 7).

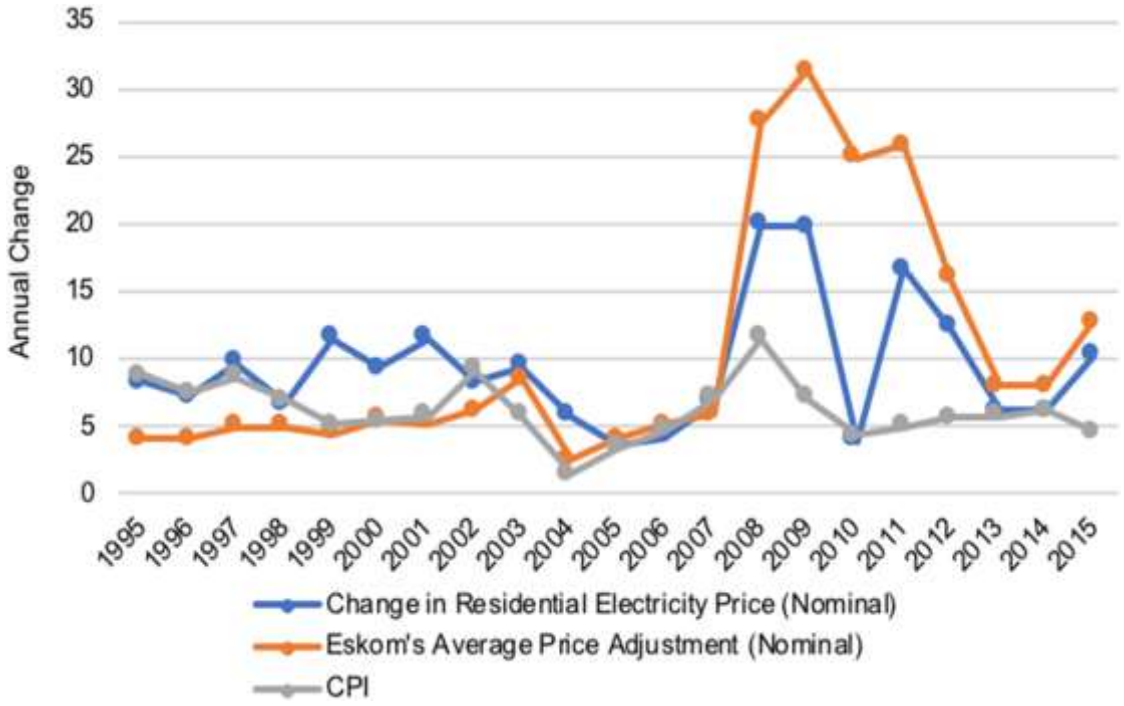

Fig. 6. Annual Changes in Nominal Electricity Prices, Eskom's Average Price Adjustment and CPI. Fig. shows the annual changes in the nominal residential price of electricity vs the average price adjustment by Eskom and how they have grown compare to CPI.
Source: Adapted from [56], [57], [58]

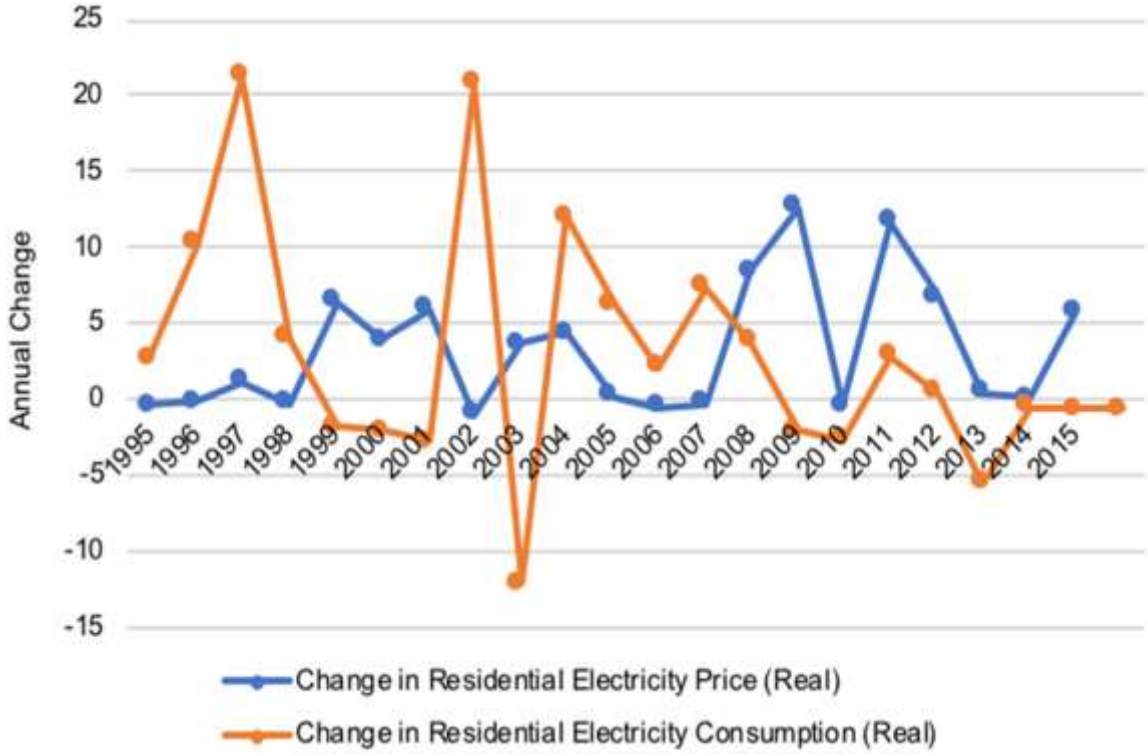

Fig. 7. Real Annual Changes in Residential Electricity Consumption vs Annual Changes in Residential Electricity Prices. Fig. portrays the relationship between residential electricity consumption and the annual changes in residential electricity prices.

Source: Adapted from [55], [56]

5.4. South African Energy and Electricity Consumption Patterns

5.4.1 Expected Energy Consumption Patterns in South African Households:

According to Statistics South Africa [40], residential energy is classified in three types: traditional, transitional and modern fuels. Traditional fuels include all solid fuels like firewood. Transitional fuels include solid fuels such as coal and other fuels such as paraffin and LPG gas. Modern fuels consist of electricity which can originate from both the electricity grid or from renewable sources. In line with this classification, residential energy use in South Africa is expected to continue transitioning from traditional fuels towards modern fuels [40]. Additionally, electricity demand is expected to continue growing at the same growth rate of population [40,46].

Due to urbanisation, electrification – especially in rural areas – and increasing purchasing power of households, the energy consumption patterns by South African households continuously change. Even though electrification remains the key factor influencing electricity consumption by households, poorer households are still

expected to rely on other sources of energy even after having access to electricity. Therefore, as part of the fuel transition, most South African households have moved towards consuming more transitional fuels, with the share of traditional fuels used for cooking and heating decreasing.

5.4.2 Prevalence of Traditional Fuels and Biomass Consumption in South African Households:

Due to their easy access and low costs incurred by the residential consumers, traditional fuels such as firewood and other forms of biomass including agricultural waste and charcoal, are used for cooking. The use of these fuels can be hazardous, and can negatively affect health, the environment and the socio-economic development of households [46]. The consequences of not having access to electricity and relying on biomass are vast. Firstly, it has been proven, that households without access to electricity need to spend a significant amount of time fetching and harvesting biomass; this translates in fewer hours spent at work and hence less income earned. Secondly, the burden of collecting biomass tends to fall on women, placing unfair physical and time pressure on them. Thirdly, burning of traditional biomass inside households contributes to health-threatening indoor air pollution. Finally, unsustainably harvesting biomass can lead to heightened deforestation and land degradation [46].

Over time, poorer South African households have been more dependent on low-cost biomass fuels for cooking and heating. In South Africa, the use of solid fuels such as firewood is more concentrated on poorer provinces with large rural populations like Eastern Cape, North West and Limpopo [46].

5.4.3 Main sources of energy used by South African households:

Approximately 14 percent of South African households do not have access to electricity. Therefore, as explained in previous sections, non-electrified and poor households use alternative sources of energy to sustain their basic energy needs. It was observed, that the most common alternative sources of energy are paraffin, firewood, LPG, coal, crop residue and animal dung. There are considerably different patterns of energy consumption between electrified and non-electrified households and between rural and urban households [47,48]. Households without access to electricity – regardless of their income level and geographical location – tend to use

more solid fuels for cooking and both water and space heating than households with access to electricity. Similarly, when compared to urban households, rural households use more substitute sources of energy even if their residences are electrified. The same is true for poorer versus richer households.

5.4.3.1. Energy choice for cooking

It was observed, that households' use of electricity for cooking increased from 58 percent in 2002 to over 75 percent in 2011. Over the same periods, the use of solid fuels including coal, firewood and animal dung declined from 22 percent in 2002 to 12 percent in 2011 [46]. Between 2011 and 2012, the patterns of energy used for cooking did not really change for electrified households. However, non-electrified households did consume more firewood from 40 percent in 2011 to 54 percent in 2012, and less paraffin in 2012 compared to 2011, from 50 to 38 percent. This can be attributed mainly to increased paraffin prices [47,48].

At a provincial level, in 2012, more than 80 percent of households in Western Cape, Free State, Gauteng and Northern Cape used electricity for cooking. In Limpopo and the Eastern Cape, around 50 percent of households used electricity for cooking. As expected, the use of solid fuels for cooking is more common in both Limpopo and the Eastern Cape than in the other provinces [46]. Firewood, coal, animal dung and paraffin are the preferred alternative energy sources used for cooking.

Looking at the energy choice for cooking by income quantile, in line with the energy ladder, the use of electricity for cooking purposes increases as household's wealth increases. Conversely, the use of solid fuels and biomass for cooking purposes is negatively related to households' wealth. It was reported that less than 1 percent of households in quantile 5 – high-income households – use substitute sources of energy for cooking.

5.4.3.2. Energy choice for space heating

Energy used for space heating varies with the different weather seasons. As expected, electricity used for space heating is seasonal. Therefore, households tend to use more electricity for space heating over the winter months than during summer [46]. Between 2002 and 2012, the use of alternative sources of energy for space heating decreased from 92,8 to 72,3 percent. In spite of access to electricity increasing

between 2002 and 2012, electricity used for heating purposes decreased by over 10 percent in 2012 [46]. Similarly, there was a decrease on the percentage of households using firewood as an alternative source of energy for space heating from over 23 percent in 2002 to around 16 percent in 2012 [46].

In 2012, at a provincial level, around 40 percent of households in North West, KwaZulu-Natal and the Western Cape did not use energy for space heating. Using electricity for space heating is more prominent in Gauteng, North West and Northern Cape and least common in both the Western Cape and Eastern Cape. Firewood as an energy source used for space heating is mostly used in Mpumalanga and Eastern Cape; whilst paraffin is commonly used in the Eastern Cape and Free State [46].

Households living in formal housing tend to use electricity for space heating. Yet, more access to electricity does not necessarily translate into increased electricity use for domestic purposes. Less than half of electrified households used electricity for space heating purposes. As measured by income quantiles, the use of electricity for space heating purposes increases with household wealth [46].

5.4.3.3. Energy choice for heating water

Sanitary activities such as bathing, washing clothes and washing dishes are the main activities for which water is heated for. Energy used for water heating purposes is highly linked to income level; wealthier households have been reported to have more electric geysers, washing machines and dishwashers than poorer households [46].

Nationally, in 2012, more than 75 percent of electrified households used electricity for heating water, whilst around 12 percent of households used solid fuels and around 7 percent used paraffin. Households residing in formal houses use more electricity to heat water than households in informal dwellings [46]. Income and electricity use are positively related. It was observed, that as income rises, the use of electricity for heating water increases. Conversely, there is an inverse relationship between income per capita and the use of solid fuels for water heating purposes. Over 85 percent of electrified households used electricity to heat water. On the other hand, households with no access to electricity used paraffin, solid fuels and LPG as alternative energy sources to heat water.

5.4.3.4. Energy choice for lighting

Lighting is key to households' social development and security. Households need lighting for reading, studying and socialising. Between 2002 and 2011, the use of electricity for lighting in electrified households increased from 76,2 percent to over 87 percent [46]. As expected, the increase in electricity used for lighting resulted in decreases in paraffin and candles used as alternative energy sources for lighting purposes [46]. There was no change in the patterns of electricity consumption for lighting by electrified households between 2011 and 2012. In both occasions, electrified households used electricity almost exclusively as a source of lighting – 97 percent, with less than 1 percent of electrified households reporting that they still use candles. However, non-electrified households relying on candles as the main source of energy for lighting, with paraffin being the second most used energy source, decreased from 67 percent in 2011 to 59 percent in 2012.

Understandably, electricity used for lighting is highly correlated to access to electricity. Households in Western Cape and KwaZulu-Natal use more electricity for lighting purposes than households in the rest of the country. Paraffin is commonly used in Eastern Cape, whilst candles are preferred in KwaZulu-Natal [46].

The percentage of households using electricity for lighting increases as income per capita increases. Around 95 percent of households in income quantile 5 use electricity for lighting [46].

5.5. NIDS Findings

In this section, we evaluate the key results observed from the NIDS dataset regarding households' access to electricity, the type of energy used by households and households' expenditure on electricity and energy in South Africa. These results are evaluated to determine the different patterns of residential electricity consumption in South Africa for the period 2008-2014.

As mention in the data section, a common feature observed in the NIDS dataset is the increase in the number of households over time (except during Wave 2 in 2010 where the number of households declined compared to Wave 1 in 2008). This increase in the number of households was due to the fact that NIDS follows individuals – and not households – over time. Therefore, as individuals move out of their original households, they are now counted as part of a new household [52].

Table 1 provides estimates for the four different NIDS Waves of the percentage of households that have access to electricity in 2008 (Wave 1), 2010 (Wave 2), 2012 (Wave 3) and 2014 (Wave 4). It can be concluded that electricity access has been increasing over time from 74,4 percent in 2008 to 75,7 percent in 2010, 83,3 percent in 2012 and 87 percent in 2014. Overall, access to electricity is reasonably high across South Africa and the NIDS results are in line with the electrification reports by the South African Department of Energy which estimate a national electrification rate of over 86 percent [42].

Table 1: NIDS Access to Electricity

%	Yes	No	Missing	Refused	Don't Know	Total
Wave 1 (2008) - 7296 Households	74,40	21,57	4,03	-	-	100
Wave 2 (2010) - 6782 Households	75,67	23,98	0,07	0,28	-	100
Wave 3 (2012) - 8033 Households	83,34	16,56	-	0,07	0,025	100
Wave 4 (2014) - 9618 Households	87,02	12,98	-	-	-	100

Source: Adapted from SALDRU Waves 1 to 4 Datasets [54–57]

With regards to household spending on electricity, an increasing trend can be observed between 2008 and 2014 with 65,9 percent of households spending on electricity in 2008 compared to over 72 percent in 2014 (Table 2). An inverse trend is observed with regards to expenditure on other energy sources; whereby, 32,4 percent of households reported to have spent on other energy sources in 2008 compared to 25,9 percent in 2014 (Table 3).

Table 2: NIDS Household Expenditure on Electricity

%	Yes	No	Missing	Refused	Don't Know	Total
Wave 1 (2008) - 7296 Households	65,93	33,62	0,36	0,08	0,01	100
Wave 2 (2010) - 6782 Households	-	-	-	-	-	-
Wave 3 (2012) - 8033 Households	73,45	26,23	-	0,09	0,24	100
Wave 4 (2014) - 9618 Households	72,98	26,72	-	0,02	0,28	100

Source: Adapted from SALDRU Waves 1 to 4 Datasets [54–57]

Table 3: NIDS Household Expenditure on Other Energy Sources

%	Yes	No	Missing	Refused	Don't Know	Total
Wave 1 (2008) - 7296 Households	32,35	66,76	0,78	0,08	0,03	100
Wave 2 (2010) - 6782 Households	-	-	-	-	-	-
Wave 3 (2012) - 8033 Households	28,63	71,18	-	0,14	0,05	100
Wave 4 (2014) - 9618 Households	25,85	74,03	-	0,09	0,03	100

Source: Adapted from SALDRU Waves 1 to 4 Datasets [54–57]

Between Wave 1 in 2008 and Wave 4 in 2014, a greater share of households are using electricity from mains for cooking, heating and lighting. This seems to be in line with increases in access to electricity. Firewood and paraffin are the preferred alternative energy sources for cooking. For heating, firewood is the preferred energy source. After electricity, paraffin and candles are the preferred energy sources for lighting (Tables 4 to 6).

Table 4: NIDS Sources of Energy used by Households for Cooking

%	Animal Dung	Candles	Coal	Electricity from Generator	Electricity from Mains	Gas	Paraffin	Refuse	Solar Energy	Wood	Neighbour	Other	None	Missing	Don't Know	Total
Wave 1 (2008) - 7296 Households	0,18	0,00	1,03	0,53	64,36	2,67	11,47	-	0,01	19,00	-	0,04	0,10	0,60	-	100
Wave 2 (2010) - 6782 Households	0,16	0,01	1,31	0,24	72,65	1,58	8,14	0,24	0,25	14,49	0,01	0,00	0,52	0,40	0,00	100
Wave 3 (2012) - 8033 Households	0,09	0,00	0,75	0,16	74,90	2,59	5,69	0,07	0,01	15,60	0,00	0,01	0,09	0,04	0,01	100
Wave 4 (2014) - 9618 Households	0,03	0,00	0,55	0,81	77,56	2,87	4,42	0,00	0,09	13,42	0,00	0,05	0,17	0,00	0,02	100

Source: Adapted from SALDRU Waves 1 to 4 Datasets [54–57]

Table 5: NIDS Sources of Energy used by Households for Heating

%	Animal Dung	Candles	Coal	Electricity from Generator	Electricity from Mains	Gas	Paraffin	Refuse	Solar Energy	Wood	Neighbour	Other	None	Missing	Don't Know	Total
Wave 1 (2008) - 7296 Households	0,22	0,00	2,44	0,49	52,25	0,82	7,10	-	0,03	25,00	-	0,04	10,20	1,41	-	100
Wave 2 (2010) - 6782 Households	0,25	0,00	2,15	0,29	65,50	0,80	7,95	0,25	0,25	17,02	0,00	0,06	5,13	0,32	0,03	100
Wave 3 (2012) - 8033 Households	0,10	0,00	1,46	0,16	64,00	1,10	5,78	0,09	0,05	20,53	0,00	0,00	6,67	0,05	0,02	100
Wave 4 (2014) - 9618 Households	0,05	0,00	1,40	0,60	65,17	1,00	5,20	0,00	0,10	18,01	0,00	0,08	8,38	0,00	0,00	100

Source: Adapted from SALDRU Waves 1 to 4 Datasets [54–57]

Table 6: NIDS Sources of Energy used by Households for Lighting

%	Animal Dung	Candles	Coal	Electricity from Generator	Electricity from Mains	Gas	Paraffin	Refuse	Solar Energy	Wood	Neighbour	Other	None	Missing	Don't Know	Total
Wave 1 (2008) - 7296 Households	0,00	18,28	0,00	0,52	76,58	0,11	3,48	-	0,18	0,00	-	0,03	0,16	0,66	-	100
Wave 2 (2010) - 6782 Households	0,00	13,86	0,00	0,35	80,51	0,10	3,85	0,22	0,16	0,00	0,00	0,04	0,50	0,40	0,00	100
Wave 3 (2012) - 8033 Households	0,00	12,62	0,00	0,24	84,75	0,14	1,90	0,07	0,19	0,00	0,00	0,00	0,06	0,01	0,01	100
Wave 4 (2014) - 9618 Households	0,00	9,04	0,00	0,61	87,52	0,07	1,86	0,00	0,73	0,00	0,00	0,04	0,11	0,00	0,01	100

Source: Adapted from SALDRU Waves 1 to 4 Datasets [54–57]

In line with the results reported by Statistics South Africa [46], 70 percent of households still rely on other energy sources to satisfy their energy needs. The reliance on these alternative energy sources suggests that lower to middle-income households still perceive electricity as one of the energy options available to consume on a daily basis [46,60]. However, as reported above, households are increasingly

using electricity from mains for cooking, heating and lighting. These increases in both electricity access and use of electricity from mains is a positive sign towards electricity becoming the main – and possibly the only – source of energy that South African households will use in future to satisfy their energy needs.

6. Conclusion and discussion

After analysing the trends, evolution and characteristics of energy consumption in the South African residential sector, it is evident that the country still faces significant socio-economic disparities. More than 70 percent of low-income households rely on sources of energy other than electricity to satisfy their basic energy needs, whilst medium and high-income households are reported to have near-universal electricity access. South African households that have access to electricity use it to cover their basic energy needs of lighting, cooking and heating. However, as observed in the data analysis, electrified households still rely on other sources of energy such as coal, paraffin, candles, gas and firewood to meet these needs. Households without access to electricity primarily depend on candles, firewood, paraffin and coal.

With an electrification rate of 86 percent in 2016, South Africa has made great progress in that field. Even so, there is still a considerable amount of rural and low-income households that are energy poor and cannot afford using electricity to cover all their basic energy needs, despite being electrified and enjoying the benefits of the Free Basic Electricity programme. Therefore, these households still view electricity as an additional source of energy and are still dependent on different sources of energy such as wood and paraffin to satisfy their energy needs. As per Davis [25] and Statistics South Africa [59], this proves that South Africa has a typical energy ladder where households progressively move away from low-quality energy sources such as wood and paraffin towards convenient and versatile modern sources of energy such as electricity and gas as income rises.

Electrified households use electricity as their main source of energy for lighting; only about 3 percent of electrified households rely on candles and paraffin for lighting. The main source of energy for lighting for non-electrified households is candles – which is used by around 60 percent of non-electrified households – followed by paraffin. The use of electricity for cooking has increased over time, but still approximately 20 percent of households use other sources of energy for cooking

purposes. For non-electrified households, firewood, coal, crop residue, animal dung and paraffin are the main energy sources for cooking. With regards to the use of electricity for heating domestic space, it was found that around 40 percent of all households use alternative energy sources or opt for wearing warmer clothing and blankets. Around 45 percent of electrified households use electricity for domestic heating, only a minimal percentage of households uses other sources of energy such as firewood and paraffin. For non-electrified households, firewood is the main source of energy for space heating purposes, with paraffin being the second most used source. For heating water for bathing purposes, most households rely on a single source of energy. Around 65 percent of South African households use electric appliances to heat water for bathing purposes. Electrified households tend to use either a geyser or a kettle, whereas non-electrified households tend to prefer using firewood or paraffin.

Results from the NIDS dataset indicated that electricity access is reasonably high across South Africa. Also, households' spending on electricity is increasing; inversely, expenditure on other sources of energy such as paraffin and wood is declining. In line with increases in access to electricity, South African households are using more electricity from mains to satisfy their daily energy needs.

With more households expected to be connected to the grid and with new grid connections planned to be – at least partially – based on renewable energy sources, electricity consumption patterns by South African households are expected to change over time. This will ultimately influence energy consumption and electricity demand. Therefore, future research will use the information gathered in this paper to inform and propose policies that will aim at changing consumer behaviour and the way new electricity connections are planned in South Africa. Reducing energy consumption in the residential sector and planning most future connections to be based on renewable energy sources can be one of the many policies and measures that South Africa can implement to reduce GHG emissions and comply with different climate change agreements such as the Paris Agreement.

A negative relationship between residential electricity consumption and residential prices of electricity can be observed by simply looking at the data as presented in Figure 7. Residential electricity prices have been identified as one of the key factors determining residential electricity consumption and its estimation will inform policy makers on the effects of the price structure to residential consumers' behaviour. As

part of future research, estimating the various determinants of residential electricity demand in South Africa and controlling for events such as the global financial crisis and subsequent recession is imperative.

Acknowledgements

The authors would like to acknowledge funding received from the South African National Research Foundation NRF). We also would like to acknowledge the Southern Africa Labour and Development Research Unit (SALDRU) for granting us permissions to use the National Income Dynamics Study (NIDS) dataset. We are grateful for the valuable feedback and comments received from colleagues at the University of Pretoria, in particular Heinrich Bohlmann, the editor and two anonymous referees. The usual caveats apply.

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Appendix: Definitions

Access to electricity: is the percentage of population with access to electricity. Electrification data are collected from industry, national surveys and international sources [1].

Electricity demand: total gross electricity generated, less own use in generation, plus net trade (imports less exports), less transmission and distribution losses [1].

Energy Poverty: lack of access to modern sources of energy, and a reliance on biomass for cooking and heating [61]. The preferred definition of energy poverty by the Department of Energy and by Statistics South Africa is based on the expenditure-based approach, which defines energy poverty as a household that spends more than 10 percent of their net income on energy [47].

Free Basic Electricity: refers to the amount of energy which is deemed sufficient to provide basic electricity services to poor households [46].

Household: a group of persons who live together and provide themselves jointly with food and/or other essentials for living, or a single person who lives alone [46].

Mains Electricity: is defined as the general-purpose alternating-current (AC) electric power that is supplied to households [46].

Quantile: A quantile is one-fifth (20%) of a given number. The monetary cut values for income quantile are as follows [46]:

- Quantile 1: R0 – R390
- Quantile 2: R391 – R764
- Quantile 3: R765 – R1499
- Quantile 4: R1500 – R3997
- Quantile 5: Larger than R3997

Rural: farms and traditional areas characterised by low population densities, low levels of economic activity and low levels of infrastructure [46].

Rural Formal: farms and traditional areas that are characterised by low population densities, low levels of economic activity and low levels of infrastructure [46].

Urban: cities and towns that are usually characterised by higher population densities, high levels of economic activities and high levels of infrastructure [46].

Urban Informal: settlements or ‘squatter camps’ that are usually located in urban areas [46].