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Analysing the South African residential sector's energy profile

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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% of non-electrified households rely on solid fuels for cooking, heating and lighting. Low-income South African households consume between 5% and 10% of their total energy in lighting; space heating and cooking account for the remainder 85–90% 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% of households still spend on other energy sources.

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% 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 Fig. 1, data derived from the South African Energy Balances [3], in 2014, the residential sector in South Africa was responsible for 23% of total electricity consumption – up from 20,1% in 2013 and 19,8% in 1994 [3]. Fig. 1 highlights how the residential sector is one of the largest sectors with regards to electricity consumption in South Africa.

As depicted in Fig. 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

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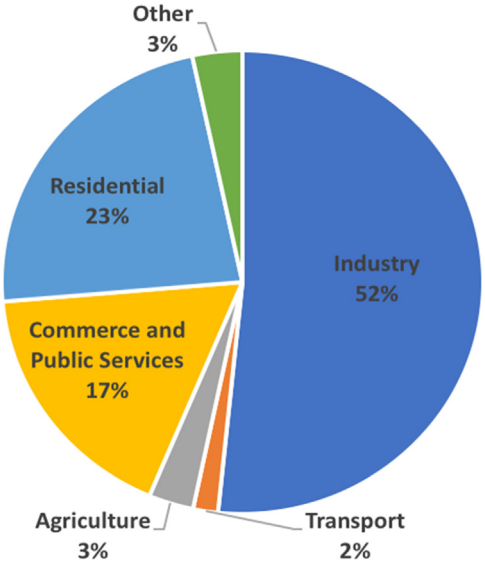

Fig. 1. South African Sectoral Electricity Consumption in 2014. Fig. shows electricity consumption in the main sector in the South African economy in 2014. It highlights how the residential sector is one of the largest sectors with regards to electricity consumption in South Africa.
Source: Adapted from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

programmes that South Africa has in place, which have provided electricity connections to over 85% of households in the country.

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. 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. The 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 1995–1998. By 1999, the electrification of rural households had increased to around 46%, compared to 12% 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

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