Eurasian Journal of Business and Management, 8(3), 2020, 191-204
DOI: 10.15604/ejbm.2020.08.03.003

EURASIAN JOURNAL OF BUSINESS AND MANAGEMENT

www.eurasianpublications.com

ENERGY DEMAND AND RACE EXPLAINED IN SOUTH AFRICA: A CASE OF ELECTRICITY

David Mhlanga
University of Johannesburg, South Africa
Email: dmhlanga@uj.ac.za

Rufaro Garidzirai
Walter Sisulu University, South Africa
Email: garidzirairufaro@gmail.com

Received: May 27, 2020 Accepted: August 2, 2020

Abstract

The study investigated the influence of race in the demand for energy in South Africa using electricity as a case study. The driving force behind the study was to establish whether race still plays a role in access to energy in the country, 26 years into democracy. The study's contribution is premised on influencing the development of policy that addresses energy inequality in South Africa and the world at large. Using the logistic regression analysis, the study found that race still plays a role in the demand for energy in South Africa. The odds of demand for electricity for the White population was 46.748 per cent higher than that of Blacks, Colored, and Indians combined. Other significant variables were gender, age of household head, net household income per month in Rand and household size. Despite constituting much of the populace in South Africa, the demand for electricity of the Black population was third compared to other races. Such findings reflect the reality that many of the Black households are suffering from energy poverty. Given these results, it is recommended that the South African government invests more in energy and alternative sources of clean energy such as solar and wind which can cater for much of the population.

Keywords: Energy, Electricity, Demand, Race, South Africa

1. Introduction

During the apartheid era, energy services in South Africa were apportioned according to race and socioeconomic status (Carruthers, 2019; Baker, 2016). The black majority experienced energy poverty in contrast to the white minority who enjoyed efficient energy services (Fakier, 2018). Although it is 26 years into South Africa's independence, one can still trace high inequality in the energy sector. Access to energy in South Africa is largely accredited to one's socio-economic status, rather than the need for energy services (Garcia-Casals *et al.* 2019). An aggravating factor of the inequality in energy supply is the fuel shortage, electricity blackouts and national load shedding issue that has preyed on the country since 2008 (Eskom, 2020). These factors have brought to South Africa a reality that the security of energy supply will be tenuous soon. Energy security and the access to clean, reliable, safe, ample, and most important affordable energy has become the priority of the South African government. Without clean, reliable, safe, ample, and affordable energy, the government cannot develop the economy, let alone address the inequality of the apartheid era regarding the availability of energy to all South Africans.

It should be borne in mind that in the past three decades, the consumption of energy in South Africa has escalated exponentially (National Treasury, 2020a). Simply put, there has been intense demand for sources of energy in the form of gas, solar, electricity, paraffin, and oil. Households demand the sources of energy for heating, lighting, and cooking to mention but a few. This increase is linked to the rapid increase in population and urbanization (Avtar *et al.* 2019). It is approximated that 64 per cent of South Africa's population currently resides in urban areas (Statistics South Africa, 2020a). Of the 64 per cent, 40 per cent of the population is in metropolitan municipalities (National Treasury, 2020b). It is projected that urban populations will reach 70 per cent by 2030 (United Nations, 2020a). In that said, if the energy problem in South Africa is not addressed to meet the growing demand, more people are likely to suffer since almost 45 per cent of the population is already suffering from energy poverty (Statistics South Africa, 2020b). This usher in the concept of energy poverty, which is, in the South African context, the lack of sufficient access to modern energy essential for human development (Mbewe, 2018). The services essential for human development have been defined as access by households to clean cooking, electricity, and space heating facilities such as stoves and fuels that are air pollution free in houses (Ateba *et al.* 2018).

Noteworthy is that these services are heftily priced for the average South African, especially for 20 per cent of the population that lives in informal settlements (International Energy Agency, 2019). This means that the right to access the reasonable and reliable energy services in terms of Sustainable Development Goals is compromised (United Nations, 2020b). Thus, most informal settlers end up resorting to *izinyoka,* which is the illegal connection of electricity since they cannot afford gas and paraffin. It is therefore evident that charging high tariffs, particularly for low-income households, does not inescapably reduce energy poverty or promote household welfare if households are incapable of affording electricity services (Pacudan and Mahani, 2019), stirred by these factors and the scarcity of literature on this discipline (Ateba *et al*. 2018; Huxham *et al.* 2019), the study examined the influence of race on the demand for energy in South Africa with a desire to assess if race still influences access to energy in the country using electricity as a case study. The study was based on the fact that, before 1994, South Africa was overwhelmingly characterized by unequal access to energy services promulgated by apartheid regulations that discriminated against the natives who constituted much of the population. This study is pertinent in influencing the development of policy that addresses the energy inequality in South Africa. Precisely, this study sets to make three contributions that were not covered by previous studies. First, there is no study that was done on the role of race in energy demand. Thus, the study covers this research *lacuna*. Second, majority of the related studies done on demand for energy are at a local level while this study digs deeper into South Africa providing critical intuitions into the role of race on demand for energy. Third, majority of the studies employed factor analysis while the current study utilized the unique logit regression model that provides robust and accurate estimates.

The rest of the study is systematized as follows. Section 1 discussed the introduction and background of the study while Section 2 discusses the energy demand distribution in South Africa. Section 3 presents the energy theory and the empirical literature related to energy demand. Research methodology and the empirical results were discussed in Section 4 and 5 respectively. Finally, Section 6 concludes the paper with policy recommendations.

2. Energy demand distribution in South Africa

The energy-economic space has undergone three main phases. The first phase is the period from 1948-1994 (Mbewe, 2018). This period is called the apartheid phase, where certain groups were economically and politically isolated. Thus, certain ethnic groups, such as the white minority, had access to energy security to the detriment of others. The second phase is called the post-democracy phase from 1994-2000 (National Treasury, 2020b). During this period, policy began to change in favor of the previously disadvantaged groups such as blacks and Indians. Of these policies, the most pertinent is the 1998 White Paper on Energy, Free Basic Alternative Energy (FBAE), Free Basic Electricity (FBE) and the praiseworthy national electrification and housing program (Sustainable Energy Africa, 2014). From 2000, the government has also emphasized policies that promote job creation, economic growth, and energy security (Department of Energy, 2018). The common objective of these three policies was to provide basic services to poor households, with priority on energy security. South Africa has managed to achieve household electrification rates of 85 per cent through the Department of Energy (2019). However, two decades into democracy, the country still grapples with notable levels of energy poverty, regardless of the enormous efforts by the government to curb the energy crisis.

South Africa has five main energy sources. These are coal, renewable resources, crude oil, gas and nuclear (National Treasury, 2020a). Figure 1 shows the composition of the energy sources in South Africa. Figure 1 further shows that coal is the major energy source in South Africa. It contributes about 77 per cent of energy as it is in abundance. Moreover, South Africa is one of the major exporters of coal globally (Department of Mineral Resources and Energy, 2020). Coal is also used in electricity generation and power generation. The non-renewable (20 per cent) is the second contributing source of energy in South Africa, followed by crude oil contributing about 16 per cent to the country’s energy. Gas and nuclear produce 3 per cent and 2 per cent respectively.

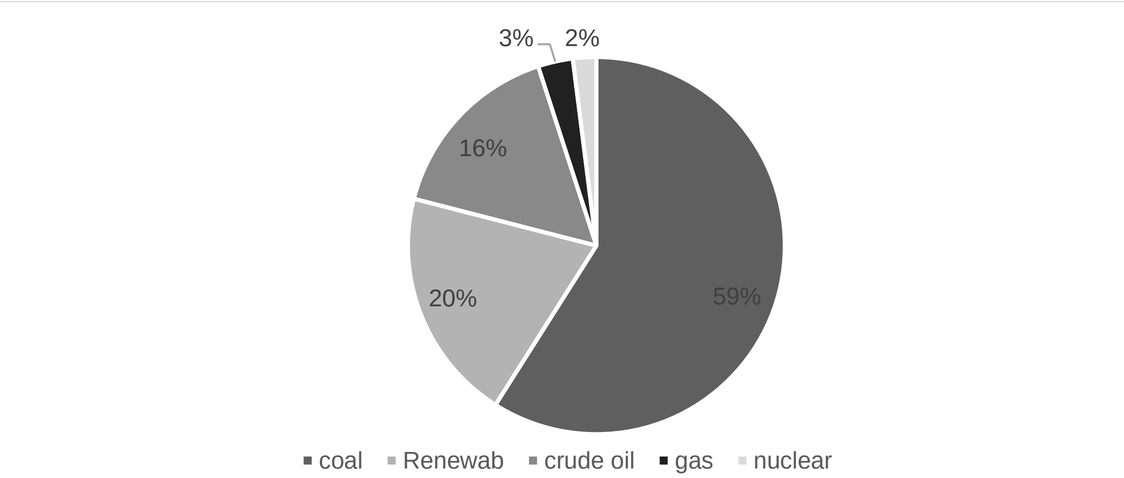

Figure 1. Energy sources in South Africa
Source: Department of Mineral Resources and Energy (2020)

3. Literature review

The definition of energy poverty has created many debates on what it entails. This has been caused by different living standards of households in different countries and regions. Thus, energy expects to post four approaches to define energy poverty, namely the: physical ability of modern energy, the physical energy requirements approach, the reliability of energy supply and the deprivations approach (Bouzarovski, 2017; Mbewe, 2018). The access to modern energy approach focuses on the obtainability of current energy sources to carry out daily activities such as cooking and lighting (Ateba *et al.* 2018). On the other hand, the physical energy requirements approach is the measure of energy needed to perform basics such as heating etc. (Hills *et al.* 2014). This approach is technical as it requires time to determine the amount of energy needed considering the multidimensionality of socio-economic factors such as gender, income, sex of the households, age, and household size (Pauchauri, 2011). The third approach is the reliability of energy supply, which means people demand energy according to the supply of energy (Sultan and Hilton, 2019). For instance, if gas is not easily available, then the demand for gas is low compared to other energy sources. The last definition is the deprivation approach which defines energy poverty as the lack of basic access to cooking space, electricity, modern fuels, and appliances ownership (Nussbaumer *et al*. 2012). This approach focuses on the multidimensional measures of energy poverty such as cooling, lighting, communication, entertainment, and heating (Culver, 2017). For this study, the deprivation definition of energy poverty was adopted since it covers the multidimensional energy approaches. The approach claims that households access energy in the form of electricity (electrification rate) and cooking fuels (Culver, 2017). Electrification rate is the number of people that have electricity connection within a population (World Bank, 2019). Furthermore, the approach also accesses modern cooking services such as electricity, gas, paraffin, etc. (Mbewe, 2018). More importantly is that these two methods of accessing energy solely depend on socio-economic factors such as race, income, age, gender, and household size of the household. These socio-economic factors were discussed in the subsequent empirical literature section.

3.1. Race and demand for energy

The relationship between race and energy poverty remains unclear since the literature shows mixed results. For instance, a survey done in 2004 by the American Association for Blacks in Energy pointed out that African Americans consume more energy compared to other races. Thus, African Americans are likely to experience energy poverty. A decade later, two American based studies by Bednar *et al.* (2017); Rosa-Aquino (2019) found that at least 65 per cent of blacks demand more energy than any other race. The authors articulated that blacks spend a large portion of their income on energy and therefore, there is left with less money to spend on other essential goods and services. A South African based study found contrary results from the American based studies. Ismail and Khembo (2015) pointed out that the Colored ethnic group is energy poor as they lack basic commodities. Conversely, Ateba *et al.* (2018) found that most African blacks in South Africa do not have access to energy, thus, they are energy poor compared to other ethnic groups.

3.2. Income level and energy consumption

There is a positive association between level of income and the demand for energy. Households with high levels of income tend to demand more energy compared to those with lower levels of income. This notion is supported by Supasa *et al.* (2016) and Han and Wu (2018) who propound that income level is a significant factor in explaining the demand for energy. Bednar *et al.* (2017) dissented with the notion and concluded that the level of income inversely affects energy poverty. Thus, poor households spend a large part of their income on energy consumption, thus making them energy poor. Israel-Akinbo *et al.* (2018) concur with Bednar *et al.* (2017) that poor households spent their little income on energy and remain energy poor. Some of the poor households end up resorting to dirty energy.

3.3. Household size and energy consumption

Noteworthy is that the number of households determines the energy consumed in a household. Therefore, the household size directly influences energy use behavior. Longhi (2015) enunciates that household size affects the demand for energy used. Consequently, a large household size demands more energy and is likely to be energy poor. Soltani *et al.* (2019) and Yalcintas and Kaya (2017) further contend that large households end up using dirty energy since more energy is required.

3.4. Gender and demand for energy

There is a general belief that females demand more energy than their male counterparts. This general notion was supported by the studies done by Petrova and Simcock (2019) and Wilhite (2017) who concluded that gender is significant in explaining the demand for energy. The authors articulated that females demand more energy for cooking, heating, cleaning, and ironing, while man only demands energy for entertainment purposes. Sustainable Energy Africa (2016) supports this finding and further expounds that females face energy poverty. Sustainable Energy

Africa (2016) further claim that the household head has a significant part of gender and energy poverty. A household that is headed by a female is likely to be energy poor than a household that is headed by a male.

3.5. Age and energy consumption

Does age matter in energy consumption? Deutsch and Timpe (2012) found that age is significant in explaining the demand for energy and people of a young age demand more energy compared to the ageing population. Contrary, Schrager *et al*. (2014) found that old people consume a lot of energy and they do not have techniques of saving energy. The more they are idle, the more they demand and use energy. The consensus is that there is a positive relationship between the demand for energy poverty and age. Thus, the demand for energy grows as one gets old and households with people from the ageing population are energy deprived.

4. Data and methodology

The 2018 General Household Survey (GHS) was used in this study. Variables relevant to the study were extracted from the GHS data to fulfil the objective of the study. The data had a sample size of 20908, distributed across all the 9 provinces in South Africa.

4.1. Dependent variable

The dependent variable is dichotomous, that is, the household either uses electricity or not. This is represented by a 0 or 1 respectively. The dependent variable is generated from the question which was asking participants if their households have access to/use electricity. It is important to note that the question included all households that use electricity. A household that uses electricity does not necessarily have to be connected to the *mains* electricity supply. Mains electricity supply refers to cases where electricity is supplied by companies like Eskom and other local designated suppliers such as municipalities. This means that the electricity from a generator and other devices is not part of the mains electricity supply (Statistics South Africa, 2018). The dependent variable data was recorded to appear in a binary form, wherein circumstances, where the household had access to electricity, assumes a value of 1, while circumstances where the household had no access to electricity take the value of 0. The subsequent section discusses the independent variables used in this study.

4.2. Independent variables

This section discusses the independent variables used in this study in a form of a table. Thus, Table 1 explains how independent variables were measured.

Table 1. Independent variables

Independent variable	Description of the variable
Race/Population Group	Is a categorical variable which explains the grouping of humans based on shared physical or social qualities? In this variable 1=African Black, 2= Colored, 3=Indian/Asian, 4=White. The variable is expected to be -/+ depending on the reference category in the categorical variable.
Gender	This variable is a dummy variable where 1= male and 0 otherwise. The variable is expected to be + influence on the choice of public health care centers for women and negative for private healthcare institutions.
Age	This variable is a continuous variable which explains the number of years of an individual. The variable is expected to be a positive influence on access to public and private health facilities.
Household size	Explains the number of people in the household, the variable is expected to have a positive influence on the choice of public institutions and traditional institutions, while negative on the private institution.
Net household income	Net household income is the income received by the household. The variable is expected to have a positive +/- influence on the demand for private health care

Source: Authors analysis

4.3. Empirical model: The logit model

The dependent variable, in this case, is dichotomous which motivated the use of conditional probability models. As a result, the study used the logit regression defined as a model employed to approximate the chance of a certain event using different types of independent variables (Breen *et al.* 2018). This methodology was deemed fit because it accommodates the nature of variables under investigation. The model also provides the authors with accurate estimates that are not biased (Alzen *et al.* 2017). Several researchers such as Kitila (2019), Mhlanga and Garidzirai (2020) and Dunga (2019) have employed the logit regression model. These authors posit that logit model is easy to employ, efficient, provides the accurate estimate and direction of the relationship.

The equation of the logit model transforms the log-odds of success to a linear component as shown below:

$$\log\left(\frac{\pi_i}{1-\pi_i}\right) = \sum_{k=0}^{K} x_{ik}\,\beta_k \; i = 1,2,\dots,N \tag{1}$$

In Equation (1), to find parameters where the probability of the observed data is the greatest, we employ the maximum likelihood estimation. To proceed with the estimation of the logit model, the first thing is to state the probability that $Y = 1$. The probability that $Y = 0$ is written as $1 - \hat{P}$. Where $\hat{P}$ is the probability. $Y = 1$ and $Y = 0$ only show that the household has access to electricity or not. $Y = 1$ when a household has access to electricity and $Y = 0$ when a household does not have access to electricity. This will lead to the following equation:

$$\ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X \tag{2}$$

To find the expected probability that Y=1 for all the values of X, the equation is calculated as shown below:

$$\hat{P} = \frac{\exp(\beta_0+\beta_1 X)}{1+exp(\beta_0+\beta_1 X)} = \frac{e^{\beta_0+\beta_1 X}}{1+e^{\beta_0+\beta_1 X}} \tag{3}$$

The model with the variables used as the factors influencing the demand for energy will be expressed as:

$$\ln\left(\frac{P}{1-P}\right) = \beta_0 + \sum_i^n \emptyset_i + \sum_j^n \emptyset_j + \varepsilon \tag{4}$$

Equation (4) above $\sum_i^n \emptyset_i$ represents all the factors in the model, while all the covariates are shown by $\sum_j^n \emptyset_j$. Substituting the above equation with Z will make the equation appear as follows:

$$Z=\beta_0 + \emptyset_1 Race + \emptyset_2 Age + \emptyset_3 Household\ size + \emptyset_3 Net\ household\ income + \emptyset_4 Gender + \varepsilon \tag{5}$$

5. Results and discussion

This section discusses the descriptive statistics and logistic model results. Thus, the subsequent section presents the descriptive statistics results.

5.1. Descriptive statistics

The study discussed the following descriptive statistics such as study's population, gender distribution, sources of electricity, supplier of electricity, etc. The subsequent section discusses the study's population.

5.1.1. Study population

All the population groups in South Africa were part of the study namely: Black African, Colored, Indian, and White. Table 2 shows the distribution of the population. Table 2 shows that Blacks African constitutes 80.9 per cent of the sample were Blacks, while the remaining 19.1 per cent was shared among the Whites (9.5 per cent), Colored (7.1 per cent) and Indians (2.4 per cent). Table 3 indicates the gender distribution of the population.

Table 2. Study of population distribution

Race	Count out of 20908	Percentage
Blacks African	17,361	80.9%
Colored	1,659	7.1%
Indian	391	2.4%
White	1,497	9.5%

Source: Author's calculations based on Statistics South Africa (2018)

5.1.2. Gender distribution

The results in Table 3 show that 11948 (58.4 per cent) are male-headed households, while 8960 (41.6 per cent) are female-headed households. Thus, the sample size of the study had more male-headed households compared to female-headed households.

Table 3. Gender distribution of the study

Gender	Frequency	Percentage
Male Headed Households	11,948	58.4%
Female-Headed Households	8,960	41.6%
Total	20,908	100

Source: Author's analysis based on Statistics South Africa (2018)

5.1.3. Access to electricity

The information on access to electricity was derived from asking households if they have access to electricity. This question was asked to all households that use electricity regardless of whether they were connected to the main electricity supply or not. A household that uses electricity does not necessarily have to be connected to the MAINS electricity supply. Table 4 indicates that from the sample of 20908, about 19853 (95 per cent) households had access to electricity in South Africa compared to 1041 (4.9 per cent) who had no access. These households were all the households who were using electricity regardless of whether they were connected to the main electricity supply or not.

Table 4. Access to electricity in South Africa

Variable (Access/No access)	Number	Percentage
Access	19,853	95.0%
No access	1,041	4.9%
Do not Know	6	0.0%
Unspecified	8	0.0%

Source: Author's analysis based on Statistics South Africa (2018)

5.1.4. Main source of electricity

Table 5 explains the households' main source of electricity. The information shows the different ways in which the households are connected to the main electricity supply. Table 5 also shows other sources not outlined in the given categories since provision has been made to specify it when the research was conducted. Table 5 shows that households with an in-house pre-paid meter were 71.5 per cent, while those with an in-house convectional meter were 11.1 per cent.

Households connected to other sources which the household pays for, such as households connected to a neighbor's line and paying that neighbor were 7.6 per cent. On the other hand, households connected to other sources which the household does not pay for were 2.1 per cent. In the sample, 0.0 per cent were using a generator, while 0.3 per cent were using home power. Households who were using other sources of energy were 0.9 per cent.

Table 5. The main source of electricity

Source	Number of Households	Percentage
In-house conventional meter	2,331	11.1%
In-house pre-paid meter	14,944	71.5%
Connected to another source which the household pays for (connected to neighbors' line and paying neighbors)	1,581	7.6%
Connected to another source which the household pays for (connected to neighbors' line and not paying)	442	2.1%
Generator	8	0.0%
Home solar panels	61	0.3%
Other	189	0.9%
Not applicable	1,047	5.0%
Unspecified	305	1.5%

Source: Authors calculations based on Statistics South Africa (2018)

5.1.5. Households connected to the main electricity supply

Table 6 presents the number of households who were connected to the main electricity supply. The sample showed that 84.6 per cent of the households in the sample were connected to the main electricity supply, while only 10.3 per cent were not connected to the main electricity supply. As explained earlier main electricity supply refers to cases where electricity is supplied by companies like Eskom and other local designated suppliers such as municipalities. Thus, power from a generator and other devices is not part of the main supply.

Table 6. Households connected to the main electricity supply in South Africa

Nature of connection	Number of Households	Percentage
Connected to the mains electricity supply	18,020	84.6%
Not connected	1,826	10.3%
Do not know	15	0.1%
Not applicable	1,047	5.0%

Source: Author's calculations based on Statistics South Africa (2018)

5.1.6. Household supplier of electricity

Table 7 shows the supplier of electricity in South Africa. This information was generated from a question asking households to establish the supplier of the electricity that the household receives. The question was directed to households connected to the main electricity supply (MAINS). The data indicated that 48.5 per cent of households received electricity from Eskom, the largest supplier of electricity in South Africa. Households who were receiving electricity from various Municipalities were 33.5 per cent

Table 7. Household supplier of electricity

Supplier of electricity	Number of Households	Percentage
Municipality	7,000	33.5%
Eskom	10,140	48.5%
Do not know	146	0.7%
Other suppliers	137	0.7%
Not applicable	2,888	13.8%
Unspecified	597	2.9%

Source: Author's calculations based on Statistics South Africa (2018)

5.1.7. Free basic electricity in South Africa

Table 8 shows the total number of households receiving free basic electricity in South Africa from the sample. The data revealed that 61.4 per cent of households were not getting free basic electricity. Households who were receiving free basic electricity were 19.4 per cent 4054 from a sample of 20908.

Table 8. Households who receive free basic electricity

Free basic electricity	Number of households	Percentage
Yes	4,054	19.4%
No	12,836	61.4%
Do not know	418	2.0%
Not Applicable	2,888	13.8%
Unspecified	712	3.4%

Source: Author's calculations based on Statistics South Africa (2018)

5.2. Logistic regression results

The logistic results are shown in Table 9, which shows five variables namely race, the gender of the household head, age of the household head, net household income per month in Rand and household size. The logit results in Table 9 illustrate that race was a significant factor at a 1 per cent level of significance in influencing the demand for electricity in South Africa with Blacks as a reference category. The results indicated that being White in South Africa had a positive significant influence on the demand for electricity with a p-value of 0.000 and odds ratio of 46.784. The probability of demand for electricity was 46.748 per cent higher for the White population compared to Blacks, Colored and Indians combined. The results also indicated that being Indian in South Africa had a positive and significant influence on the probability of demand for electricity in South Africa. The variable, Indian, had a p-value of 0.000 and an odds ratio of 8.085. The probability of demand for Indians was 8.085 higher for Indians compared to Colored and Blacks. Indians were the second racial group with a higher probability of demand compared to Colored and Blacks the reference category.

Furthermore, the results indicated that being Colored had a positive significant influence on the demand for electricity in South Africa. The variable Colored had a p-value of 0.000 and an odds ratio of 2.694. The Colored racial group had the lowest probability of demand for electricity compared to other racial groups, Whites, Indians and Blacks the reference category in the logit analysis. The odds of demand for electricity was 2.694 lower compared to other racial groups. Blacks who were the reference had an odds ratio of 6.823. In terms of demand for electricity, Blacks were third in South Africa from the sample.

The results also showed that the gender of the household head was significant at a 1 per cent level of significance, with a positive influence on the demand for electricity. The variable had a p-value of 0.001 and odds ratio of 1.242. The meaning of the variable gender is that being female increases the probability of demand for electricity in South Africa compared to males who were the reference variable in the logit analysis. These results were in line with the findings by Petrova and Simcock (2019) and Wilhite (2017) who shared the argument that women were likely to demand more energy than their male counterparts. These authors found that females demand more energy for cooking, heating, cleaning, and ironing, while man only demands energy for entertainment purposes.

Table 9. Logistic regression results

Variable	B	S.E.	Wald	Df	Sig.	Exp(B)
Race of the household head			72.539	3	0.000***	
Race(1) Coloureds	0.991	0.177	31.354	1	0.000***	2.694
Race (2) Indian	2.090	0.581	12.946	1	0.000***	8.085
Race (3) White	3.846	0.709	29.434	1	0.000***	46.784
Gender (1) Female	0.216	0.067	10.332	1	0.001***	1.242
Age of household head	0.010	0.002	20.790	1	0.000***	1.010
Net household income per month in Rand	0.000	0.000	0.004	1	0.952	1.000
Household size	0.100	0.016	36.516	1	0.000***	1.105
Constant	1.920	0.102	357.052	1	0.000***	6.823

Note: *** represents 1 percent level of significance. B stands for Beta value, S.E stands for Standard Error, Df stands for degrees of freedom.

Source: Author's Calculations based on Statistics South Africa (2018)

The results went further to show that age positively influences the demand for electricity. The variable was significant at a 1 per cent level of significance, with a p-value of 0.010 and odds ratio of 1.010. The results showed that a 1 per cent increase in the age of a household head will lead to an increase in the demand for electricity by approximately 1.010. The results were supported by Deutsch and Timpe (2012) who found that age is significant in explaining the demand for energy. The authors found that people of a young age demand more energy compared to the ageing population. On the other hand, Schrager *et al.* (2014) found that old people consume a lot of energy and they do not have techniques of saving energy. The more they are idle, the more they demand and use energy.

The results also indicated that net household income was a significant variable at a 1 per cent level of significance in influencing the demand for electricity. The variable of electricity had a P- value of 1.000. The meaning of the results was that a 1 per cent change in the value of net household income would lead to an increase in the probability of demand for electricity by approximately 1.000. The results were supported by Supasa *et al.* (2016) and Han and Wu (2018) who propound that income level is a significant factor in explaining the demand for energy. Moreover, Bednar *et al.* (2017) concluded that the level of income inversely affects energy poverty. Thus, poor households spend a large part of their income on energy consumption, thus making them energy poor.

The results further highlighted that household size was also a significant variable that influenced the probability of demand for electricity. The variable had a positive influence on the demand for electricity and it was significant at a 1 per cent level of significance, with a p-value of 0.100 and odds ratio of 1.105. The meaning of the results was that the size of the household increased the probability of demand for electricity. A rise in the size of the household by one unit increased the probability of demand for public health care by 1.105. These results were in line with the notion that the number of households determines the energy consumed in a household which directly influences the energy use behavior (Longhi, 2015). Longhi (2015) went further to state that household size affects the demand for energy used, in that a large household size demands more energy and is likely to be energy poor. Therefore, the number of people in a household influences the demand for energy.

6. Conclusions and policy recommendations

The study investigated the influence of race in the demand for energy in South Africa, to assess the influence of racial differences in access to energy in the country. Before democracy in South Africa, access to energy was largely accredited to one's socio-economic status, rather than the need for energy services. The study found that race still plays a crucial role in the demand for energy in South Africa. Thus, White population demand more energy compared to the other three racial groups combined. Furthermore, gender, age of household head, net household income per month in Rand and household size were also found to be significant in explaining the demand for electricity in South Africa. Given these results, it is recommended that the South African government invest more in energy sources which cater for most of the population. Despite being the majority in the country, the Black population's demand for electricity is third compared to other races. This reflects the reality that many of the Black households are affected by energy poverty. Although the government has made much progress in terms of ensuring that previously disadvantaged groups also access energy, through the provision of free basic electricity, much still needs to be done in terms of the number of households who have access to energy in the rural areas. More investment in the energy sector, especially on clean solar and wind energy, could help reduce the gap between the population groups in terms of access. In addition to the above, the government needs to come up with a sustainable public-private partnership where it partners with the private sector to ensure that investments in clean and cheaper sources of energy can be made available to the nation. Although the study achieved its objective, few limitations were identified. For instance, the study did not consider many sources of energy as it focused on electricity. Thus, the next will focus on other sources.

References

Alzen, J. L., Langdon, L. S., and Otero, V. K., 2018. A logistic regression investigation of the relationship between the learning assistant model and failure rates in introductory STEM courses. *International Journal of STEM Education***,** 56(5), pp. 1-12. https://doi.org/10.1186/s40594-018-0152-1

Ateba, B. B., Prinsloo, J. J., and Fourie, E., 2018. The impact of energy fuel choice determinants on sustainable energy consumption of selected South African households. *Journal of Energy in Southern Africa*, 12(2), pp. 1-20. https://doi.org/10.17159/2413-3051/2018/v29i3a4714

Avtar, R., Tripathi, S., and Aggarwal, A. K., 2019. Assessment of energy–population–urbanization nexus with changing energy industry scenario in India. *Land*, 8(1), pp. 1-24. https://doi.org/10.3390/land8080124

Baker, L., 2016. *Post-apartheid electricity policy and the emergence of South Africa's renewable energy sector.* WIDER Working Paper 2016/15. https://doi.org/10.35188/UNU-WIDER/2016/058-4

Bednar, D. J., Reames, T. G., and Keoleian, G. A., 2017. The intersection of energy and justice: modeling the spatial racial/ethnic and socioeconomic patterns of urban residential heating consumption and efficiency in Detroit, Michigan. *Energy and Building*, 143(2), pp. 25-34. https://doi.org/10.1016/j.enbuild.2017.03.028

Bouzarovski, S., 2017. *Energy poverty: (Dis)Assembling Europe's infrastructural divide*. London: Palgrave Macmillan.

Breen, R., Karlson, K. B., and Holm, A., 2018. Interpreting and understanding Logits, Probits, and other nonlinear probability models. *Annual Review of Sociology*, 44(1), pp. 39-54. https://doi.org/10.1146/annurev-soc-073117-041429

Carruthers, J., 2019. Energy, environment, and equity in South Africa. *Environment Justice*, 12(3), pp. 11–27. https://doi.org/10.1089/env.2018.0027

Culver, L., 2017. *Energy poverty: What you measure matters*. In: Pre-symposium White Paper for - Reducing Energy Poverty with Natural Gas: Changing Political, Business, and

Technology Paradigms. 2017 Stanford, CA: Natural Gas Initiative, Stanford University. pp. 1–25.

Department of Energy, 2018. *South African energy sector report.* [online] Available at: <http://www.energy.gov.za/files/media/explained/2018-South-African-Energy-Sector-Report.pdf> [Accessed on 2 April 2020].

Department of Energy, 2019. *Annual performance plan*. [online] Available at: <http://www.energy.gov.za/files/aboutus/DoE-Annual-Performance-Plan-2019-20.pdf> [Accessed on 3 June 2020].

Department of Mineral Resources and Energy, 2020. *Beneficiation economics*. [online] Available at: <http://www.dmr.gov.za/mineral-policy-promotion/beneficiation-economics> [Accessed on 18 May 2020].

Deutsch, M., Timpe, P., 2012. *The effect of age on residential energy demand.* [pdf] Available at: <https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2013/8-dynamics-of-consumption/the-effect-of-age-on-residential-energy-demand/2013/8-053-13_Deutsch.pdf/> [Accessed on 12 March 2020].

Dunga, S. H., 2019. Analysis of the demand for private healthcare in South Africa. *Stud. Univ. Babes-Bolyai Oeconomica Sciendo,* 64(1), pp. 59-70. https://doi.org/10.2478/subboec-2019-0005

Eskom, 2020. *What is load shedding?* [online] Available at: <https://www.definitions.net/definition/ESKOM> [Accessed on 20 May 2020].

Fakier, K., 2018. Women and renewable energy in a South African community: Exploring energy poverty and environmental racism. *Journal of International Women's Studies* 19(5), pp. 165–76.

Garcia-Casals, X., Ferroukhi, R., Parajuli, B., 2019. Measuring the socio-economic footprint of the energy transition. *Energy Transitions,* 3(1–2), pp. 105-118. https://doi.org/10.1007/s41825-019-00018-6

Han, H., Wu, S., 2018. Rural residential energy transition and energy consumption intensity in China. *Energy Economics*, 74, pp. 523-534. https://doi.org/10.1016/j.eneco.2018.04.033

Hills, A. P., Mokhtar, N., Byrne, N. M., 2014. Assessment of physical activity and energy expenditure: An overview of objective measures. *Frontiers in Nutrition*, 1(2), p. 1-5. https://doi.org/10.3389/fnut.2014.00005

Huxham, M., Anwar, M., Nelson, D., 2019. Understanding the impact of a low carbon transition on South Africa. A CPI Energy Finance Report. Climate Policy Initiative.

International Energy Agency, 2019. *South Africa energy outlook.* [online] Available at: <https://www.iea.org/articles/south-africa-energy-outlook> [Accessed 2 March 2020].

Ismail, Z., and Khembo P., 2015. Determinants of energy poverty in South Africa. *Journal of Energy South Africa*, 26(2), pp. 66–78. https://doi.org/10.17159/2413-3051/2015/v26i3a2130

Israel-Akinbo, S., Snowball, J., Fraser, G., 2018. *An investigation of multidimensional energy poverty amongst South African low-income households.* [online] Available at: <https://2017.essa.org.za/fullpaper/essa_3281.pdf> [Accessed on 1 March 2020].

Kitila, A. W., 2019. Determinants of homeownership in the condominium housing sites of Ambo, Ethiopia. *UKH Journal of Social Sciences*, *3*(2), pp. 1-18. https://doi.org/10.25079/ukhjss.v3n2y2019.pp1-18

Longhi, S., 2015. Residential energy expenditures and the relevance of changes in household circumstances. *Energy Economics*, 49(C), pp.440-450. https://doi.org/10.1016/j.eneco.2015.03.018

Mbewe, S., 2018. *Investigating household energy poverty in South Africa by using unidimensional and multidimensional measures*. Cape Town: University of Cape Town.

Mhlanga, D., and Garidzirai, R., 2020. The influence of racial differences in the demand for healthcare in South Africa: A case of public healthcare. *International Journal of Environment Research and Public Health,* 17(14), pp. 1-10. https://doi.org/10.3390/ijerph17145043

National Treasury, 2020a. *Budget review 2030.* [online] Available at: <http://www.treasury.gov.za/documents/National%20Budget/2020/review/FullBR.pdf> [Accessed on 1 May 2020].

National Treasury, 2020b. *Estimates of national expenditure*. [online] Available at: <http://www.treasury.gov.za/documents/National%20Budget/2020/ene/Foreward%20and%20Introduction.pdf> [Accessed on 1 April 2020].

Nussbaumer, P., Bazilian, M., and Modi, V. 2012. Measuring energy poverty: Focusing on what matters. *Renewable and Sustainable Energy Reviews*, 16, pp. 231-243. https://doi.org/10.1016/j.rser.2011.07.150

Pachauri, S., 2011. Reaching an international consensus on defining modern energy access. *Current Opinion in Environmental Sustainability*, 3(2), pp. 10-29. https://doi.org/10.1016/j.cosust.2011.07.005

Pacudan, R., and Hamdan, M., 2019. Electricity tariff reforms, welfare impacts, and energy poverty implications. *Energy Policy*, 132(2), pp. 332-343. https://doi.org/10.1016/j.enpol.2019.05.033

Petrova, S., and Simcock, N., 2019. Gender and energy: domestic inequities reconsidered. *Social Culture Geography*, 12(2), pp. 10-29. https://doi.org/10.1080/14649365.2019.1645200

Rosa-Aquino, P., 2019. *Fight the power? Cheaper electricity, dirtier air? Black communities navigate a tricky relationship with polluters.* [online] Available at: <https://grist.org/article/more-jobs-dirtier-air-black-communities-navigate-a-tricky relationship-with-their-polluters/> [Accessed on 21 February 2020].

Schrager, M. A., Schrack, J. A., Simonsick, E. M., Ferrucci, L., 2014. Association between energy availability and physical activity in older adults. *American Journal of Physical Medical Rehabilitation*, 93(10), pp. 876-83. https://doi.org/10.1097/PHM.0000000000000108

Soltani, M., Rahmani, O., Beiranvand, P. A., Ghaderpour, Y., Ngah, I., Misnan, S. H., 2019. Determinants of variation in household energy choice and consumption: Case from Mahabad city, Iran. *Sustainability*, 11(2), pp. 1- 25. https://doi.org/10.3390/su11174775

Statistics South Africa, 2018. *Statistical release PO318. General Household Survey 2018.* [online] Available at: <www.statssa.gov.zainfo@statssa.gov.za> [Accessed on 9 April 2020].

Statistics South Africa, 2020a. *Population characteristics*. [online] Available at: <http://www.statssa.gov.za/?p=12362> [Accessed on 17 April 2020].

Statistics South Africa, 2020b. *National poverty lines, 2020*. Pretoria: South Africa.

Sultan, V., and Hilton, B., 2019. Electric grid reliability research. *Energy Informatics*, 2(1), pp. 1-15. https://doi.org/10.1186/s42162-019-0069-z

Supasa, T., Hsiau, S., Lin, S., Wongsapai, W., Wu, J., 2016. Has energy conservation been an effective policy for Thailand? An input–output structural decomposition analysis from 1995 to 2010. *Energy Policy,* 98, pp. 210-220. https://doi.org/10.1016/j.enpol.2016.08.028

Sustainable Energy Africa, 2014. *Tackling urban energy poverty in South Africa.* Cape Town: South Africa.

Sustainable Energy Africa, 2016. *Energy poverty and gender in urban South Africa 2016*. [online] Available at: <https://za.boell.org/sites/default/files/status_quo_report_-_urban_energy_poverty_and_gender_in_south_africa-_final-1.pdf> [Accessed on 10 May 2020].

United Nations, 2020a. *Urbanization: expanding opportunities, but deeper divides. 2020*. [online] Available at: <https://www.un.org/development/desa/en/news/social/urbanization-expanding-opportunities-but-deeper-divides.html> [Accessed 26 May 2020].

United Nations, 2020b. *About the sustainable development goals.* [online] Available at: <https://www.un.org/sustainabledevelopment/sustainable-development-goals/> [Accessed 3 March 2020].

Wilhite, H., 2017. *Gender implications of energy use and energy access*. UC Berkeley: Center for Effective Global Action. [online] Available at: <https://escholarship.org/uc/item/6420h0xx> [Accessed on 10 April 2020].

World Bank, 2019. *Tracking SDG7: International bank for reconstruction and development.* [online]. Available at: <https://www.worldbank.org/en/who-we-are/ibrd> [Accessed on 2 February 2020].

Yalcintas, M., and Kaya, A., 2017. Roles of income, price and household size on residential electricity consumption: Comparison of Hawaii with similar climate zone states. *Energy Reports,* 3, pp. 109-118. https://doi.org/10.1016/j.egyr.2017.07.002