Energy Policy 36 (2008) 2814–2820

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Determinants of electricity demand for newly electrified low-income African households

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ARTICLE INFO

Available online 15 May 2008

Keywords:
Electrification
Determinants
Consumption

ABSTRACT

Access to clean, affordable and appropriate energy is an important enabler of development. Energy allows households to meet their most basic subsistence needs; it is a central feature of all the millennium development goals (MDGs) and, while a lack of access to energy may not be a cause of poverty, addressing the energy needs of the impoverished lets them access services which in turn address the causes of poverty.

While much is known about the factors affecting the decisions made when choosing between fuel types within a household, few quantitative studies have been carried out in South Africa to determine the extent to which these factors affect energy choice decisions. It is assumed that the factors traditionally included in economic demand such as price and income of the household affect choice; tastes and preferences as well as external factors such as distance to fuel suppliers are expected to influence preferences.

This study follows two typical low-income rural sites in South Africa, Antioch and Garagapola, where the Electricity Basic Services Support Tariff (EBSST) was piloted in 2002. The EBSST is set at 50 kWh/month per household for low domestic consumers; this is worth approximately R20[1] (±US$3). This subsidy is a lifeline tariff, where households receive the set amount of units per month, free of charge irrespective of whether more units are purchased. These data (collected in 2001 and 2002), recently collated with detailed electricity consumption data, allow us to determine the drivers of electricity consumption within these households. The sample analysed is taken from the initial phase of the study, when no FBE had been introduced to the households. This enabled the study presented here to make use of the well-populated datasets to assess what affects the electricity use decision in these households.

This paper attempts to assess which factors affected the decision-making process for electricity consumption within these households. A brief history of the electricity industry and the electrification is provided and the theoretical background for the electricity consumption model is provided.

It was found that income, woodfuel usage, iron ownership and credit obtained were significant in determining consumption levels within these households. Price and cross-price elasticities were difficult to assess due to lack of data within the sample. The results have many possible implications for policy, including the effect that easily obtained credit has for low-income households.

1. Introduction—electrification in South Africa

Prior to 1994, the majority of households in South Africa had little access to energy (and other basic) services due to the policies that existed. This meant that there existed a large backlog of households to be electrified at the start of the 1990s. The "Electricity for All" programme that was launched around this time, under the auspices of Eskom,[2] was established in order to electrify the backlog of households that existed.

The National Electrification Programme (NEP) officially commenced in 1994.[3] It was an ambitious, albeit successful, venture

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[1] South African Rands.

[2] Eskom is the major electricity supplier in South Africa.

[3] Details of the National Electrification Programme are in Department of Minerals and Energy (2001). Integrated National Electrification Programme planning and implementation manual: module 1—Background on Electrification. Available: http://www.dme.gov.za/energy/documents.stm

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doi:10.1016/j.enpol.2008.02.032

that targeted households, schools and clinics in previously disadvantaged households at the cost of about R7 billion (±US\$1 billion) (Prasad, 2006). The National Electrification Forum was established to define the objectives of the NEP, including the household connection targets (Gaunt, 2005). These goals became one of the primary objectives of subsequent government economic programmes, namely the Reconstruction and Development Programme[4] (RDP) and subsequently the growth, employment and redistribution (GEAR) strategy.

The NEP targeted an increase in the number of household connections to 67% of all households (approximately 2.5 million houses) by 2000 (Department of Minerals and Energy, 2001; Gaunt, 2005) and to complete the entire backlog of grid electrification by 2012 (Gaunt, 2003). As the majority of these areas were in rural and outlying areas that are serviced by Eskom, they were responsible for a large part of the electrification that took place during the initial 5-year period (Gaunt, 2005).

During phase 1 (1994–1999), approximately 66% of all households were electrified; of this 46% of rural households were electrified while 80% of urban households were electrified (Prasad, 2006). Phase 2, which began in 2000, targeted an additional 300,000 connections per annum over the next 5 years; according to Prasad (2006), this target has largely been met. In rural areas, this target has been met via a combination of grid, mini-grid and off-grid connections (Department of Mineral and Energy Affairs, 1998).

It was expected that, with the increase of household connections over the previous years, that demand would rise concomitantly, to approximately 350 kWh/month for each household connection. However, it was found that electricity consumption among the majority of low-income households is below 50 kWh per month, and households consume 132 kWh/ month on average throughout South Africa (Prasad, 2006). This is less than expected, and makes cost recovery for electrification exceedingly difficult.

2. Energy choices for low-income households

The majority of the energy used in developing countries comes from traditional fuels such as wood, dung, candles and (particularly in South Africa) kerosene. Human energy is generally utilised to obtain these energy sources (Heltberg, 2004).

The oft-mooted concept of the energy ladder suggests that as households' incomes increase, they will in turn switch to using more advanced energy forms such as electricity, liquid petroleum gas or natural gas (which is not widely used in South Africa). In reality most households use a combination of fuels (from both up and down "the ladder") at any one time (Heltberg, 2004; Prasad, 2006).

In general, households' fuel choices (and the subsequent "energy portfolio" used) are driven by the size and diversity of the household, the income of the household as well as other factors such as education, distance to supplier and availability of natural resources (Heltberg, 2004). Prasad (2006) mentions that the cost and availability of suitable appliances is another important factor considered when making decisions over energy use. The relative prices and the number of services that the appliance can provide are important factors when considering which appliances to use in conjunction with energy sources.

Fuel stacking is an important aspect of low-income households as some of the income may be irregular due to the type of employment undertaken by household members (this is often from agricultural work or informal selling of goods). This is often the result of a specific budgeting strategy in order to maximise fuel security as opposed to increasing the household's welfare (Davis, 1998). Access to electricity may influence fuel choice, but as it is a relatively expensive fuel (without considering the influence that lifeline subsidies have on price), the anticipated extent of fuel-switching to electricity does not take place. This lack of fuel-switching is exacerbated by status attached to owning certain appliances by the community, as well as the ability to serve multiple purposes.

Households that are electrified, but still fall into low-income categories, are predominantly rural or are in areas where there is little industrialisation, still have a large prevalence of fuelwood, paraffin and candle usage (Davis, 1998; Victor and Victor, 2002). This indicates that the transition has not taken place as anticipated among newly electrified households (this was confirmed from the intensive candle usage that was present among all households).

3. Theoretical setting

Neoclassical theory suggests that the primary economic variables in determining the demand for any good or service are individual and/or household tastes and demands; further, the prices of these goods and services as well as available income also influence the demand of consumer goods and services. Thus, these variables are incorporated into the majority of energy demand models (Varian, 1992).

Households (and communities in general) see electricity as being a normal good, whereas paraffin, coal and other traditionally used energy sources such as biomass are perceived to be inferior goods.[5] Households' utility is also derived from the service that electricity provides (i.e. being able to operate domestic appliances, televisions, etc.) as opposed to other goods such as chocolate where utility is derived from the direct consumption of the good.

A general household utility function incorporating the household's energy demand would generally take the form of

$$U = U(ES(E, A, F), G, S, z) \text{ subject to} \quad m \leqslant p_1x_1 + p_2x_2 + \cdots + p_nx_n \tag{1}$$

where ES is the energy services consumed by the household, E the electricity, A the appliances, F other fuels consumed by the household, G the goods (durables included) consumed by the household, S the services consumed by the household, z the tastes and preferences of the household, m the income of household, p_n the price of good x_n, and x_n the quantity of good n consumed.

In order for the household to maximise their utility (and, as such, minimise their expenditure) a Lagrangian function is assumed (Eq. (2)):

$$L = U(ES(E, A, F), G, S) - \lambda(p_{ES}x_{ES} + p_Gx_G + p_Sx_S - m) \tag{2}$$

The first-order conditions from the Lagrangian function allow us to derive the Marshallian demand function for the household's demand for energy services.

Thus, the household's demand for energy services can be stated as follows:

$$ES = (p_{ES}, m, z) \tag{3}$$

The household's tastes and preferences (z) are included in the demand function as they form part of the decision process in

[4] The RDP as a macro-economic policy in South Africa was subsequently replaced by GEAR in 1996. Following GEAR, the Accelerated and Shared Growth Initiative for South Africa (ASGISA) has been implemented to support the macro-economic policy.

[5] An inferior good is a good or service that a household or individual purchases less of as income rises.

determining which fuels are used in the household—this also incorporates any externalities that may impact on health and productivity and thus influence any decisions made.

4. Dataset and descriptive statistics

The dataset, comprises data that was obtained from the NRS National Load Research Programme (NLR)[6]; in addition to this, data from a study conducted by the Energy Research Centre (ERC) to assess the impacts of EBSST was also used. Both sets of data were merged, in order to obtain a dataset that allowed us to study the determinants of energy demand, as well as the changes that might occur once a lifeline subsidy such as the EBSST in South Africa is introduced. Analysis was carried out on these data to test for validity of the database contents.

For the houses sampled in the NLR database, the areas surveyed were generally hosted by Eskom or municipalities who collected these data on behalf of the project. These areas tended to be selected, initially, be on a *willingness-to-participate* basis but further development of the project meant that sites were selected according to supply level, mean age and income. Each district surveyed had at least 60 households sampled, which were chosen randomly (Dekenah et al., 1998). The sample analysed in the survey contains less households per village as, when collating the two datasets, fewer households had valid data points across both databases.

The NLR data include metered electricity consumption data, sales data and some socio-economic data. The EBSST dataset that was collated with the NLR data contains more comprehensive socio-economic data. Both sets of data have information regarding appliance ownership, alternative fuel usage as well as time-of-use data for the appliances and alternative fuels.

The EBSST baseline survey that is used in this study was part of a panel-data study that was carried out at a number of sites around South Africa, and followed an Eskom research project that was assessing the impact of electrification (University of Cape Town, 2003). The sites were predominantly rural, although there were two peri-urban and one urban site surveyed. The same sampling procedure was used for both studies.[7] Only Antioch and Garagapola (both rural households) were analysed in this study as both sites contained extensive socio-economic data and metered consumption data.

The collated dataset has a sample size of 92 households, from the two sites, Antioch (40 households) and Garagapola (52 households). Antioch is situated in the Eastern Cape, in the Drakensberg. It is a remote mountainous region. The closest large town is Umzimkulu, approximately 35 km away. Most homesteads in this village are traditional rondavels,[8] and have garden plots associated with them—these are mostly used for subsistence farming (University of Cape Town, 2002).

There is a local electricity vending station for the residents of the village, and water is available from communal taps. At the time of the pre-FBE implementation study, residents complained about poor service; mostly this was due to the vendor rationing the amount of electricity units sold, and running out of electricity units to sell (University of Cape Town, 2002). This could mean that demand is dampened, and consequently the results may not reflect the true extent of the relationships that exist between consumption and socio-economic factors.

Garagapola is situated on the border between the Northern Province and Mpumalanga in the north of South Africa. It is approximately 20 km from the nearest towns, and is situated near the mining industry of the north. As a result, a number of residents work on the mines, and are generally more well off than those residents living in Antioch (University of Cape Town, 2002).

All the households are connected to grid electricity, and have access to water from the communal taps in the villages. The village is situated at the base of a mountain, and most households have relatively large plots; woodfuel is used to meet energy needs, and residents undertake some subsistence farming (University of Cape Town, 2002). Households in both villages are price-takers with respect to their electricity consumption. (Table 1)

Due to the nature of the households studied, the data from the sample did not show a normal distribution (was skewed to the left) and as such is heteroskedastic.[9] As no *a priori* functional form is suggested by theory a logarithmic functional form for the regression analysis was used. In addition, a previous study by Zarnikau (2003) finds no conclusive evidence that any one type of functional form is superior to another thus allowing us to use the log-linear form in good conscience.

Given this, and the descriptive statistics, the following general model will be used:

$$Wh = f(PElec, PAltFuels, Income, Rooms, HHSize, ApplCost, TimeElec, lights, credit)$$

where *Wh* is the average number of watt hours used every 5-min,[10] *PElec* the price of electricity paid by the household in c/kWh, *PAltFuels* the price of alternative fuels paid by the household, *Income* the total income earned per month by the household, *HHSize* the number of persons living in the household, *ApplCost* the cost of appliances owned (most commonly used), *TimeElec* the number of years household has been electrified for, *Lights* the number of working electric lights a household has installed and *Credit* whether the household has had access to credit in the past.

It is expected that the signs of the coefficients for real income and price of substitutes will be positive, while the signs of the coefficients for price of electricity and appliance cost are likely to be negative. The coefficients for time electrified should also be positive (this is thought to be due to a learning-by-doing effect of using electricity over time, thus realising the positive benefits of electrical energy). It is also expected that the credit obtained will have positive coefficient as it increases the ability to use electrical energy.

It is expected that household size and floor area would have positive coefficients as larger families would consume more electricity, as well as use more electricity to light and cool or heat the rooms in the house depending on the seasonal

[6] The NRS NLR has been conducted by Marcus Dekenah Consulting (MDC) since 1998 and is funded by ESKOM. It is the study of domestic electricity consumption across all income strata from sites across South Africa. This data were released into the academic domain under the supervision of ERC with funding from the Programme for Energy and Sustainable Development (PESD) at Stanford University.

[7] Details of the sampling procedure can be found in Thom, C., Mohlakoana, N., Dekenah, M., Heunis, S., 2000. Case studies on the impact of electrification in rural areas. Eskom Report RES/RR/00/11953. Version March 2001 (Qualitative Research). Eskom Resources and Strategy Division, Rosherville; Thom, C., 2001. Case studies on the impact of electrification in rural areas. Cycle 2. Eskom Report RES/RR/01/16289. Eskom Resources and Strategy Division, Rosherville.

[8] A rondavels is a round hut, with a thatched conical roof. It is typically constructed in rural areas of South Africa.

[9] Heteroskedasticity occurs where the variance of the random error term in the regression model is not constant. The problem generally occurs where data are highly skewed, or where outliers and error-learning can occur within models. As a consequence, estimators within regression models may be inflated (Gujarati, 2003).

[10] When measuring consumption at the chosen villages, data loggers measured actual household consumption in amperes for every 5-min. The average reading over the length of the study, converted to Watt hours, is used for the purposes of this study.

Table 1
Descriptive variables

	Variable	Unit	No. of observations	Mean	Std. dev.	Min	Max
	Wh (5-min average)		92	11.094	8.789	0.615	24.443
Antioch			40	7.678	7.577	0.656	27.575
Garagapola			52	13.721	8.812	0.615	34.443
	Electricity price	c/kWh	85	37.72	0.616	34.65	42.41
Antioch			35	37.67	0.075	37.43	37.74
Garagapola			50	37.76	0.802	34.65	42.41
	Income	Rands	81	848.83	760.09	100	4500
Antioch			39	640.51	544.41	100	3500
Garagapola			42	1042.26	879.195	100	4500
	Household size		83	5.59	2.794	1	14
Antioch			39	5.154	2.916	1	14
Garagapola			44	5.977	2.654	1	12
	Number of rooms		83	3.771	2.032	1	9
Antioch			39	2.897	1.483	1	7
Garagapola			44	4.545	2.151	1	9
	Lights		83	3.831	2.251	0	9
Antioch			39	2.795	1.454	0	7
Garagapola			44	4.75	2.441	0	9
	Proportion of households with cooking appliances		83	0.434	0.499	0	1
Antioch			39	0.432	0.502	0	1
Garagapola			44	0.436	0.501	0	1
	Radio price	Rands	49	97.12	11.64	0	400
Antioch			17	94.59	102.79	0	350
Garagapola			32	98.47	120.57	0	400
	Price of irons	Rands	56	35.93	42.02	0	160
Antioch			30	31.53	36.96	0	120
Garagapola			26	40.99	47.43	0	160
	Paraffin price	Rands	84	3.07	0.926	0.94	6.00
Antioch			36	2.72	0.777	0.94	4.00
Garagapola			48	3.32	0.953	1.40	6.00
	Candle price	Rands	92	0.58	0.27	0.17	2.50
Antioch			38	0.61	0.194	0.42	1.67
Garagapola			54	0.56	0.321	0.17	2.50
	Year electrified	Years	83	3.87	0.558	2	6
Antioch			39	3.600	0.549	2	4
Garagapola			44	4.113	0.442	3	6

requirement. Halvorsen (1975) was unsure of the effect as he hypothesised that households with increased floor space and larger numbers would substitute electrical power consumption with the use of natural gas for certain requirements that would be energy intensive. This hypothesis was concurred with by Leth-Peterson (2001) in his study on Danish households. Some urban households in South Africa tend to rely only on electricity, particularly those with a large proportion of discretionary income so they would not substitute any other fuel for electricity to meet heating purposes; lower income households are still likely to substitute fuel types to meet and other demands, especially heating and cooking as it is particularly energy intensive.

5. Analysis and results

As prices for certain fuels, particularly fuelwood, are not available in either dataset both dummy variables for usage as well as fuel prices paid by the household are used in the models tabulated in Table 2. The same methodology was attempted for appliance prices, but as there were too few data points in all cases therefore dummy variables for ownership were used for the analysis.

Model 1 does not account for any fuel substitution or household characteristics. Models 2 and 3 are the most pure, using relative paraffin and candle prices to explain quantity of electricity used. Models 4–7 include different household characteristics to explain demand decisions regarding electricity usage. Electricity price is not included in the models as the electricity price range is approximately 7.5 cents and does not seem to make any impact on households' decisions.[11]

Heteroskedasticity was still present in the models, even though the log transformations had been made to these data. As the study was conducted on cross-sectional data, this was not unexpected.

The Ramsey RESET test for mis-specification indicated that there were possible explanatory variables missing from all the models tested excluding models two and three. Models 2 and 3 included the income and alternative fuel variables (price of paraffin and candles, respectively); it is unclear why the RESET test indicated that there were no omitted variables as when further analysis was conducted, the test again indicated that there were in fact missing variables. However, the indication that there may be omitted variables could be as a result of insufficient appliance price data and lack of data for alternative fuel prices such as wood.

In all the models featured in Table 2, it was found that the demand for electricity was income inelastic. In other words, for a percentage change in income, ceteris paribus, there was little

[11] During the regression analysis, any regressions run that included the price variable found that the price variable was insignificant. All other variables that were tested had the same results as those regressions that excluded the price variable.

Table 2
Determinants of electricity demand

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Dependent variable	ln (kWh)	ln (kWh)	Ln (kWh)	ln (kWh)	ln (kWh)	ln (kWh)	ln (kWh)
ln (income)	0.532 (3.22)***	0.343 (2.08)**	0.379 (2.24)**	0.299 (1.92)*	0.244 (1.80)*	0.278 (1.87)**	0.243 (1.66)*
ln (price of paraffin)	–	0.709 (2.09)**	0.647 (1.88)*	0.466 (1.55)	0.406 (1.44)	0.680 (2.35)**	0.442 (1.42)
ln (price of candles)	–	–	−0.396 (−1.27)	–	–	–	–
ln (rooms)	–	–	–	–	0.371 (2.38)**	–	–
ln (household size)	–	–	–	−0.097 (−0.56)	–	–	–
ln (time electrified)	–	–	–	0.443 (0.65)	–	–	–
Wood dummy	–	–	–	−0.495 (−2.15)**	−0.478 (−2.21)**	−0.707 (−3.31)***	−0.586 (−2.67)***
Iron ownership	–	–	–	–	–	0.572 (2.77)***	0.546 (2.69)***
Cooking appliance ownership	–	–	–	0.650 (3.03)***	0.691 (3.52)***	Dropped	0.418 (1.87)*
ln (lights)	–	–	–	0.271 (1.56)	–	0.281 (1.62)	0.327 (1.90)*
Credit obtained	–	–	–	–	–	0.342 (1.48)	0.397 (1.73)*
Constant	−4.428 (−4.11)***	−3.863 (−3.68)***	−4.264 (−3.92)***	−4.098 (−3.36)***	−3.363 (−3.73)***	−3.783 (−3.82)***	−3.673 (−3.78)***
N	81	70	67	68	70	68	68
Adjusted R^2	0.1161	0.1206	0.1342	0.3875	0.4140	0.4011	0.4247
Ramsey reset (Prob.)	3.31 (0.024)	1.13 (0.345)	1.50 (0.223)	4.95 (0.004)	4.91 (0.0040)	3.80 (0.015)	3.55 (0.019)

Notes: *T*-values in parentheses; ***indicate significance at the 1% level; **indicate significance at the 5% level; *indicates significance at the 10%.

change in the number of units of electricity consumed on a monthly basis. The cross-price elasticity of demand relating to paraffin was inelastic. This indicates that whilst demand for electricity will increase if the paraffin price increases, the change will only be by a small proportion. This is largely due to the convenience of purchasing paraffin as it is available from local spaza shops (small informal retail shops typically operated from residential houses in low-income suburbs), and can be bought in any quantity desired; the associated appliances are also readily available and a great deal more affordable than electric appliances. The price of candles was insignificant.

The most comprehensive model run, namely model 7, obtained an R^2 of 0.42. In this model, the price of paraffin was insignificant ($t = 1.42$) although the wood dummy variable, which indicates whether households use wood or not, was highly significant ($t = 2.67$). Previous models run (Models 2, 3 and 6) indicated that paraffin was, in fact, significant as have previous studies (Holtedahl and Joutz, 2004; Filippini and Pachauri, 2004). Other models tested (not included in the results) that used a dummy variable for paraffin showed that paraffin usage was significant.

Income was found to be significant across all models tested, and showed a positive relationship with electricity demand; this indicates that the use of electricity is a cost-based decision. Wood usage was also significant in models 4–7; as noted previously both villages have access to wood and either collect or buy woodfuel (collection of woodfuel in these areas is more prevalent). The use of wood as an energy source is also linked to income levels to a certain extent, as it is freely available and there is not necessarily any monetary cost involved in using wood. It has also been hypothesised that in more rural areas, woodfuel collection is part of the social interaction that occurs among the females in the village. Another reason for using wood is that due to high infrastructure costs electricity supply to rural areas is usually delayed and supply costs are generally higher than those in urban areas due to household density, thus making woodfuel a much cheaper and more accessible alternative to electricity.

Model 4 included the time electrified variable and household size variable. Both of these were insignificant ($t = 0.65$ and 0.57, respectively). While it was not unexpected that household size does not affect electricity usage as most of the end-use demands of household members can be met simultaneously (e.g. entertainment or cooking), it was unexpected that time electrified was insignificant. This suggests that there may be an inherent willingness in most households to use electricity; it also suggests that usage is then hampered by factors such as income which may prevent access to the service.

Predictably, appliance ownership (including lights) was significant across models 4–7, particularly in model 7, where all three appliances (cooking appliance and iron ownership as well the number of electric lights in the households) were tested. This is unsurprising as appliances are needed to make use of electricity. In addition, as cost hampers the usage of electricity, low-income households are more likely to use electricity for "cheaper" services such as lighting, ironing and entertainment where the appliances are cheaper to purchase and the per-unit cost of using the appliance is also less expensive than, for example, using a four-plate stove.

The ability to obtain credit was also found to be fairly important. This is understandable as appliances tend to, as noted before, be quite expensive and therefore unaffordable for newly electrified low-income households. The extent to how much credit is obtained, however, is unknown. This, potentially, is important because if households are able to obtain large amounts of credit easily, it could have a negative effect on household welfare in the long run.

Although electricity price was not included, income and paraffin price tended to be significant across all the models. This highlights the importance of the price–income relationship of fuels in meeting household energy needs.

6. Policy implications

6.1. Income elasticities and electricity demand

Income remained inelastic throughout all the models tested in Section 5. This reflects the fact that electricity is a basic need. This fact has been adopted into policy, as stated by the energy white paper (1998) and upheld by the World Bank in their respective publications on energy.

The new energy pricing policy (2004) released by the Department of Mineral and Energy Affairs proposes that households that have low electricity in consumption will be charged tariffs that are less than cost. Funding for this shortfall in covering costs would be catered for via cross-subsidising from higher income and/or higher consumption users. While on paper this solution appears to be feasible (and has been successfully implemented for other commodities), the model derived suggests that for electricity there is room for cross-subsidisation but one needs to take price sensitivity into account.

6.2. Appliance costs

Gaunt (2003) identified two primary constraints to the use of electricity. The first is that the initial cost of obtaining access to electricity is high. The initial cost includes the infrastructure cost (obtaining connection to the grid) as well as the cost of obtaining appliances to utilise with the service. There is also a redundancy cost included in this initial cost. The existing household infrastructure and appliances have usually been purchased and designed around the lack of electrical services. Low-income households cannot easily afford to turn the existing equipment into sunk costs. The utility that they obtain from the existing methods may still exceed that which could be supplied by the use of electricity.

The second constraint is the continued cost of electricity consumption, i.e. the everyday cost of using electricity. Included in these costs are not just the unit costs of supply but also the costs of new appliance purchases, repairs and maintenance. As consumers are price sensitive, the cost of acquiring appliances—especially those that would confer greater positive externalities such as improved health from clean air and fresh food—would be prohibitive to the actual uptake of households to use electricity.

Credit in South Africa is reasonably easy to access, and allows households to obtain appliances that are otherwise unaffordable.[12] The danger of this is that households may find themselves unable to meet the required repayments. Long term this means that the households may find that their welfare is harmed. This is of particular importance for developing countries in Africa as levels of savings are generally quite low, and should be increased for macroeconomic conditions to improve.

Another option for households to obtain appliances are government schemes to reduce the cost of appliances. Currently, these have not been mooted, however, should government implement a scheme that enabled reduced cost appliances, either through subsidies or vouchers, for "basic needs" such as food preservation, cooking, heating and lighting, it would allow households not only to gain the basic benefits from electricity, but the qualitative benefits as well. Examples of this are a reduction in household pollution and the health benefits that derive from this; a decrease in food costs as storage and preservation allow for the purchase of larger quantities at cheaper prices and an increase in the amount of leisure time available.

An implication of a subsidised appliance scheme could be that the amount of electricity consumed would increase dramatically. This would have an effect on the capacity of the electricity supply and generation network. Skilled demand management by the Electricity Supply Industry is required if the policy goal of successfully connecting all households (both rural and urban) by 2012 is to be achieved, especially in light of the decreasing reserve margin that South Africa is experiencing in its generation capacity. The demand curve and its seasonality will have to be carefully monitored and the data collected used to build reliable forecast models which can then be used to ensure that the targets are reached. Government and the electricity regulator need to ensure this is put in place.

7. Summary and conclusion

Electricity is viewed by many, including the South African government and the World Bank, as a necessary basic service which should be available to all citizens. Given this, it is necessary to establish possible determinants of household electricity demand in South Africa. Previous studies conducted predate these changes in policy and therefore apart from guiding policy through dated data could also lead to incorrect policy determination through the studies being focused on other themes.

The NRS Load Research data (a mirror site is housed at UCT) collated with data from a panel study to assess the feasibility of EBSST in South Africa, has allowed a more current and pertinent analysis to be conducted. This collated dataset has allowed a study to be conducted on a comprehensive set of data which included metered consumption readings, appliance and alternative fuel data; most importantly, price data for electricity and alternative fuels were available. This would provide more pertinent and relevant data to be provided as input to policymaking and implementation.

The model has shown that electricity demand is income inelastic. The inference from this is that households in South Africa see electricity as a basic need. The Government has a stated policy of "a better life for all" with a clear focus on poverty alleviation. If they are to be seen as delivering on policy then they will need to facilitate the provision of the basic (or perceived basic) needs of all South Africans. This justifies the government's decision to intervene in the supply side in order to provide free basic electricity to households in the country.

The observations in the sample confirmed that low-income households are price sensitive (the cross-price elasticities of substitute energy services were inelastic and indicated that fuels were indeed substitutes for each other). While income elasticities do not rule out cross-subsidisation as a method of providing affordable services to lower income households, high-income groups could be over-burdened and as a result alter the quantity of electricity consumed. For instance, it could lead to a decrease in demand (although it is unlikely in South Africa, where the majority of middle and high-income households tend to rely only on electricity to meet their energy needs) and thus make cross-subsidisation at the required levels difficult to achieve.

Cost of appliances was not addressed in depth in this paper. The model implies that apart from price sensitivity, cost of appliances also has an effect on demand. Should appliance costs be subsidised, then demand for electricity would most likely increase in the long run and demand management schemes would need to be reviewed. As this paper is a review of short-run household electricity demand of previously disadvantaged individuals in rural South Africa, the estimates obtained would obviously not apply in the long run. More research conducted in the future would be required to determine which variables affect household electricity demand across all individuals in South Africa.

In summary, the results of the analysis suggest that income is a significant component of energy demand in low-income households, as is appliance ownership and access to credit. As income relates to the quantity of any good that households can consume, cross-subsidisation is a solution to ensuring affordability. This needs to be considered carefully as price sensitivity exists among higher income and usage groups as well. By implication then, the pricing policies for each group will have to be carefully decided by Eskom. Access to credit and alternative appliance ownership schemes would also need to be considered when trying to increase the usage of electricity among low-income households.

Acknowledgements

The support of this and related work by David Victor of Stanford University's Programme on Energy and Sustainable

[12] The introduction of new laws for credit provision within South Africa will, likely, have an impact on households and the ability to purchase appliances.

Development is gratefully acknowledged. So too is the support of Hendri Geldenhuys of ESKOM. Alison Hughes, Bruno Merven, Gisela Prasad and Bill Cowan of the Energy Reseach Centre are also acknowledged for their intellectual contributions to research programme from which this work emanated.

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