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Economic Analysis of Energy Poverty in South Lunzu, Malawi

Betchani H. M. Tchereni[2], Wynand Grobler[3] and Steven H. Dunga[4]

Abstract

Using economics approaches of measuring energy poverty, the findings of the study suggest that over 90 percent of the households sampled were energy poor. The Logit model of energy poverty reveal that household expenditure on transport, income level, age, and education level of head of household, household size and home size, are important factors in explaining the state of energy poverty in South Lunzu Township. . Households who spent more on schooling were also spending more on food items and their expenditure on energy resources was less than 10 percent of the total expenditure per month. The major recommendation of this study is that campaigns emphasising on the abilities of Renewable Energy be developed and disseminated. Also there should be a deliberate effort to make cheaper sources of renewable energy like solar available to poorer townships

Key words: Energy poverty, Logit, Probability, South Lunzu, Choice.

1.0 Introduction

Most households and industries in the Sub-Saharan Africa use traditional and unclean energy resources for many activities such as cooking, lighting and drying of farm produce. In Malawi currently household energy consumption accounts for 84 percent of the total energy used, the dominant energy source being biomass (99 percent) (NSO, 2012; GOM, 2006). An Installed electricity capacity of 283 MW is clearly not enough to satisfy an estimated electricity demand of about 330 MW. People largely depend on biomass especially firewood and charcoal for their household and farm energy needs. The attainment of the Millennium Development Goals (MDGs) rests on the availability and access of affordable energy to all people. To achieve the MDGs and sustainable development in general, policies and strategies that will encourage the use of green energy both at the household and industrial level are important. Energy is important to eradicate poverty through improved education, health services and even provide employment to many people with a variety of skills.

The state of energy poverty needs immediate attention. There has been little attention on the energy demand and supply nexus. Research has concentrated on production, engineering and rural areas neglecting energy access problems for urban dwellers. The objective of this study was to analyse the state of energy poverty in an urban poor society environment. Specifically, the paper aimed at identifying the determinants of energy poverty in South Lunzu Township by first computing the energy poverty level and secondly econometrically analyse factors that determine its level.

2.0 Literature Review

Energy poverty has been defined as the state of deprivation where a household or indeed an economic agent is barely able to meet at most the minimum energy requirements for basic needs (IEA, 2010; Modi *et al,* 2005; Foster

[2] University of Malawi and North-West University, Corresponding author. Email: betchereni@gmail.com.
[3] North-West University, Vaal Triangle
[4] University of Malawi and North-West University.

et al, 2000). Many authors have provided the definition in theory but in practice they fail to agree on what exactly is the minimum level below which a household can be classified as being energy poor (Pachauri & Spreng, 2003; Pachauri et al, 2004; Mirza & Szirmai, 2010). The International Energy Agency believes that there is a minimum level of energy consumption for the rural areas on the one hand and urban locations on the other. For rural areas, the minimum estimated comprises of two light bulbs, 5 hours of radio while for the urban areas with additional appliances such as television and refrigerator, the requirements would be higher (Foster et al, 2000). However, other important energy needs such as cooking, ironing, and washing are not included.

More and more efforts in modern times are leaning towards an investigation that should establish an energy poverty line. Authors such as Fahmy (2011), Foster et al (2000), and Pachauri et al (2004) have established an energy poverty line for specific areas based on techniques that are scientific from both engineering and economic sciences.

Table 1 African electrification rates 2005

	Africa	Sub-Saharan Africa	North Africa
Population without electricity (millions)	554.0	547.0	7.0
population with electricity (millions)	337.0	191.0	146.0
Electrification rate (percent)	37.8	25.9	95.5
Urban electrification rate (percent)	67.9	58.3	98.7
Rural electrification rate (percent)	19.0	8.0	91.8

Source: IEA (2006B)

Using access as a method of determining whether a household is energy poor or not, many studies have shown that Africa is lagging behind in the provision of modern energy facilities. As table 1 show, 554 million people did not have access to electricity in Africa in 2006. The SSA had the highest number of people without electricity at 547 million. This suggests that generally the SSA has the lowest electrification rate compared to the Northern Africa. Compared to Asia, Africa is still the lowest. This leads to a clear conclusion that energy poverty is more pronounced in the SSA than anywhere else in the world.

Table 2 Number of People without Electricity and Relying on Biomass

	Number of people lacking access to electricity	Number of people relying on the biomass for cooking
Africa	587	657
Sub-Saharan Africa	585	653
Developing Asia	799	1937
China	8	423
India	404	855
other Asia	387	659
Latin America	31	85
Developing countries	1438	2679
World	1441	2679

Source: IEA (2009B)

Further, table 2 summarises the number of people lacking access to electricity compared to those who rely on biomass for their cooking needs. Still the table shows that Africa has a higher number of people who lack access to electricity after Asia as supplied by the main grid. A further observation shows that in Africa it is the Sub-Saharan Africa region which has more people lacking access to modern electricity with 653 million people out of a total of 657 million representing 24 percent of the world total number of people still relying on biomass for their cooking needs. Poor countries have low energy intensity measured by the ratio of total amount of energy consumed to Gross Domestic Product (GDP). Low energy intensity levels are an indication that a country is consuming very low amounts of energy which might imply that access is also very poor. However, care has to be taken as low energy intensity figures might also be an indication of energy efficiency per unit of output.

3.0 The research process

Random Sampling was used to collect survey data in Blantyre City's high density area of South Lunzu Township (SLT) which lies to the east of Ndirande Mountain. SLT has twelve sectors of which data was collected in areas Five, Six, Seven, Eight and Ten. Households were randomly chosen and in total, the survey collected data through questionnaire administration to 319 heads of household and their spouses. South Lunzu Township is a relatively new area compared to other Townships around Blantyre. It emerged mainly due to its closeness to two main industrial areas of Chirimba and Limbe. It is therefore preferred by such people who work in the nearby industrial areas. Recently however South Lunzu has seen an increase in relatively middle income settlers building and renting homes in the area. This is due to availability of utility supplies such as water, electricity and relatively good feeder streets. The Township is more organised and well planned with formal and city council recognised settlements. In each sector there are plots each one facing a gravel feeder street thereby making each household accessible. The city council organised the area and made available water and electricity connection to be within a reasonably affordable connection distance from a main supplying line.

Stratified random sampling was used to choose households from where respondents were drawn. If a head of household was not available, the spouse or partner was requested to respond to the questions. A semi structured questionnaire was given to the enumerators to be used for the collection of information. It had a set of questions on demographics (age, sex, and household size), socioeconomic aspects (employment, education, knowledge) and energy use. Discrete choice analysis using logistic models for binary were adopted to analyse determinants of energy poverty.

4.0 Analysis of determinants of energy poverty

This study adopted energy expenditure methods to identify those energy poor households. Energy poverty measures calculated in this way are referred to as Economics Measures (Pachauri et al, 2004). In expenditure terms, a household is considered to be energy poor if 10 percent or more of its expenditure is on energy facilities (Fahmy 2011). This definition therefore demands a clear explanation and data on energy expenditure at the household level and total income. In this sample, Out of the 319 households, 2.9 percent frequently used hydroelectric power for cooking meals. A small group representing 0.63 percent use LP Gas and just 1 household representing 0.31 percent depend mostly on solar power. This is a worrisome development considering that solar power, electricity and LP gas are renewables and the percentage of those who use these resources combined is just about 3.84 percent.

3.1 Expenditure approach of measuring energy poverty

Expenditure on energy is calculated by adding together all the money-metric costs incurred to fetch energy facilities. These include:

i. Transport cost to and from the place of fetching the energy facility;
ii. Actual purchase cost of the facility;

The formula for this calculation is given by:

$$EEX_{ij} = ETPT_{ij} + APC_{ij} \quad (30)$$

Where EEX_{ij} total expenditure on energy facility i by household j; $ETPT_{ij}$ is transport expenses incurred towards the acquisition of energy facility i by household j; and APC_{ij} is the actual purchase cost of energy facility i by household j. since the expenditure on transport as a recurrent activity mainly involves purchases of energy, ETPT includes therefore transport expenses the household incurred per month. For those who commute, bus fares are a direct function of the price of petrol and diesel on the energy market. Particularly, walking and cycling do not involve the use of energy whose cost can be quantified in monetary terms. For those who used cars for travel, the cost of petrol and diesel was added.

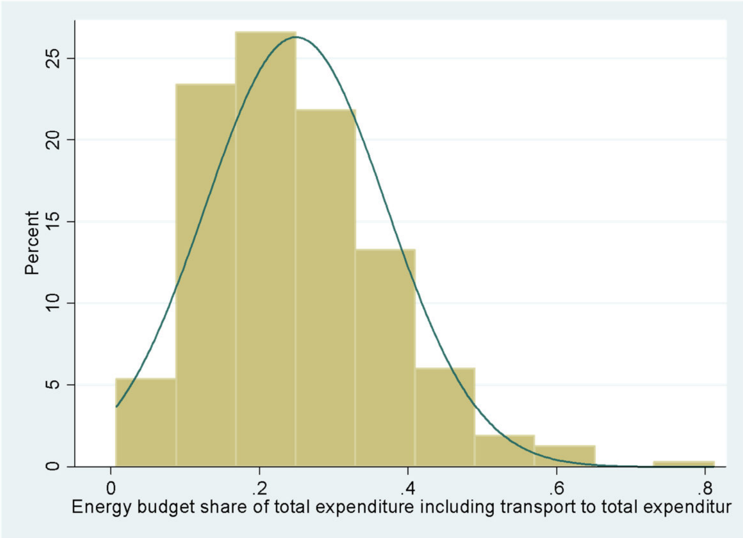
Table 3 Frequency for energy poverty

Energy Poverty Dummy Variable	Frequency	Percent	Cumulative frequency
Energy well-off	62	19.44	19.44
Energy Poor	257	80.56	100
Total	319	100	

Source: Energy Poverty and Sustainable Development survey data, 2012.

Table 3 provides a summary of energy poverty statistics using the income or economics approach. From the table, 62 households representing about 19 percent of the sample were not energy poor. These households were spending less than 10 percent of their income on energy commodities including transportation. On the other hand out of a total of 319 households, 257 were found to be energy poor representing about 81 percent of the sample. Figure 2 shows the distribution of the share of energy expenditure as a percentage of household's total monthly expenditure. As can be observed, the distribution is normal with a mean of around 18 percent and a standard deviation of 0.11. This shows that it is 'normal' for a household to be energy poor in South Lunzu Township with little variability among those sampled for the study.

Figure 2 Distribution of expenditure share of energy in household budget



A third measure of energy poverty borrows from the income poverty literature to compute a relative energy poverty line using descriptive statistics methods. A relative measure of energy poverty was performed where the mean of the cost of energy was computed. Those whose cost of energy was found to be below the average were deemed as energy poor and those above the mean were well-off. Following this method as table 7.6 shows, the number of people in energy need drops to 199 representing about 62.4 percent of the sampled households while that of households deemed not energy poor were 120 representing about 37.6 percent. These results are not far from each other. Using the two methods, the story is still the same that in South Lunzu Township; at least 60 percent of the households could be classified as in energy poverty.

Table 4 Relative energy poverty summary frequencies

Relative Energy Poverty	Freq.	Percent	Cum.
Energy-well-off	120	37.62	37.62
Energy-poor	199	62.38	100
Total	319	100	

Consequently, an econometric analysis of the factors that influence the level of energy poverty in South Lunzu was performed relying on inferential statistical methods to interpret the results. A dummy variable, EPVY representing energy poverty was created taking on the value of 1 if a household was found to be energy poor and 0 otherwise.

3.2 Econometric Analysis of Energy Poverty

Those who were deemed to be energy poor were identified based on the energy expenditure budget of the household. Households whose energy expenditure budget exceeded 10 percent were regarded as being energy poor and therefore they were coded 1 and those who were spending less than 10 percent on energy facilities got a code of 0 (zero). A binary variable was consequently created which renders the reliance on Ordinary Least Squares (OLS) method of regression analysis unfit. In such a case, OLS does not give results that are best, linear and unbiased estimators. Some of the results are in fact undefined (Gujarati, 2004). Consequently, qualitative methods that try to analyse qualitative (categorical) data become handy and useful.

In the present case, one class of categorical models, a logistic regression, was estimated. This class of regressions use predictors to estimate probabilities that an event does or does not occur relying on similar inferential statistical methods as in OLS (Gujarati, 2004; Green, 2003). Theoretically, a decision maker, n, faces J alternatives. The utility that the economic agent obtains from alternative j can be represented as:

$$U_{nj} = V_{nj} + \varepsilon_{nj} \quad (1)$$

Where, U_{nj} is total utility; V_{nj} and ε_{nj} utility known by the researcher and stochastic utility, respectively. The logit function is obtained by assuming that each ε_{nj} is independently, identically distributed extreme value. The density for each unobserved component of utility is:

$$f(\varepsilon_{nj}) = e^{-\varepsilon_{nj}} e^{-e^{-\varepsilon_{nj}}} \quad (2)$$

and the cumulative distribution is given by:

$$F(\varepsilon_{nj}) = e^{-e^{-\varepsilon_{nj}}} \quad (3)$$

From the foregoing the probability that decision maker n chooses

The following empirical model is suggested:

$$f(EPVY) = (exp\_tpt, exp\_food, exp\_sch, gender, educ, exp\_home, hhsize, hmsize, marital, \varepsilon)$$

Table 5 Results of the Logit Model and elasticities

EPVY	Odds Ratio	ey/ex	z-score	P>|z|
exp_tpt	1.00081	0.2	5.75	0.000***
exp_food	0.9999	-0.49	-4.23	0.000***
exp_sch	0.99989	-0.19	-4.28	0.000***
Gender	1.20806	0.02	0.47	0.637
Educ	1.00925	0.02	0.15	0.881
exp_home	0.99997	-0.02	-0.58	0.562
Hhsize	1.21124	0.18	1.87	0.061*
Hmsize	0.99699	-0.03	-0.54	0.591
Marital	1.26664	0.11	1.66	0.097*
_cons	1.47712		0.43	0.665

Where *, **, and *** means statistically significant at the 10%, 5% and 1% level of significance.

The results in table 5 show that there is a positive and statistically significant relationship between energy poverty and transport expenditure. The null hypothesis that the level of transport expenditure does not affect the level of energy poverty is therefore rejected at the 1 percent level of statistical significance. The results suggest that the odds ratio of 1.0008 was in favour of transport expenditure to increase the energy poverty level. In terms of elasticity as reported in table 5 the relationship between transport expenditure and energy poverty was inelastic. A 1 percentage increase in transport expenditure could increase energy poverty by 0.2 percent.

There was a statistically negative relationship between food expenditure as represented by exp_food and energy poverty rejecting the null hypothesis of no relationship between the two. At 1 percent level of significance, the odds ratio predicts that households which spend more on food are likely to be better off in energy access. As table 5 shows, for every 1 percentage point increase in food budget, there is likely to be a 0.49 percentage decrease in energy poverty.

At 1 percent level of statistical significance, the null that there is no relationship between expenditure on education and energy poverty is. In terms of elasticity, the relationship is however inelastic as increasing education expenditure by 1 percentage points is likely to lower energy poverty by 0.19 percent. Said differently, low energy poverty levels are likely to be associated with higher expenditures in education for members of household as funds are released from spending on energy and the gains are moved towards improved and quality education. There was a positive relationship between Gender and energy poverty although the association was statistically insignificant to reject the null hypothesis that there is no relationship between the two variables. The odds ratio however show that one is likely to be energy poor if they are male than female. Culturally men do not go to the forest to fetch firewood the way women do in Malawi and many other parts of Africa. The gender elasticity of energy poverty is inelastic at 0.02 percent. That means a 1 percent increase in males is expected to increase energy poverty by 0.02 percent.

At any level of standard statistical significance, education of the head of household could not be a statistically significant factor in explaining the behaviour of energy poverty in South Lunzu although there was a positive relationship between level of education and energy poverty. This result is strange considering that higher education levels are associated with higher income levels and therefore the energy share in the expenditure budget should be smaller. There was a statistically insignificant relationship between home expenditure as represented by exp_home and energy poverty. Higher expenditures on accommodation were likely to be associated with lower energy poverty levels. In terms of elasticity an increase in home expenditure by 1 percent was likely to lead to a 0.02 percent decrease in energy poverty. Households that were spending higher amounts of their income on housing were likely to be less energy poor compared to those that were staying in low cost accommodations.

Household size represented by hhsize had a statistically significant positive relationship with energy poverty at the 10 percent level of significance. The odds were that it was more likely for a household with more members to be energy poor than those with fewer members. The household size elasticity of energy poverty was inelastic at 0.18 implying that a 1 percent increase in household poverty was likely to increase energy poverty of the household by 0.18 percent. There was a negative relationship between size of the dwelling unit as represented by hmsize and energy poverty. The relationship however was statistically insignificant to suggest that the size of the dwelling unit (house) can be relied upon to explain the behaviour of energy poverty at the household level in South Lunzu. However although insignificant, the negative relationship suggests that households dwelling in larger houses were likely to be less energy poor compared to those living in smaller units. On marital status which was represented by marital, the relationship was positive and statistically significant at the 10 percent level of significance suggesting that homes with married couples were more likely to be energy poor than those who were not.

3.3 Evaluation of the Energy Poverty Regression Model

Logistic analysis relies on other statistics to analyse the reliability of any model. The Log-Likelihood Ratio test which is distributed as a Chi-Square is computed to test the overall performance of the model. Table 6 presents the results of the Log-likelihood ratio test. The Chi-Square statistic was 131.54 and it was statistically significant to reject the null hypothesis that the overall explanatory power of the model could not be relied upon. The predictors in the logistic regression were collectively important in explaining the behaviour of energy poverty in South Lunzu.

Table 6 Log-likelihood Ratio Test of the Logistic regression

Logistic regression	**Number of observations**	**316**
	LR chi2(9)	131.54
	Prob > chi2	0.000***
	Pseudo R2	0.4204
Log likelihood		-90.68

Where *** means statistically significant at the 1% level.

The Pseudo Pseudo R-squared) was 42 percent implying that the model explained about 42 percent of the deviations in the probability of energy poverty in South Lunzu.

A further goodness of fit test that is recommended for logistic regressions in the literature is the Hosmer-Lomeshow (HL) Chi-square statistic (Peng, Lee & Ingersoll, 2002). The statistic is distributed as a Pearson Chi-square and evaluated through a log-likelihood estimation calculated from a 2 x g table of observed and expected frequencies. Where g is the number of groups formed from expected probabilities of each one of the observations. As table 7 shows, the null hypothesis that the model was a good fit to explain the deviations in the behaviour of energy poverty is accepted even at the 10 percent level of significance. The value of the HL statistic was 3.4 with the probability to accept the null hypothesis of about 91 percent.

Table 7 Results of Chi-Square test of goodness of fit

number of observations	**316**
Hosmer-Lemeshow chi2(8)	3.4
Prob > chi2 = 0.9069	0.9069

5.0 Conclusion

South Lunzu Township is an energy poor stricken community with more than 80 percent of the households living below the energy poverty line. In this area, more than 40 percent of the households depend on biomass for their cooking needs. For those who have electricity, only less than 10 percent use it for both cooking and lighting, about 70 percent of the households did not rely on electricity for their cooking needs. In terms of factors that affect the level of energy poverty which include expenditure on transport, income levels, age of the head of household, education level of head of household, household size and home size, relate differently. The results of this study in chapter show that gender, expenditure on housing and marital status cannot be relied upon as important predictors of the probability of energy poverty in South Lunzu. Expenditure on education was associated with lower levels of energy poverty. Households who spent more on schooling were also spending more on food items and their expenditure on energy resources was less than 10 percent of the total expenditure per month. In addition, those households which spent more on food were also likely to be energy well-off. This could be explained in the sense that higher expenditures on food might imply that the household was also well-off in terms of income poverty.

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